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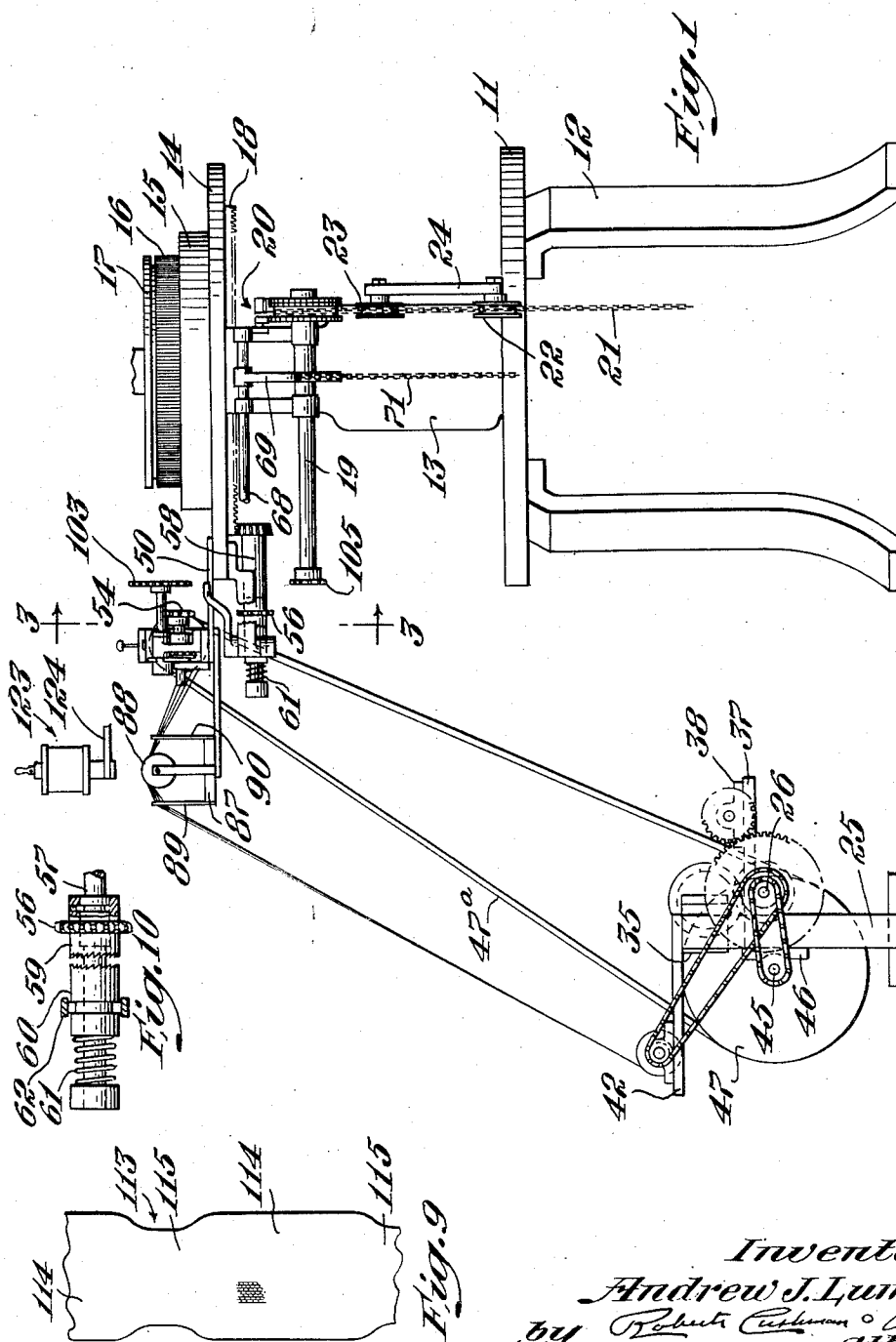
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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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5 Sheets-Sheet 1



