Sept. 1, 1942. F. H. REICHEL ET AL 2,294,630

PROCESS AND APPARATUS FOR PRODUCING ELASTIC FILAMENTS

Filed March 29, 1940

Fig. 1.

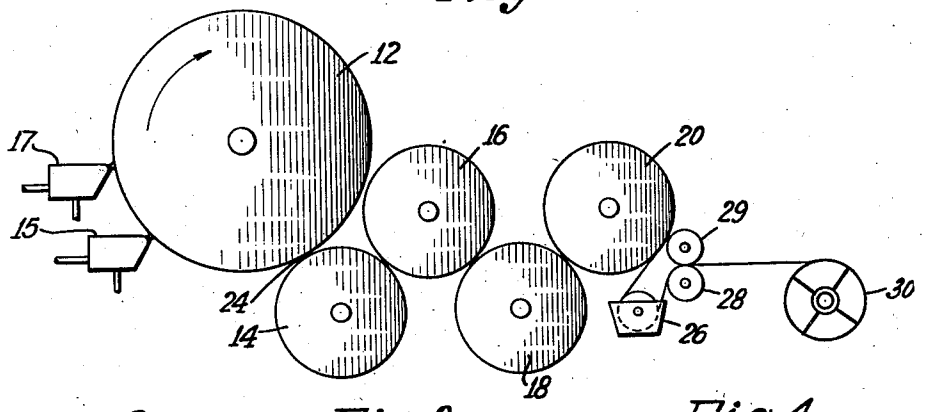


Fig. 2.

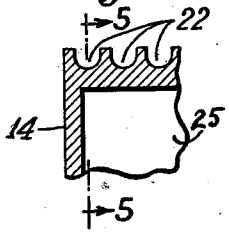


Fig. 3.

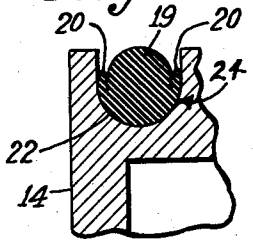


Fig. 4.

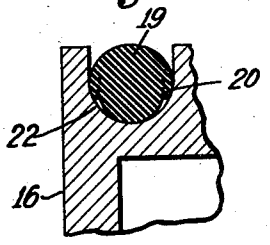
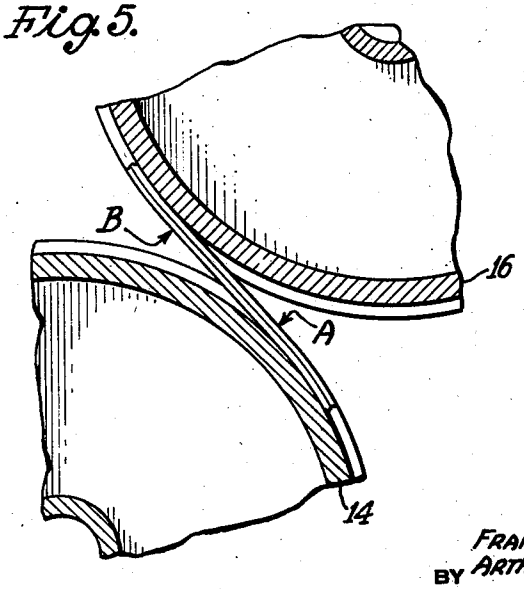


Fig. 5.



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PROCESS AND APPARATUS FOR PRODUCING ELASTIC FILAMENTS

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19 Claims. (Cl. 18—8)

The present invention relates to elastic filaments. More particularly, it relates to the production of elastic filaments capable of use for textile purposes wherein the shape, strength, modulus of elasticity and other characteristics are of importance.

In the production of elastic filaments heretofore from liquid or plastic rubber-containing compositions it has been customary to form the filaments in relatively large sizes and to reduce the size of the filaments by stretching them over substantial lengths, and thereafter relieving the stresses in the stretched filament by the use of heat. Such processes have been beset with certain difficulties due primarily to the peculiar properties of rubber. For example, it is practically impossible to form a filament from rubber which is entirely uniform in cross-section throughout an extended length. The variation in cross-section and variation in structure or composition all give rise to weak spots or sections in a filament. These weak spots may be due to variation in the rubber composition or in the flow of the composition during formation of the filament. When such non-uniform filaments are stretched the majority of the stretch takes place in the weak spots, making them thinner and therefore weaker than desired and leaving the adjacent stronger portions of the thread substantially unstretched and therefore larger and much stronger. This variation in stretch and size causes the filaments to be non-uniform in strength, modulus of elasticity and shape. Thus considerable difficulty has been experienced heretofore in producing uniform rubber filaments for use in making articles of wearing apparel and the like.

It is an object of the present invention to provide a method and apparatus for producing elastic filaments which overcome the foregoing difficulties.

