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METHOD AND APPARATUS FOR WINDING THREAD

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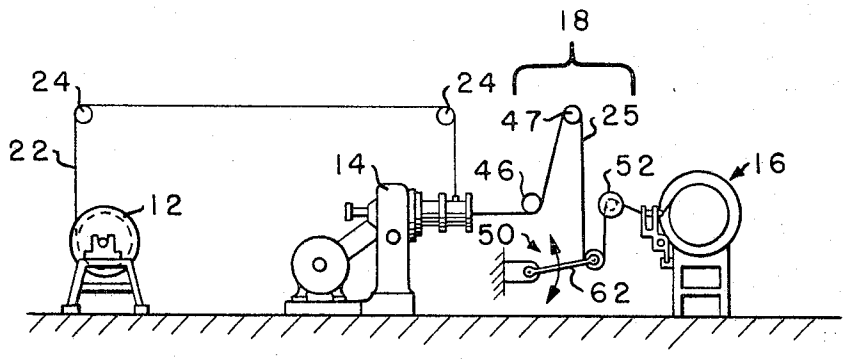


FIG.-1-

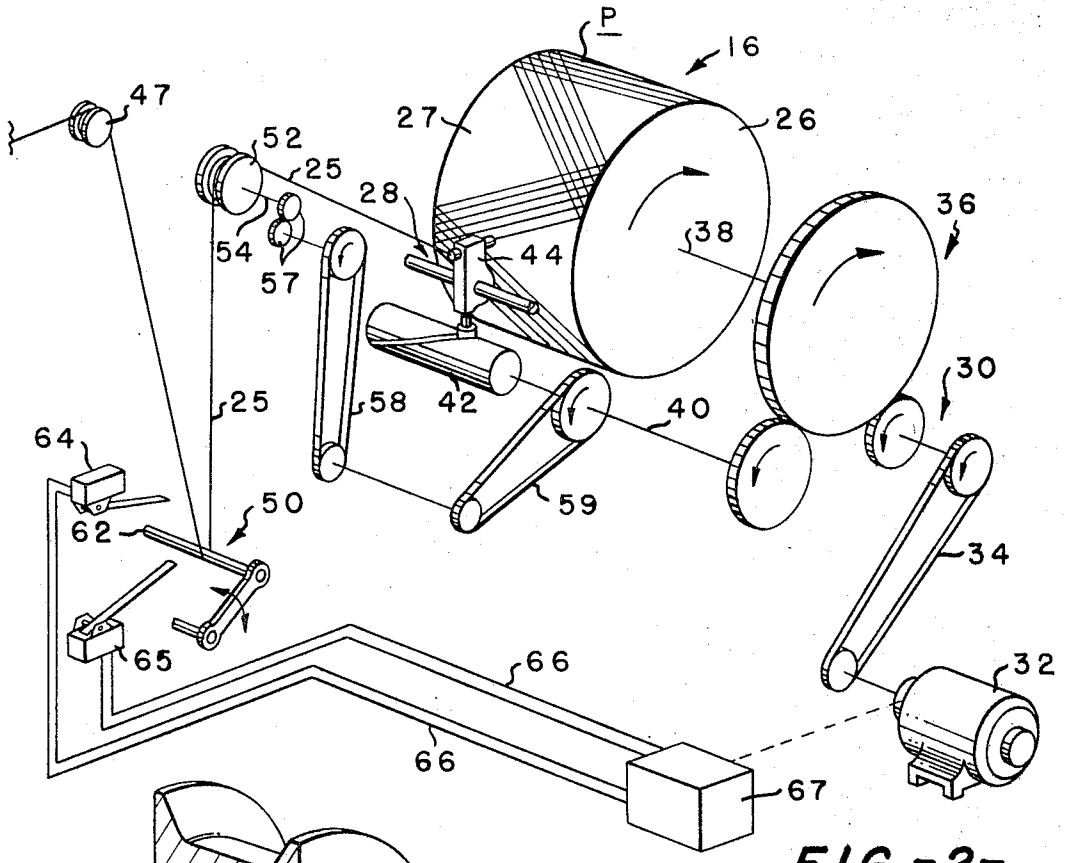


FIG.-2-

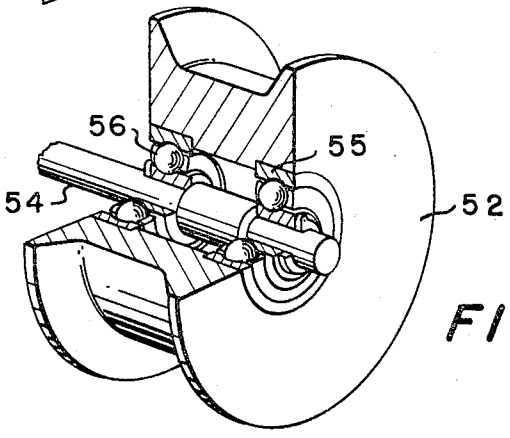


FIG.-3-

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METHOD AND APPARATUS FOR WINDING THREAD

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ABSTRACT OF THE DISCLOSURE

Method and apparatus for winding a continuous thread onto a rotating support surface in a desired pattern wherein the tensional forces tending to displace the thread from the path in which it is laid on the support surface are minimized by imparting feeding force to the thread during abrupt changes in the direction of the thread lay path and by reducing the force resisting linear movement of the thread onto the surface.

This invention relates to method and apparatus for winding a continuous thread onto a rotating support surface in a desired pattern, and more particularly to an improved method and apparatus for forming annular reinforcing belts for use in the construction of pneumatic tires.

It is known to provide an annular reinforcing belt, or breaker strip, between the tread and carcass portions of a pneumatic tire to increase its resistance to road hazards and to provide greater road stability and longer wear life for the tire. Such belts are generally composed of one or more layers, or plies, of parallel, relatively inextensible, threads or cords coated with or embedded in an insulating material, such as rubber, with the adjacent plies running in opposite directions and diagonally to the centerline of the belt to provide increased strength and longitudinal extensibility to the belt during use.

A particularly desirable method of producing such a belt, in that it minimizes the number of free ends of reinforcing thread in the belt and provides a splice free belt construction, involves winding one or more continuous lengths of thread onto a rotating support surface having affinity for the thread, while employing thread guide means to traverse the rotating surface and adhesively secure the thread in a generally zigzag path thereon. During the winding operation, the belt is formed by incrementally displacing the zigzag thread path along the periphery of the support surface to build up a plurality of plies of parallel threads extending generally diagonally to the direction of movement of the support surface.