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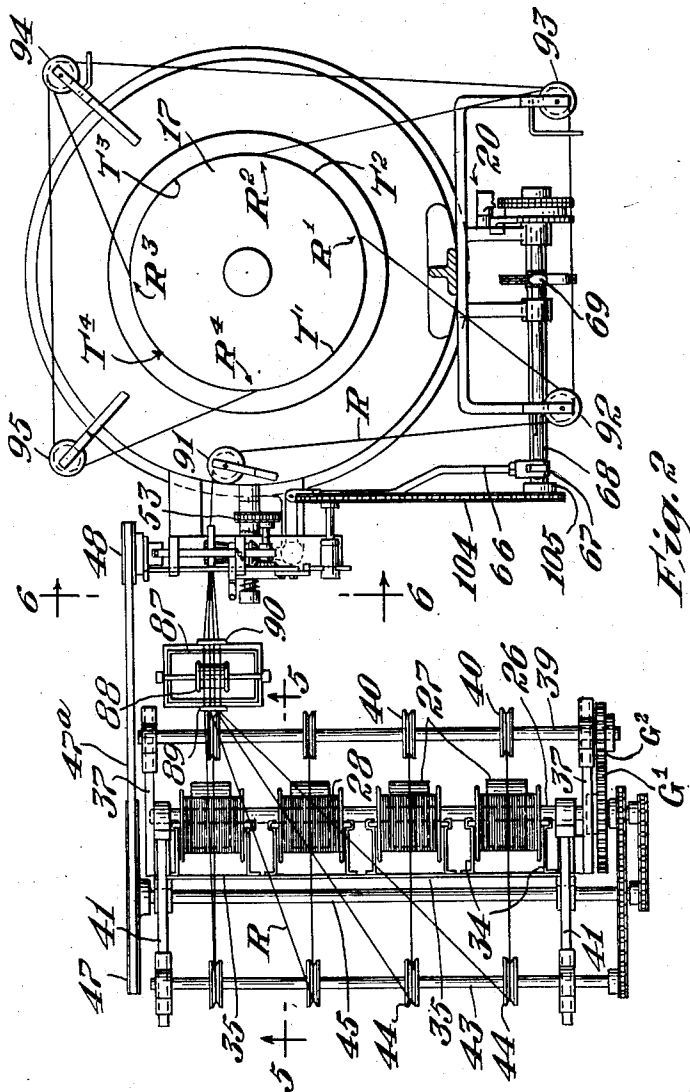
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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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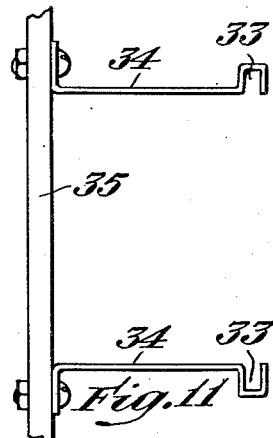
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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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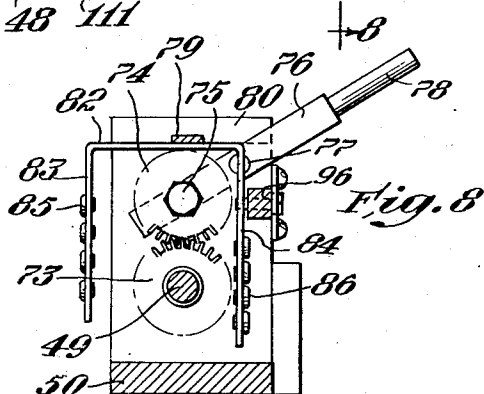
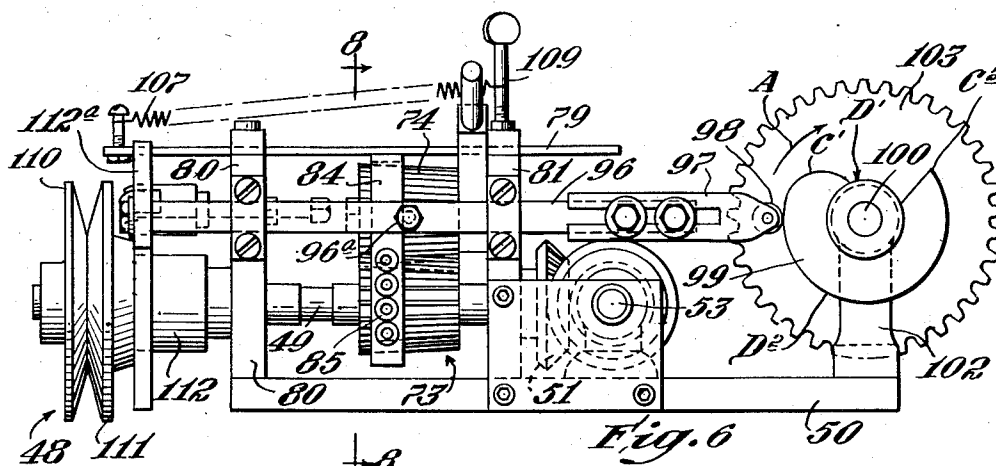
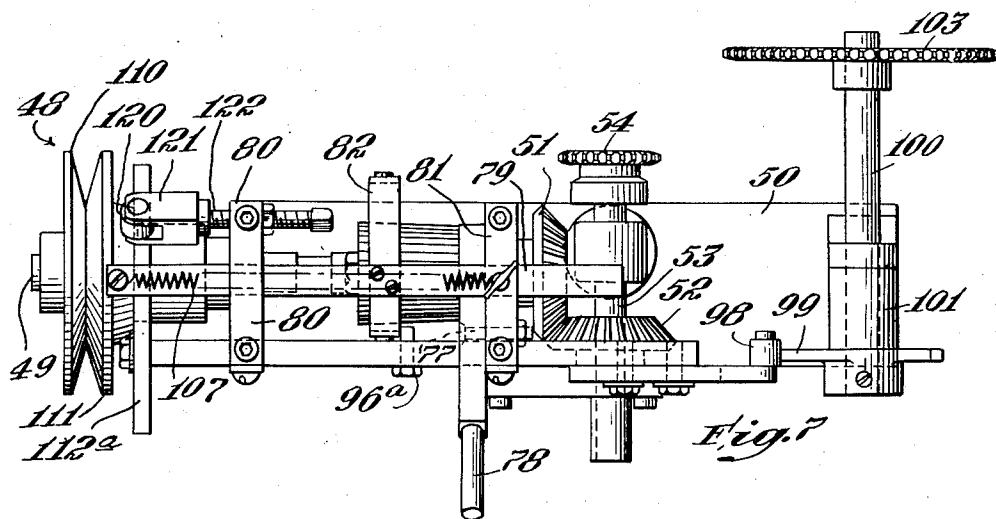
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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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5 Sheets-Sheet 4



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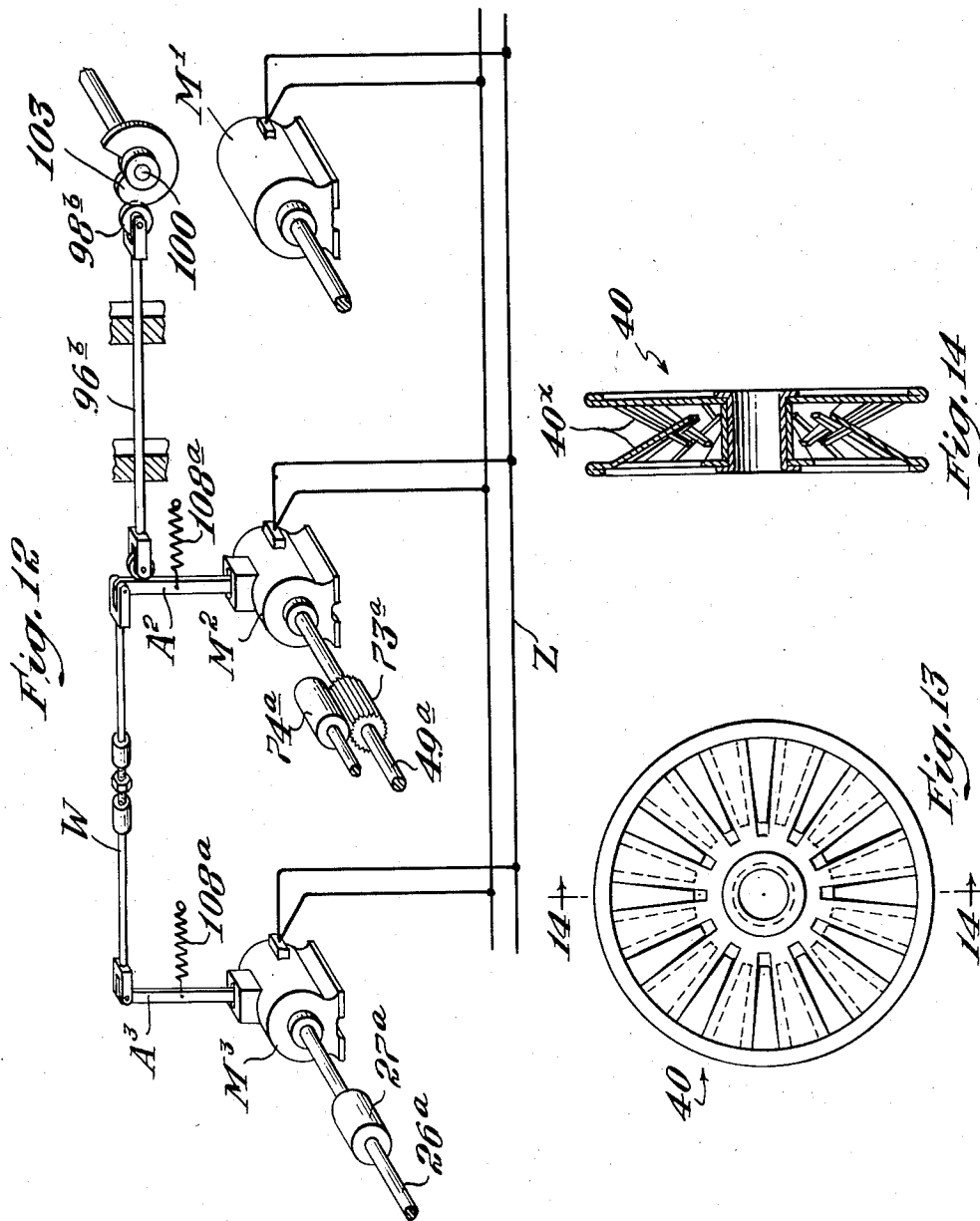
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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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5 Sheets-Sheet 5



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YARN TENSIONING APPARATUS FOR KNITTING MACHINES

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18 Claims. (Cl. 66—132)

This invention pertains to the art of knitting and relates more especially to improvements in yarn tensioning, the invention being of particular value in the knitting of rubber elastic yarn, although of broader utility.

While the feeding mechanism of the present invention is highly useful and desirable for feeding inelastic yarn (that is to say ordinary textile yarn) to the knitting machine, because of the complete control which it affords with respect to the rate of yarn delivery, it is of especial importance when knitting seamless goods fashioned by variation in yarn tension. It is of even greater value in the feeding of covered rubber yarn (that is to say a yarn comprising a rubber-elastic core thread encased in a helical wrapping or wrappings of textile yarn), but its optimum value is evidenced when it is employed for delivering bare or uncovered rubber elastic thread to the knitting machine. As herein employed the term "rubber thread" or "rubber-elastic strand" is intended to include all threads or yarns having the stretch characteristics of vulcanized, natural rubber whether actually of rubber, synthetic rubber or other material, and whether or not the rubber is covered.

Elastic garments, for instance so-called "foundation" garments, are knitted from inelastic textile yarn such as cotton, silk, rayon, nylon, etc., with included rubber-elastic yarn designed to impart a much greater constrictive effect than is inherent in fabric knitted from usual inelastic textile yarns alone. However, in order that an elastic garment may provide the characteristic constrictive effect desired, it is necessary that the rubber-elastic yarn be stretched or elongated by tensioning it before it is fed to the knitting needles, otherwise the garment would have little more constrictive effect than though the rubber-elastic yarn were not introduced.

Although it is possible and a common practice to introduce rubber-elastic yarn into knitted fabric (particularly rib knit fabric) without delivering the rubber-elastic yarn into the knitting needles, or at least without drawing the rubber-elastic yarn into constituent loops of the completed fabric, such a procedure results in the so-called "one-way stretch" fabric in which the constrictive effect of the rubber is exerted almost entirely in a widthwise direction, that is to say transversely of the knitted wales. However, for use in making foundation garments of the better grade, the fabric employed is required to have "two-way" stretch, that is to say the constrictive effect of the rubber must be felt both longitudinally and transversely of the knitted wales. To reach this result it is necessary to deliver the rubber-elastic yarn into the needle hooks and to draw it into loops which are cast off onto previous loops in customary knitting manner so as to form permanent stitches of the knitted fabric.

It is also requisite in the manufacture of knitted fabric, for example circular knit tubular fabric which is to be cut into lengths each to form one garment, that the diameter of the knitted tube vary from point to point (in order that the garment may conform to the human anatomy).

In fashioning certain types of garment, for example foundation garments like girdles, it is sometimes desirable,

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from the manufacturing standpoint at least, to do the fashioning (variation in diameter of the knitted tube) solely by variation in the tension imposed upon the rubber-elastic strand as the latter is delivered to the needles, rather than by variation in stitch length. Attempts have heretofore been made to supply elastic yarn to the knitting instrumentalities by passing it through a pair of driven feed rolls of frusto-conical shape operative to receive the thread from the supply and to deliver it to the knitting needles, the thread being shifted axially of the rolls in response to pattern means thereby to increase or decrease the rate of delivery of the thread to the machine. However, this procedure, alone, has been inadequate to produce the desired results, for if the rubber thread enters the bite of said feed rolls in slack condition at one time and highly stretched and attenuated at other times, the variable feed action of the rolls may be substantially nullified. Such variation in stretch of the rubber as it approaches the feed rolls may be due to various causes, among them the tendency of the convolutions of the thread supply to adhere to one another, and this tendency may vary with temperature, atmospheric moisture, electrostatic effects, etc. Heretofore it has been customary to wind rubber thread to form a cross-wound conical mass and to pull it off over the end of the cone-supporting spindle; such a mode of delivery tends to impart twist to the thread and under such conditions bare rubber tends to kink and snarl; and the tendency of the thread to stick to the conical yarn mass, for causes above mentioned, results in a widely varying rate of release of the thread on its way to the feed rolls.

Bare rubber thread as a knitting material possesses many advantages as compared with covered rubber yarn, although the latter is very generally employed in the manufacture of constrictive garments such, for example, as girdles, abdominal bands, bathing suits, hosiery tops, surgical stockings, etc.

Bare rubber thread, of a size capable of developing a predetermined stretch resistance, is much smaller in external diameter than a covered rubber yarn having the same degree of stretch resistance. Moreover, it is far more flexible than a covered rubber yarn containing the same amount of rubber, and so a garment knitted with bare rubber is much more pliable, lighter in weight and more sheer than one knitted with covered rubber. Covered rubber yarn has a harsh feel due to the surface convolutions of its covering, and when used in combination with such smooth textile threads as silk or rayon it tends to nullify the soft, pleasant feel of the goods normally resultant from the use of such textile materials. Furthermore, covered rubber yarn absorbs perspiration and is difficult to cleanse, whereas bare rubber is non-absorbent.

For the above reasons, among others, it has long been recognized as desirable to use bare rubber thread instead of covered rubber yarn but whereas covered rubber yarn may be handled in much the same way as inelastic textile yarn in delivering it to the knitting instrumentalities (certain well recognized precautions being observed in view of the greater stretchability of the covered rubber yarn as compared with ordinary textile yarn) the delivery of bare rubber thread to the knitting machine has been attended with so great difficulty that its use has heretofore been quite restricted as compared with the widespread employment of covered rubber yarn.

Among the difficulties in feeding bare rubber thread to the knitting machine has already been mentioned, the tendency of the convolutions of bare rubber thread, forming a supply mass or package, to adhere to one another so that when it is attempted to unwind the thread by applying pull to its end, the thread may resist unwrapping until it has been highly stressed and stretched, and when the

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adhesion is finally overcome the thread snaps from off the supply mass and the resultant long length of free thread is easily caught in adjacent parts of the machine or by adjacent yarns. Bare rubber thread is extremely stretchable and in stretching, decreases the diameter; and its surface is normally tacky (to a very slight, but nevertheless functional, degree) so that when it is passed about fixed guide posts or through usual yarn guide eyes or customary yarn tension devices it develops strong but irregular frictional resistance so that its feed to the machine is uncertain and irregular. These characteristics among others, make it impossible to handle bare rubber thread in the same way or by the same means as textile or even covered rubber thread, that is to say by drawing the thread from the supply and through a friction type tension merely by the action of the knitting needles. Whereas down-draft of the knitting needles, when applied to textile yarn, draws off a substantially uniform and predetermined length from the supply and through the tension means to form the desired stitch loop, the stretch and friction characteristics of bare rubber thread cause the latter to stretch, in response to needle draft, rather than to draw off from the supply and as this effect is uncertain and variable, the resultant fabric is non-uniform in appearance and its constrictive effect is substantially unpredictable.