Typical apparatus for continuously coating a moving thread and forming reinforcing belts therefrom is disclosed in U.S. Pat. No. 3,113,738 and includes an extruder for applying an adhesive protective covering such as unvulcanized rubber, to a longitudinally moving thread, and a support drum and traverse mechanism for winding the coated thread into a reinforcing belt. The drum is rotated continuously to draw the coated thread, by way of appropriate thread guide means, from the extruder and onto its peripheral surface, while the traverse mechanism is reciprocated across the surface to lay and adhesively secure the thread in the desired pattern.

In the use of a rotating drum and traverse mechanism of the type described to produce continuous thread reinforcing belts, problems exist in obtaining a uniform thread pattern on the drum surface during the winding operation. The tension imposed on the thread as it is longitudinally drawn onto the drum and subjected to the action of the reciprocating traverse mechanism tends to dislocate the thread from the desired path or pattern in which it is laid on the drum. Dislocation of the thread from the lay path due to tensional forces acting on the thread is most pronounced at points of abrupt change in the direction of the lay path, and is particularly acute at the side edges of the drum where the corners of the zigzag thread path are laid and the linear velocity of the thread momentarily approaches zero. As the traverse mechanism moves away from the corners and the thread velocity rapidly increases, increased tension causes the thread corners to be pulled inwardly way from the edges of the drum, resulting in irregular thread patterns in the belt. These irregular or non-uniform thread patterns produce non-uniform load-carrying characteristics in the tires in which the belts are incorporated which consequently cause excess vibration in the tires and reduce their overall performance during use.