The present invention has for its principal object the provision of a method of and means for feeding rubber-elastic yarn, in particular bare rubber yarn, to the needles of a knitting machine in such a way as to make it practically possible to produce a two-way stretch seamless fabric tube of uniform appearance, varying in diameter from point to point longitudinally as desired, and at each point in its length possessing the desired predetermined degree of constrictive effect. A further object is to provide a novel method of and apparatus for use in delivering highly stretchable yarn, for example bare rubber thread, to a knitting machine at a predetermined rate and with predetermined elongation and with provision for accurately varying such rate and elongation for fashioning the knitted fabric. A further object is to provide means for feeding rubber elastic yarn to a knitting machine in such a way that it enters the needle hooks under an exact predetermined tension and in such a manner that the tension is substantially independent of the stitch length. It is a further object to provide means for feeding rubber elastic strands to a knitting machine which is capable of handling a plurality of such rubber-elastic strands, for example, for delivering such rubber strands to each of several feeds of a given knitting machine and so that at each feed the rubber-elastic strand will be delivered at the same predetermined tension. Other and further objects and advantages of the invention will be pointed out in the following more detailed description and by reference to the accompanying drawings wherein

Fig. 1 is a fragmentary, more or less diagrammatic, elevation of a circular knitting machine of a conventional type having the improved yarn delivery means of the present invention associated therewith;

Fig. 2 is a diagrammatic plan view of the apparatus of Fig. 1, some parts being omitted;

Fig. 3 is a fragmentary vertical section, to larger scale, substantially in the plane of the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary plan view of a clutch-actuating lever, with associated parts, forming a desirable part of the improved mechanism;

Fig. 5 is a fragmentary vertical section, to larger scale, substantially on the line 5—5 of Fig. 2;

Fig. 6 is a vertical section, to larger scale, substantially on the line 6—6 of Fig. 2;

Fig. 7 is a plan view of the parts shown in Fig. 6;

Fig. 8 is a fragmentary vertical section on the line 8—8 of Fig. 6;

Fig. 9 is a diagrammatic elevation illustrative of a type of fabric which may be made by the use of the mechanism of the present invention;

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Fig. 10 is a fragmentary front elevation, showing details of a clutch which may be employed;

Fig. 11 is a fragmentary plan view showing a spool-positioning frame;

Fig. 12 is a diagrammatic perspective view illustrating a modified construction; and

Figs. 13 and 14 are detail views illustrating yarn-advancing pulleys.

It will be understood that the improved strand-feeding mechanism of the present invention is applicable to knitting machines of other types, but for convenience, it is here illustrated in combination with a circular knitting machine 10 of conventional type which may, for example, be of the kind commonly known in the trade as a "Wildman" machine, commonly employed for making underwear. This machine is of the independent needle type designed to form rib knitted fabric, and employs a rotary needle cylinder and a fixed cam cylinder, and has eight feeds, the rubber-elastic strand being delivered at alternate feeds only.

As here illustrated, for specific example, the machine comprises a stand 11 provided with rigid legs 12, the frame 13 of the machine being mounted on the stand 11 and supporting the head or table 14 upon which, as here illustrated, the stationary cam cylinder 15 is mounted. Within the cam cylinder 15 is arranged the rotary needle cylinder 16, with which cooperates the dial 17, suitably supported and driven by customary means not herein illustrated. The frame carries the usual mechanism, not here specifically illustrated, for controlling stitch length; yarn changers, supports, tensions, etc., for the textile yarns; and other customary parts and devices which are not herein shown since they form no essential part of the present invention. The needle cylinder is provided at its lower edge with the usual annular gear 18 by means of which it is driven, and, because the main pattern shaft is employed for driving elements of the novel feed mechanism of the present invention, said shaft is here shown at 19 and the customary mechanism, whereby the shaft 19 is intermittently driven, is indicated diagrammatically at 20. The patterning mechanism includes the long endless chain 21 (Fig. 3) which is trained about a sprocket wheel on the shaft 19 and passes about idler guide rolls 22 and 23 mounted on a support 24 carried by the machine frame.

In accordance with the present invention (Fig. 1) a stand 25 is provided which is conveniently secured to the floor at a point suitably spaced from the knitting machine proper. This stand 25 carries bearings for a shaft 26 (Figs. 1, 2 and 5) on which cylindrical drive rolls 27 are mounted, there being one of these rolls 27 for each feed of the machine to which rubber yarn is to be delivered. The peripheral surface of each of the rolls 27 forms a support for a supply mass 28 (Figs. 2 and 5) of rubber-elastic strand wound (desirably with a "spool-wind") on a spool 29 having a tubular barrel 30 through which passes a spindle 31 whose opposite ends are received in substantially vertical guide slots 33 (Fig. 11) in brackets 34, one at each end of each spool. The several brackets 34 are fixedly secured to a transversely extending bar 35 (Figs. 2 and 5) whose opposite ends are supported by the stand 25. With this arrangement each spool is free to rise and fall, the weight of the spool and supply mass being supported by the corresponding cylinder or drum 27. By turning the drum or cylinder 27, the supply mass on the spool is rotated in such a way as positively to unwind its rubber strand.

The stand 25 is provided at each end with a bracket 37 extending toward the right, as viewed in Figs. 1, 2 and 5, each of these brackets carrying a bearing block 38. The opposite ends of a shaft 39 are mounted to turn in bearings in blocks 38 and on this shaft 39 grooved guide pulleys 40 are mounted, one of these guide pulleys being arranged opposite to the peripheral face of each of the drive

rolls 27, respectively, and being designed to receive the rubber thread from the corresponding spool 29. The stand 25 also carries brackets 41 extending to the left, as viewed in Figs. 1, 2 and 5, on which bearing blocks 42 are mounted. A shaft 43, parallel to the shaft 39, has its opposite ends arranged to turn in bearings in blocks 42, and, on this shaft 43, grooved guide pulleys 44 are mounted, the several guide pulleys 44 being in the same vertical planes as corresponding guide pulleys 40 so as to receive the rubber strand from the latter, the rubber strand being indicated by the letter R (Fig. 5). Desirably, the guide pulleys 40 and 44 are of the construction illustrated in Figs. 13 and 14, having grooves defined by interlaced fingers 40^x which provide a tortuous course for the strand, thereby to provide a strong grip on the rubber strand as it passes about the pulley. A shaft 45, parallel to the shafts 39 and 43, is mounted to turn in bearings in blocks 46 carried by the stand 25, and at one end this shaft is provided with a grooved pulley 47 (Fig. 1) about which is trained a V-belt 47^a which also passes about a grooved pulley 48 (Figs. 2, 6 and 7) of the kind comprised in a so-called "Reeves" drive.

This pulley 48 is mounted on a rotary feed shaft 49 (Figs. 6 and 7) which turns in bearings in a supporting frame 50 (Figs. 1, 6 and 7) which is fixedly secured to the head or table 14 of the knitting machine. A bevel gear 51 is mounted on the shaft 49 and engages a bevel gear 52 on a horizontal transverse shaft 53 also mounted in bearings carried by the frame member 50 and which is provided with a sprocket wheel 54 (Figs. 1 and 7) about which is entrained a chain 55 (Fig. 3) which embraces another sprocket 56 (Figs. 3 and 10) on a shaft 57 which turns in a bearing sleeve 58 (Fig. 1) supported at the underside of the table 14 of the knitting machine. The sprocket wheel 56 (Fig. 10) is free to turn on the shaft 57 and has a hub 59 (Fig. 10) forming one element of a clutch. The complementary element 60 of the clutch is splined to the shaft 57 and is urged toward the member 59 by a spring 61. The pinion shown in Fig. 1 and which is fixed to shaft 57 engages the annular gear 18, thus constantly turning the shaft 57. The member 60 is provided with a peripheral groove which receives pins carried by a fork 62 (Figs. 4 and 10) forming one arm of a lever 63 pivoted at 64 to turn about a vertical axis and which has a second arm 65 connected by a rod 66 (Figs. 3 and 4) to the upper arm 67 of a bell crank lever fixed to a shaft 68 and which carries an arm 69 (Figs. 1 and 3) provided with a cam follower 70 designed to be engaged at times by lugs L on an endless chain 71 which passes over a sprocket wheel 72 fixed to the pattern shaft 19. When the member 70 is engaged by one of the lugs L, the arm 69 is raised and thus, by means of the connections above described, disengages the clutch members 59 and 60, whereupon the feed of the rubber strands temporarily ceases. While this means for stopping the delivery of rubber elastic strand at intervals is useful, it is to be understood as merely illustrative of any appropriate means for accomplishing this result. Moreover, in knitting certain types of fabric, for example, tubular fabric for girdles, no cessation of rubber strand delivery may be necessary, so that the clutch may be dispensed with, but in knitting surgical stockings, for example, upon a circular stocking knitting machine, it is desirable to provide means for intermitting rubber strand feed, for example, when knitting heels.

The shaft 49 (Figs. 6, 7 and 8) carries a toothed feed roll 73 of truncated, conical form with which meshes a complementary toothed feed roll 74 carried by a stub shaft 75 (Fig. 8) mounted on one arm of a lever 76 which is pivotally supported by a bolt 77 (Figs. 7 and 8) passing through an upright member 81 of the frame 50. The lever 76 is provided with a handle portion 78, and, after first loosening the bolt 77, the handle 78 may be manipulated so as to predetermine the depth of mesh of the teeth of the rolls 73 and 74, thereby to vary the basic rate of

yarn delivery. When once adjusted, the bolt 77 is tightened to hold the parts in adjusted position.

Above the shaft 49 there is arranged a horizontal, longitudinally slidable bar 79, slidable in guideways in upright members 80 and 81 of the frame 50. A transversely extending traverse member 82 (Fig. 8) is fixedly secured to the bar 79 and carries parallel, spaced downwardly directed arms 83 and 84 disposed at opposite sides, respectively, of the toothed feed rolls 73 and 74. Each of the members 83 and 84 is provided with guide eyes 85 and 86, in number corresponding to the number of rubber strands to be delivered, each rubber strand passing through a guide eye 85, then between the feed rolls 73 and 74, and then through one of the guide eyes 86. By moving the bar 79 longitudinally, the point at which the rubber thread enters the bite of the feed rolls 73 and 74 may be shifted axially of said rolls, and since these feed rolls are frusto-conical, such shifting of the threads will vary the speed of thread delivery, even though the rolls be turned at a uniform rate of speed.

The rubber threads R, in leaving the grooved pulleys 44 (Fig. 1) extend up to a thread-guiding device comprising a stand 87 rigidly supported by the frame 50 and which carries an idler roll 88 (Figs. 1 and 2) over which all of the rubber strands pass, the stand 87 also having fixed guide members 89 and 90 at opposite sides of the roll 88, each guide member 89 and 90 having guide eyes for the several rubber strands. From the guide eyes in the part 90 the several strands extend to the guide eyes 85 in the traverse member 84 above referred to.

After leaving the guide eyes 86, the several rubber strands pass about a guide roll 91 (Fig. 2) supported on the frame of the knitting machine and then about another guide roll 92, also supported by the frame of the knitting machine. From this roll 92 one of the rubber strands extends to the first rubber feed R¹. [The present machine is shown as having four feeds R¹, R², R³ and R⁴ at which rubber elastic strands (with or without associated textile yarns are delivered) and four intervening feeds T¹, T², T³ and T⁴ for textile yarns only.] The remaining elastic strands pass to and about a guide roll 93 and in leaving this roll one of the rubber strands extends to the second rubber feed R². The remaining elastic strands then pass about a guide roll 94 and in leaving this roll one strand extends to the third rubber feed R³ while the remaining strand passes about a guide roll 95 and then extends to the rubber feed R⁴.

Referring to Figs. 6 and 7, the frame 50 carries a horizontal bar 96 slidable in guideways in the uprights 80 and 81. As shown in Fig. 6, the bar 96 is provided with an adjustable end portion 97 which carries a cam follower roll 98 engaging the peripheral surface of a cam 99 mounted on a shaft 100 which turns in a bearing sleeve 101 (Fig. 7) supported by a post 102 mounted on the frame 50. A sprocket wheel 103 is fixed to the shaft 100 and is embraced by a sprocket chain 104 (Fig. 3) which also embraces a sprocket wheel 105 fixed to the pattern shaft 19. The bar 96 has a pin 96^a (Figs. 6, 7 and 8) which bears against the edge of the traverse member 84, and a tension spring 107 (Fig. 6) (secured at one end to the bar 79 and at its opposite end to a fixed stud 109 carried by the frame 50) constantly urges the bar 96 toward the right so as to keep the roll 98 in contact with the cam 99.

The Reeves pulley 48 on the end of shaft 49 comprises a fixed flange 110, and an axially movable flange 111, the latter having a hub 112 slidable along the shaft 49. A fork element 112^a is secured to the left-hand end of bar 96 and bears against the right-hand face of the flange 111. To limit movement of the flange 111 toward the right (as permitted by the contour of cam 98) there is provided an adjustable abutment comprising a roll 120 (Fig. 7) mounted in a fork member 121 carried by a rod 122 having screw threaded engagement with an opening in the upright part 80.

In order to lubricate the rubber thread, there is provided a container 123 (Fig. 1) carried by an arm 124 supported by the frame 50, the container 123 being located directly above the strand guide roll 88 and having a suitable delivery orifice, preferably adjustable, through which lubricant slowly drips onto the bare rubber threads as they pass over the roll 88. If desired, the stand 87 which supports the roll 88 may be provided with an up-standing rim or equivalent means to form a container for surplus lubricant, and from this container a drain pipe (not shown) may, if desired, extend to any suitable point.

In Fig. 9 there is diagrammatically illustrated a length of fabric 113 such as may be knitted by the use of the improved mechanism of the present invention. As illustrated, this fabric comprises portions 114 of maximum diameter with interposed portions 115 of minimum diameter.