Although it would be possible to substantially reduce the tension on the thread being wound on the drum by providing means for positively feeding the thread onto the drum from a point closely adjacent its surface, such is not practical because of various factors which require that the speed of movement of the thread onto the drum surface be varied continuously to insure a uniform thread pattern during the formation of the belt. Such factors include variation in the cross-sectional size of the thread along its length, gradual increase in the diameter of the annular surface on which the thread is laid due to thread build-up on the winding drum, variation in the length of the thread path leading to the drum caused by the periodic displacement of the reciprocating traverse mechanism from a centerline of the drum during winding, and the aforementioned abrupt changes in the direction of the thread lay path on the surface of the drum. Additionally, if the rotational speed of the winding drum is programmed to vary in response to temporary overfeed or underfeed conditions of the extruder which coats the thread, the longitudinal speed of the thread passing onto the drum must be correspondingly varied.

It is therefore an object of the present invention to provide a method and apparatus for winding a continuous thread onto a rotating support surface in a desired pattern which overcomes the problems of the prior art.

It is another object of the invention to provide an apparatus for winding a continuous thread onto a rotating support surface wherein the thread can be laid on the surface in a desired pattern with minimum aberration of the thread lay path due to tensional forces acting on the thread during the winding operation.

It is a more specific object to provide a rotating drum type winding apparatus for forming annular reinforcing belts from a continuous thread wherein tensional forces acting on the thread being wound on the drum are minimized to provide a more uniform thread pattern in the belt.

It is an additional object to provide a method of winding a continuous thread onto a rotating support surface in a desired pattern wherein tensional forces tending to displace the thread from the pattern during the winding operation are minimized.

Certain objects of the invention have been stated, other objects will become apparent from the following discussion of the invention and description of the drawings, in which

FIG. 1 is a schematic elevation view of a thread coating and winding apparatus employed in the production of reinforcing belts for pneumatic tires in which the novel features of the present invention are incorporated;

FIG. 2 is an enlarged schematic perspective view of the belt forming device and adjacent thread guide components of the apparatus seen in FIG. 1, and showing in more detail the means for controlling operation of the forming device and thread guide components during the belt forming operation; and

FIG. 3 is an enlarged perspective view, with portions shown in section, of the thread guide roller for directing thread to the transverse mechanism and winding drum shown on FIG. 2.

Referring more specifically to FIG. 1, the thread coating and winding apparatus for producing annular pneumatic tire reinforcing belts by a continuous thread winding process generally includes a source of thread, such as a thread spool **12**, an extruder **14** for coating the thread, a belt forming device **16**, and guide means **18** for directing thread from the extruder **14** to the belt forming device **16**. In operation, an uncoated continuous cord or thread **22**, which may be suitably composed of various relatively inextensible materials, such as fiber glass, rayon, cotton, polyester, wire and the like, is longitudinally directed by thread guides **24** from the supply spool **12** to the extruder **14** where the moving thread is coated, in conventional manner, with a protective coating, such as unvulcanized rubber. The rubber-coated thread **25**, which possesses a tacky, pressure sensitive adhesive surface characteristic, is directed by thread guide means **18** to the belt forming device **16** where it is wound into an annular reinforcing belt.

Details of the belt forming device **16** and the associated thread guide means **18** are best shown schematically in FIG. 2. Belt forming device **16** includes a rotatable winding drum **26** having a cylindrical outer surface **27** for supporting receiving thread, and a thread traverse mechanism **28** positioned adjacent the drum surface. Drive means, generally indicated at **30**, are employed to rotate the winding drum **26** and simultaneously reciprocate the traverse mechanism **28** across the surface of the drum to lay the coated thread **25** on the surface in a generally zigzag path. The specific structural details of the thread traverse mechanism **28** and its operation are described and shown in copending United States application Ser. No. 730,301, filed May 20, 1968, which is commonly assigned with the present application.

Drive means **30** includes a variable speed motor **32**, driven by a suitable power supply, not shown, which is operatively connected by a belt and pulley arrangement **34** and gear train **36** to respective drive shafts **38**, **40** of the winding drum **26** and a barrel cam **42** of the traverse mechanism **28**. Operation of motor **32** simultaneously rotates the winding drum **26** and reciprocates a thread laying element **44** of the traverse mechanism across the surface **27** of the drum to lay and adhesively secure the coated thread in a zigzag thread path on the drum surface. During rotation of the drum, the path is incrementally displaced, due to the configuration of gear train **36**, to produce an overlapping thread pattern P.

As seen in FIGS. 1 and 2, thread guide means **18** serves to longitudinally direct thread from the extruder **14** to the traverse mechanism **28** and generally includes a pair of thread support guides **46**, **47**, thread control means **50** and a thread guide roller **52** located adjacent the traverse mechanism for supportably receiving and guiding the moving thread **25** thereto. Guide roller **52** (FIGS. 2 and 3) is preferably constructed of relatively dense material, such as stainless steel, plastic or the like, and is of sufficient radius that its moment of inertia tends to maintain rotary motion in the roller during periods when the linear speed of the thread on the drum surface approaches zero, as will be explained. Guide roller **52** is mounted for rotation on a support shaft **54** by suitable bearing means, shown as a pair of ball bearings **55**, **56** (FIG. 3), which are of a conventional type having increasing torque characteristics with increasing rotational speeds.

As seen in FIG. 2, the support shaft **54** is operatively connected by change gears **57** and interconnected pulley and belt arrangements **58**, **59** to the barrel cam drive shaft **40**. By this arrangement, variable speed motor **32** simultaneously drives the winding drum, traverse mechanism, and rotatable shaft **54** of the guide roller so that the speed of all three may be varied simultaneously and proportionately by control means **50**, as will be explained, thereby minimizing variations in tension on the thread passing from the roller **52** to the traverse mechanism and winding drum.

Control means **50** serves to vary the rate of movement of the winding drum **26**, traverse mechanism **28**, and support shaft in response to variations in the length of the thread path from extruder **14** to the traverse mechanism **28** and comprises a pivotally mounted arm **62** which engages the moving thread **25** between the thread guide **47** and guide roller **52**. Arm **62** is of sufficient weight to maintain the thread in a V-shaped path between the guide **47** and roller **52** and, as tension increases or decreases in the thread path due to variations in the rate of extrusion from the extruder **14**, the arm is pivotally displaced to lengthen or shorten the thread path between the extruder and winding drum. Spaced above and below arm **62** and engageable thereby are solenoid switches **64**, **65** which are electrically connected by conductors **66** to the variable speed control unit **67** of motor **32**. Engagement of the switches by the arm **62** serves to increase or decrease the motor speed, thereby maintaining the arm between the switches and the length of the thread path substantially constant.

In operation, the winding drum is rotated by motor **32** to draw coated thread **20** from the extruder onto the surface of the drum. During belt formation, the traverse mechanism is reciprocated across the drum surface to lay the longitudinally moving thread in a generally zigzag path and build up a plurality of plies of parallel threads. As the reciprocating thread laying element **44** of the traverse mechanism reaches the side edges of the drum to form the corners of the zigzag thread path, the linear velocity of the thread passing onto the drum surface quickly decreases, momentarily approaching zero. Due to the force imparted to the rotating guide roller by the rotating shaft **54** and the moment of inertia of the guide roller, a feeding force is applied to the thread which develops a slack in the portion of the thread between the roller and the thread laying element. This slack is highly desirable for proper formation of the corners of the pattern in that it prevents a sudden tension build-up and displacing jerk on the thread at the corners as the traverse mechanism moves away from the side edges of the drum and the linear velocity of the thread rapidly increases. By continuously rotating the support shaft of the guide roller, rotational force can be imparted to the roller during the critical period in which it has the tendency to slow down due to reduction in the linear velocity of the thread passing onto the drum surface, thereby insuring continued movement of the roller and thread and avoiding a sudden jerk on the thread as the traverse mechanism moves away from the corners. Rotation of the support shaft additionally reduces the overall frictional drag of the bearing members which resist rotation of the guide roller, thereby at all times reducing the tensional force required to draw the thread onto the drum while permitting variations in the linear speed of the thread to insure proper thread pattern formation.

By means of the present invention, and with a knowledge of the inertial characteristics of the roller and the weight of the thread being laid on the drum, the rotational speed of the roller support shaft can be readily adjusted to "tune" the guide roller for optimum thread pattern uniformity in various tire belt constructions. By further simultaneously varying the speed of movement of the winding drum, traverse mechanism and guide roller support shaft in proportionate amounts, the variations in thread tension between the guide roller and winding drum can be minimized.