It will be understood that the knitting machine will be provided with usual supports for cones or spools of textile yarns such as cotton, silk, rayon or the like, and with usual yarn-tensioning and guiding means for delivering these textile yarns to the several feed points, and that these textile yarns may be fed singly or in any desired number, simultaneously, to each feed point and that the rubber strand will be taken into the needle hooks and drawn into stitches and cast off in the same way as the textile threads. When the improved feed of the present invention is associated with certain types of knitting machines, variation in stitch length may be accomplished by raising or lowering the needle cylinder. Moreover, appropriate yarn-changing and clamping means may be provided at any or all of the knitting points at which change of yarn or cessation of yarn feed is desired, and such stitch-length-changing means and yarn-changing means will be under the control of the pattern mechanism. Since such devices and their functions are well known to those skilled in the art it has been deemed unnecessary to show them in detail herein.

In preparing the supply masses or packages 28, for example masses of bare rubber thread, the spool 29 should preferably be rotated by a roll similar to the roll 27, thereby to insure substantially uniform tensioning of the rubber thread as the diameter of the winding mass increases, preferably employing a guide so actuated as to produce a conventional "spool wind." The thread should be drawn from a supply which admits free exit of the thread, for example from a can in which the thread is loosely coiled or from a freely turning swift on which the thread is mounted in skein form. This method of winding the rubber thread on the spools results in a slight elongation of the thread, for example a 5% elongation.

Assuming that the spools of rubber thread thus prepared have been mounted in the stand 25, and that the several rubber threads have been passed about pulleys 40 and 44 and through the various thread guiding eyes, between the feed rolls 73 and 74, and about the various guide rolls 91, 92, etc., and have been taken by the needles at the several knitting points, and that an appropriate number of textile yarns have likewise been arranged for delivery to the knitting needles, the rotation of the needle cylinder gear 18 will turn the shaft 57 and the clutch element 60. Assuming that the clutch elements 59 and 60 are in engagement, the sprocket wheel 56 will be turned, thus driving the shafts 53 and 49 and thereby turning the toothed feed rolls 73 and 74 so as positively to advance the rubber threads toward the needles. During the operation of the knitting machine, the pattern shaft 19 is turned intermittently under control of the mechanism 23 and as it turns, the chain 104 drives the shaft 100 and thus slowly turns the cam 98. While knitting that portion 115 of the tubular fabric which is to be of minimum diameter, the roll 98 rests upon the concentric dwell portion D¹ (Fig. 6), of the cam, the roll 98 then being at the limit of its motion toward the right (Fig. 6). In consequence,

the guide eyes 83 are located near the smaller end of the feed roll 73 and as the effective diameter of the roll 73 determines the rate of delivery of yarn, the yarn is now being delivered at its lowest rate, that is to say the rate which is proper for the knitting of the part 113 of the garment at which the yarn tension is at a maximum, resulting in the maximum contraction of the fabric. As the cam 98 turns in the direction of the arrow A (Fig. 6), the riser portion C¹ of the cam gradually pushes the roll 98 to the left, moving the guide eyes 85 toward the larger end of the feed roll 73, thereby increasing the rate of yarn delivery and consequently decreasing the yarn tension so that the diameter of the knitted tube increases. After the roll 98 reaches the large-radius concentric dwell portion D² of the cam the guide eyes 85 remain substantially stationary and the yarn enters the bite of the feed rolls at a point near the larger end of the roll 73, the diameter of the knitted tube thus remaining substantially constant as shown at 114. The dwell D² is of sufficient circumferential extent (with reference to the rate of rotation of the cam shaft as determined by the pattern mechanism) to produce a length of knitted tube of uniform diameter of the required longitudinal extent, the dwell D² terminating at the point C² where the cam face becomes substantially radial and the roll 98 drops quickly down to the dwell D¹ of small diameter. The guide eyes 85 thus immediately return to the right-hand end of the feed rolls so that the rate of yarn delivery again becomes a minimum and the tension on the yarn becomes a maximum. However, because of the length of yarn between the bite of the rolls 73 and 74 and the feeds of the knitting machine, and because this length of yarn is already tensioned and elongated, the sudden dropping of the roll 98 at the point C² does not result in an instantaneous change in diameter of the knitted tube, the change being gradual as illustrated in Fig. 9.

Since the part 112^a, whose position varies the effective diameter of the Reeves drive, partakes of the movement of the yarn guide eyes 85, the speed of rotation of the shafts 26, 39 and 43 varies concomitantly with the variation in the rate of yarn delivery by the feed rolls 73 and 74. As the yarn masses 28 on the spools 29 are rotated by peripheral contact with the rolls 27, variation in diameter of the yarn masses has no substantial effect on the tension of the unwinding thread; if the thread is wound with a spool wind, as above suggested, its convolutions unwrap without substantial interference and the thread separates readily from the underlying convolutions as they are led off along that tangent to the roll 27 where the radial pressure on the thread is suddenly released. The relative speeds of the roll 27 and the pulleys 40 and 44 may be adjusted initially by variation in the ratio of gears G¹, G² (Fig. 2) between the shafts 26 and 39 and by change of the sprocket wheel ratios between shafts 26, 45 and 43. By this means, the initial approximate 5% elongation of the elastic strand may be maintained or gradually increased as the unwinding strand advances toward the feed rolls, and thus there is no uncertainty as to the amount of tension under which each elastic strand enters the bite of the feed rolls. The feed rolls 73 and 74 thus receive the elastic strand under a uniform and predetermined tension and thus they accurately determine the tension at which the elastic strand will be presented to the needle hooks. Thus the attenuation of the rubber thread which enters the bite of the rolls 73 and 74 may be very accurately adjusted with reference to the size and elastic characteristics of the particular thread to be used.

Referring to Fig. 12 there is illustrated a modified construction wherein the various parts are controlled electrically. Thus, as suggested, M¹ is an electric motor receiving current from mains Z and which drives the main shaft of the knitting machine. M² is a second motor whose shaft drives the toothed cylindrical bottom feed roll 73^a, this roll cooperating with the cylindrical upper feed roll

74^a, it being understood that these rolls correspond to the rolls 73 and 74 above described. The character M³ indicates another electric motor which drives a shaft 26^a on which drums 27^a, corresponding to the drums 27 above described, are mounted.

The motors M² and M³ may be of the variable speed type, the speed of each motor being controlled by a member A² and A³ respectively, here shown as levers, arranged to swing in a plane perpendicular to the plane of the respective motor shaft. These levers may actuate potentiometers or other electrical devices whereby the speeds of the motors M² and M³ are varied, the motors receiving power from the supply lines Z. As illustrated, a rigid link W connects the levers A² and A³ so that the two levers are constrained to move in the same direction and to the same amount, the link W being adjustable in length to provide for initial adjustment of the relative speeds of motors M² and M³. Springs 103^a tend to swing the levers A² and A³ to the right, as viewed in Fig. 12. A slide bar 96^b, corresponding to the bar 96 hereinabove described, is guided to slide horizontally in fixed guides and has one end bearing against the lever A². Its other end is provided with a cam follower roll 93^b which engages the peripheral edge of the cam 103 mounted on the shaft 100, as above described, the shaft 100 being turned, as above described.

As the cam is turned, the bar 96^b is moved in one direction or another, thereby swinging the arms A² and A³ and thereby constantly varying the speeds of the motors M² and M³ and in consequence varying the peripheral speed of drum 27^a and the rate at which the rubber strand is advanced by the feed rolls 73^a and 74^a.