Although the apparatus of the present invention has been described and illustrated in the drawings as being employed to form annular reinforcing belts for pneumatic tires, it should be understood that the invention may be adapted to other winding operations where it is desired to lay a continuous thread on a support surface in a uniform pattern with minimum aberration of the pattern due

to tensional forces acting on the thread during winding.

The foregoing drawings and specification have set forth a preferred embodiment of the invention and, although specific terms have been employed, they are used in a generic and descriptive sense only and not for purposes of limitation.

That which is claimed is:

1. Apparatus for winding a continuous thread on a rotating support surface in a desired pattern including means defining a rotatable support surface for receiving thread, means for rotating said surface defining means to longitudinally draw thread onto the surface, a thread guide traverse mechanism positioned adjacent the surface and movable thereover to lay thread in a desired pattern, and thread guide means for longitudinally directing thread to said traverse mechanism, said thread guide means including a guide roller positioned adjacent said traverse mechanism for supportably receiving and guiding thread thereto, a support shaft for said roller, bearing means rotatably mounting said roller on said shaft to permit rotation thereof by thread passing to said traverse mechanism, and means for rotating said support shaft to reduce the force resisting rotational movement of the roller on said shaft and thereby reduce tensional force acting on thread being laid on said support surface.

2. In an apparatus for forming annular reinforcing belts for pneumatic tires including an extruder for applying a protective coating to a longitudinally moving thread, a winding drum and thread guide traverse mechanism for receiving coated thread from the extruder, means for rotating the drum while reciprocating the traverse mechanism across the peripheral surface of the drum to draw coated thread onto the drum and lay the thread in a desired pattern on the drum surface, thread guide means for longitudinally directing the thread from the extruder to the traverse mechanism, and control means for varying the rate of movement of the drum and traverse mechanism in response to variations in the length of thread between the extruder and winding drum; the improvement wherein said thread guide means includes a roller positioned adjacent the traverse mechanism for supportably receiving and guiding thread thereto, a support shaft for said roller, bearing means rotatably mounting said roller on said shaft to permit rotation thereof by thread passing thereover to said traverse mechanism, and means for rotating said support shaft to reduce the force resisting rotational movement of the roller on said shaft and thereby reduce the tensional force acting on the thread being laid on the winding drum.

3. Apparatus as defined in claim 2 wherein said means for rotating said shaft includes means for varying the rotational speed of said shaft in direct proportion to variations in the speed of movement of the winding drum to minimize variations in tension on the thread passing onto the surface of the winding drum.

4. Apparatus as defined in claim 3 wherein said control means includes means engaging said thread between said extruder and said roller and being displaceable in response to varying tension on the thread to lengthen and shorten the thread path between said roller and the extruder, and means for varying the speed of movement of the winding drum in response to the position of said thread engaging means.

5. A method of winding a continuous thread on a rotating support surface in a desired pattern which necessitates relatively large increments of acceleration and deceleration in the velocity of the thread passing onto the rotating support surface comprising the steps of rotating the support surface to longitudinally draw thread onto the surface while while guiding the thread across the surface to lay the thread in a desired path thereon, and applying a feeding force to the thread being drawn onto the support surface at those times when the thread is undergoing relatively large increases in acceleration during its movement onto the surface to minimize its displacement from the desired path due to tension exerted on the thread.

6. A method as defined in claim 5 wherein said thread is guided onto the surface to lay the thread in a generally zig-zag path thereon, and wherein the feeding force is applied to the thread as the point of thread lay down moves away from the corners of the zig-zag path.

7. A method of winding a continuous thread on a rotating support surface in a desired pattern comprising the steps of rotating the support surface to longitudinally draw thread onto the surface while reciprocating a thread guide traverse mechanism across the surface to lay the thread in a generally zig-zag path thereon, frictionally engaging the thread by a rotatable roller to guide the thread to the traverse mechanism, and applying rotational force to the roller to impart a feeding force to the thread as the traverse mechanism moves away from the corners of the zig-zag path while permitting variations in the rotational speed of the roller in response to variations in the linear speed of the thread passing thereover.

8. A method as defined in claim 7 wherein the rotatable roller is rotatably mounted on a support shaft and wherein the rotational force is applied to the roller by rotating the support shaft.

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