Instead of using variable speed motors, the motors M² and M³ may be constant speed motors and the levers A² and A³ may control mechanical speed-changing mechanism interposed between the shafts of the motors and the shafts 49^a and 25^a.

It will be noted that whereas in the arrangement shown in Figs. 1 to 11, the speed of advance of the strand toward the needles by the feed rolls is varied by shifting the strand axially of complementary frusto-conical rolls, in the latter arrangement the variation in speed of strand advance is caused by changing the speed of rotation of cylindrical feed rolls.

While desirable embodiments of the invention have been shown by way of example it is to be understood that the invention is broadly inclusive of any and all modifications and arrangements of parts falling within the scope of the appended claims.

I claim:

1. Apparatus for use in delivering a strand to the hooks of the needles of a knitting machine of the kind wherein a pattern mechanism varies the stitch length during the production of an article, a support for a yarn supply, a rotary element about which the yarn passes on its way from the yarn supply to the needles of the knitting machine, means for turning said rotary element comprising an endless belt passing about a pulley of variable diameter, and means controlled by the pattern mechanism of the knitting machine for varying the effective diameter of said pulley.

2. Apparatus for use in delivering a strand to the hooks of the needles of a knitting machine, said apparatus comprising power-actuated, constant-speed, frusto-conical feed rolls for positively advancing the strand toward the needles, a movable strand guide for shifting the strand axially of the feed rolls thereby to vary the rate of delivery of the strand, a rotary, cylindrical drum, means operative to position a cylindrical strand mass so that its axis is parallel to that of the drum and with its peripheral surface in frictional contact with the drum, whereby turning of the drum unwinds the strand from said strand mass, means for turning the drum comprising an endless belt passing about a pulley of variable diameter, and pattern means operative concomitantly to

actuate the movable strand guide and for varying the effective diameter of the pulley.

3. Apparatus for use in delivering rubber elastic strand from a supply, consisting of a cylindrical mass mounted on a rotary support, to the needles of a knitting machine, said apparatus comprising a rotary drum and means for positioning said supply mass with its axis parallel to that of the drum and with its peripheral surface resting upon the drum, whereby rotation of the drum unwraps the strand from said mass, a pulley over which the strand passes after leaving the supply mass, said pulley having a peripheral groove defined by interlaced fingers thereby to provide a tortuous course and thus insuring a strong gripping of the strand within said peripheral groove, means for driving said pulley at an effective surface speed bearing a predetermined ratio to that of the drum, power driven feed rolls for advancing the strand toward the knitting needles, and pattern control means operative concomitantly to vary the peripheral speed of the drum and the rate of advance of the strand by the feed rolls.

4. Apparatus for use in delivering a strand to the needles of a knitting machine having an intermittently turning pattern shaft, said apparatus comprising power-actuated feed means, including a rotary shaft which turns in timed relation to the rotation of the needle cylinder, for advancing the strand toward the feed point of the knitting machine, the strand feeding means being variable in effective speed of strand delivery, variable speed, power-actuated, unwinding means for unwinding the strand from a supply mass, a movable part which is operative concomitantly to vary the effective speed of the feed means and the effective speed of the unwinding means, a cam which turns in time with the pattern shaft of the knitting machine for actuating said movable part, and independent means for varying the ratio of the strand tension subsisting between the supply means and the feed means and that subsisting between the feed means and the knitting needles.

5. Apparatus for use in delivering a strand to the hooks of the needles of a knitting machine, said apparatus comprising power-actuated feed means for advancing the strand toward the needles, said feed means comprising a pair of complementary, frusto-conical rolls between which the strand passes, means for driving one of said rolls at a substantially constant speed, a movable strand guide for shifting the strand axially of said rolls thereby to vary the effective feed velocity, means for unwinding the strand from the supply mass, including an endless band passing about a pulley of variable diameter, a cam-actuated element operative to actuate the movable strand guide, and means moving with the strand guide for varying the effective diameter of said pulley.

6. Apparatus for use in delivering a rubber elastic strand from a supply, consisting of a cylindrical mass mounted on a rotary support, to the needles of a knitting machine, said apparatus comprising a rotary drum and means for positioning said supply mass with its axis parallel to that of the drum and with its peripheral surface resting upon the drum whereby rotation of the drum unwinds the strand from said mass, a pulley over which the strand passes after leaving the supply mass, said pulley being located so that the strand leaves the supply mass in a direction substantially tangential to the surface of the drum, means for driving said pulley at an effective surface speed bearing a predetermined ratio to that of the drum, power driven feed means for advancing the strand toward the knitting needles, and pattern controlled means operative concomitantly to vary the peripheral speed of the drum and the rate of the advance of the strand by the feed means.

7. Apparatus for use in delivering a rubber elastic strand from a supply, consisting of a cylindrical mass mounted on a rotary support, to the needles of a knitting machine, said apparatus comprising a rotary drum and means for positioning said supply mass with its axis

parallel to that of the drum and with its peripheral surface resting upon the drum whereby rotation of the drum unwinds the strand from said mass, guide pulleys about which the strand passes successively after leaving the supply mass, means for driving said pulleys at effective surface speeds which bear a predetermined but variable ratio to that of the drum, feed rolls between which the strand passes and which advance the strand toward the needles, means for driving said feed rolls, means for driving the drum, and cam-actuated means operative concomitantly to vary the peripheral speed of the drum and the effective rate of advance of the strand by the feed rolls.

8. Apparatus for use in delivering rubber elastic strand from a supply, consisting of a spool-wound mass mounted on a rotary support, to the needles of a knitting machine, said apparatus comprising a rotary drum and guide means for positioning said supply mass so that it is free to rise or fall and with its axis parallel to that of the drum and with its peripheral surface pressed by gravity against the drum whereby rotation of the drum unwinds the strand from said mass, guides about which the strand passes after leaving the supply mass, means for applying lubricant to the strand and means for supporting the strand while it receives the lubricant, a pair of complementary, frusto-conical feed rolls between which the strand passes and which advance the strand toward the knitting machine needles, a strand guide movable parallel to the axes of the feed rolls and which is operative to determine the location of the strand axially of the rolls, and pattern controlled means operative concomitantly to vary the position of the strand guide and to vary the peripheral speed of the drum.

9. Apparatus for use in delivering rubber elastic strand from a cylindrical supply mass to the needles of a knitting machine of the kind having a rotary needle cylinder and pattern means for controlling the operation of elements of the machine, the pattern means including an intermittently rotating shaft, said apparatus comprising a rotary drum having frictional engagement with the periphery of the supply mass thereby to unwind the strand from said mass, a variable speed feed means for advancing the unwound strand toward the knitting needles, variable speed means for driving the drum, a cam shaft and means for transmitting motion from the pattern shaft of the knitting machine to said cam shaft, a cam on the cam shaft, and means actuable by the cam for varying the peripheral speed of the drum and the effective speed of strand delivery by the feed means.

10. Apparatus for use in delivering rubber elastic strand from a supply mass to the needles of a knitting machine of the kind having a rotary needle cylinder and pattern means for controlling the operation of elements of the machine, the pattern means comprising an intermittently rotating shaft, said apparatus comprising a rotary feed shaft, means operative normally to drive said rotary feed shaft in time with the needle cylinder of the knitting machine, strand feeding means driven by said rotary feed shaft, means driven by said rotary feed shaft for rotating a supply mass thereby to unwind the strand from the supply mass, a cam shaft, means for transmitting motion from the pattern shaft of the knitting machine to said cam shaft, a cam on the cam shaft, and means actuable by the cam operative concomitantly to vary the speed of strand delivery by the feed means and the effective rate of unwinding of the strand from the supply mass.

11. Apparatus for use in delivering rubber elastic strand from a supply mass to the needles of a knitting machine of the kind having a rotary needle cylinder and pattern means for controlling the operation of elements of the machine, the pattern means comprising an intermittently rotating shaft, said apparatus comprising a rotary feed shaft, means normally operative to drive said rotary feed shaft in time with the needle cylinder of the knitting

machine, clutch means actuable by the pattern means of the knitting machine operative at times to discontinue rotation of said rotary feed shaft, variable speed means for advancing the strand toward the knitting machine needles, variable speed means for rotating the supply mass thereby to unwind the strand, and speed varying means under control of the pattern means of the knitting machine operative concomitantly to vary the rate of strand delivery and the rate of unwinding of the strand from the supply mass.

12. Apparatus for use in delivering rubber elastic strand from a cylindrical supply mass to the needles of a knitting machine of the kind having a rotary needle cylinder and pattern means for controlling the operation of elements of the machine, the pattern means comprising an intermittently rotating shaft, said apparatus comprising a rotary feed shaft, means normally operative to drive said rotary feed shaft in time with the cylinder of the knitting machine, a pair of frusto-conical, complementary feed rolls driven by said rotary feed shaft, a strand guide movable parallel to the axes of said rolls and which is operative to vary the position of the strand axially of said rolls as it enters the bite of the rolls, a variable diameter pulley also driven by said rotary feed shaft, an unwinding drum driven by said variable diameter pulley, said drum being operative to rotate the supply mass thereby to unwind the strand therefrom, a cam shaft, means for transmitting motion from the pattern means of the knitting machine to the cam shaft, and means actuable by the cam shaft for concomitantly shifting the strand guide and for varying the effective diameter of said pulley.

13. Apparatus for use in delivering rubber elastic strand from a cylindrical supply mass to the needles of a knitting machine of the kind having a rotary needle cylinder and pattern means for controlling the operation of elements of the machine, the pattern means comprising an intermittently rotating shaft, said apparatus comprising a rotary feed shaft, means normally operative to drive said rotary feed shaft in time with the cylinder of the knitting machine, a pair of frusto-conical, complementary feed rolls driven by said rotary feed shaft, a strand guide movable parallel to the axes of said rolls and which is operative to vary the position of the strand axially of said rolls as it enters the bite of the rolls, a variable diameter pulley also driven by said rotary feed shaft, an unwinding drum driven by said variable diameter pulley, said drum being operative to rotate the supply mass thereby to unwind the strand therefrom, a cam shaft, means for transmitting motion from the pattern means of the knitting machine to the cam shaft, a slide bar carrying said strand guide and which is movable parallel to the axes of the rolls, a spring urging said bar in one direction, the cam being operative to move the slide bar in the opposite direction, means movable with the slide bar for varying the effective diameter of the pulley, and adjustable stop means for limiting the movement of the bar by the spring.

14. Apparatus for use in delivering rubber elastic strand to the needles of a circular knitting machine designed to knit tubular fabric whose diameter varies in accordance with the rate at which the rubber elastic strand is delivered to the needles, said apparatus comprising frusto-conical feed rolls having toothed peripheries between which the strand passes on its way to the needles, a guide movable parallel to the axes of the rolls for varying the position axially of the rolls at which the strand enters the bite of the rolls, a rotary drum, means for positioning a cylindrical strand supply mass with its axis parallel to that of the drum and with its peripheral surface in contact with that of the drum, a cam whose contour bears a predetermined definite relation to the desired variable diameter of the knitted tube, and means actuable by the cam for shifting the strand guide and concomitantly varying the peripheral speed of the drum.

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15. Apparatus for use in delivering rubber elastic strand to the hooks of the needles of a circular knitting machine having a rotary needle cylinder, independent needles therein and cam means for moving the needles to form stitches of uniform length, said apparatus being designed to deliver the rubber elastic strand to the needles at a variable rate thereby to vary the effective diameter of the knitted tube and comprising variable speed strand feeding means, variable speed means for rotating a supply mass to unwind the strand therefrom, a pattern cam contoured according to the predetermined desired variation in diameter of the knitted tube, and means actuable by the cam operative concomitantly to vary the rate of strand delivery and the rate of rotation of the supply mass.

16. Method of knitting two-way stretch tubular fabric which varies in diameter from point to point, said method comprising as steps providing a cylindrical supply mass of rubber elastic strand wound to form concentric layers, the wound strand being attenuated to an initial, substantially uniform degree, turning said supply mass by friction applied to its peripheral surface thereby to unwrap the strand, gripping the unwound portion of the strand and positively advancing it toward a stitch-forming point at a rate such that the strand is attenuated to a variable but constantly controlled final degree when it arrives at the stitch-forming point, drawing the strand into stitches which initially are of uniform length and, while so drawing the stitches, concomitantly varying the rate of rotation of the supply mass and the rate of advance of the unwound strand toward the stitch-drawing point thereby to vary the attenuation of the strand and consequently to vary the diameter of the completed knitted tube.

17. Method of making knitted fabric which varies in diameter from point to point, said method comprising as steps providing a cylindrical supply mass of rubber elastic strand wound to form concentric layers, the wound strand being elongated approximately 5%, turning said supply mass by friction force applied to its peripheral surface thereby to unwrap the strand, gripping the unwrapped strand and positively advancing it toward a stitch-drawing point at a rate such as to attenuate the

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strand, drawing the strand into stitches, the stitches being of uniform initial length, and concomitantly varying the rate at which the strand is unwound and the rate at which it is advanced toward the stitch-forming point thereby to vary the attenuation of the strand as it approaches the stitch-drawing point with consequent variation in diameter of the completed tube.

18. That method of knitting tubular fabric upon a circular knitting machine having an even number of feeds exceeding two, and wherein textile yarn is delivered to alternate feeds and rubber elastic strand is fed to the intervening feeds, said method comprising as steps providing supply masses of textile and rubber elastic yarn, the supply masses of rubber elastic yarn equaling in number the number of feeds at which it is to be delivered to the needles, each of said masses of rubber elastic strand being cylindrical, delivering the textile yarn to the feeds at which it is to be knitted, rotating each of said masses of rubber elastic yarn by friction force applied to its periphery, passing the several elastic strands thereby unwound from their respective strand masses through a lubricating zone where lubricant is applied to the rubber elastic strand, gripping each of the several strands between feed elements operative to advance said strand toward their several feed points at a rate such, relatively to the draft of the needles, that said strands are attenuated, and concomitantly varying the rate of unwinding of the rubber elastic strands from their supply masses and the rate at which said strands are advanced by the feed elements thereby to vary the attenuation of the rubber elastic strands and consequently to vary the diameter of the completed knitted tube.

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