It is another object of the present invention to provide a method of producing elastic filaments which are of substantially uniform shape, strength, and modulus of elasticity throughout their entire length.

It is a further object of the present invention to provide an apparatus capable of producing elastic filaments of substantial uniformity in shape, strength and modulus of elasticity throughout their lengths.

Other objects and advantages will be apparent to those skilled in the art as the description of the invention proceeds.

The method of the invention in general comprises forming an elastic filament from a rubber-containing plastic and thereafter uniformly stretching a very small length of the filament, which stretching step is preferably repeated several times with intervening drying periods, compressing the filament to force any irregularities in the contour of the filament towards the main body of the filament, which compressing step is preferably applied first to one side of the filament and then to the other side, and drying the filament while it is compressed and while in a stretched condition.

The apparatus of the invention comprises generally an apparatus for forming elastic filaments continuously from a rubber-containing plastic, and one or more shaping, stretching and drying drums operative upon the filament immediately after its formation.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangements of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure and the scope of the invention will be indicated in the claims.

For a more complete understanding of the nature and objects of the invention reference should be had to the drawing in which:

Fig. 1 is a diagrammatical view of a preferred form of apparatus of the invention which is capable of carrying out the process of the invention.

Fig. 2 is a fragmentary cross sectional view of one of the drying drums of the apparatus illustrated in Fig. 1.

Fig. 3 is a fragmentary cross sectional view on an enlarged scale of the drum illustrated in Fig. 2.

Fig. 4 is a fragmentary cross sectional view on an enlarged scale of another of the drying drums illustrated in Fig. 1.

Fig. 5 is a fragmentary cross sectional view on an enlarged scale of the drying drums illustrated in Figs. 2 to 4, taken substantially on the plane indicated by line 5—5 of Fig. 2 and looking in the direction of the arrows.

The material from which the elastic filaments may be made in the practice of the present invention may comprise a natural or synthetic rubber latex. The synthetic latex may be formed by dissolving rubber in one or more suitable organic solvents. When natural latex is used it is preferably concentrated in any well known manner prior to use. For the sake of convenience, the term "latex" has been used throughout this specification and the appended claims to indicate any rubber-containing liquid or semi-liquid plastic material.

Although the elastic filaments may be formed in any desired manner, as by extrusion, moulding and the like, from certain aspects of the invention it is preferred that the process and apparatus of forming filaments described in U. S.

Patent 2,172,018, issued September 5, 1939, to William M. Spencer, be used. Such apparatus, in brief, comprises a heated forming wheel or element provided with projections having continuous grooves extending peripherally of the projections, and latex containers positioned adjacent to the forming wheel. Each of the latex containers comprises a weir (not shown) over which a stream of latex is caused to flow and as the forming wheel rotates adjacent to the crest of each weir, latex passes from the crest of each weir to the grooves in the pickup wheel by the action of surface tension and capillary attraction, all as explained in detail in that patent. Such a forming wheel is diagrammatically illustrated and designated as 12, in Fig. 1 and the latex containers are diagrammatically illustrated and designated 15 and 17. The heat of the forming wheel causes the latex contained in the several grooves continuously to coagulate as coherent filaments which are partially dried on the forming wheel and continuously stripped from the groove by the wheel 14. The forming wheel 12 defines a forming zone for the filament.

Rubber filaments formed in accordance with the foregoing method are of the shape illustrated in Fig. 3 which comprises a main body portion 19 and fins 20 which extend laterally from the body when the filaments are stripped from the forming wheel.

Other filament forming processes frequently leave ridges, corners, fins and the like portions extending laterally from the main body portions of the filaments, which projections under some conditions of use are desirable and under others are undesirable and should preferably be eliminated.

The present invention makes it possible to substantially eliminate such projections and simultaneously stretch the elastic filament uniformly throughout its length. To this end a drying, shaping and stretching drum 14 is suitably mounted for rotation in such position that its periphery just clears the periphery of the forming wheel 12.

The drum 14 comprises a cylindrical member provided with annular grooves 22 as shown in Fig. 2. One groove is provided for each groove on the forming wheel 12. The drum 14 is preferably heated as by circulating hot water or other fluid within the hollow interior 25 of the drum in known manner, although other heating expedients such as electric heaters, gas heaters and the like may be used if so desired.

Although one such drum 14 can be used, from certain aspects of the invention it is preferred that at least two drums be employed since superior results are thereby obtained. Any desired number of drums may be included in the series depending upon the number of alternate small stretching and relatively large drying zones desired. A series of four drums has been selected for the purpose of explanation. The drums 16, 18 and 20, which are identical with drum 14, are suitably mounted for rotation so that their peripheries just clear each other successively and so that a maximum amount of the groove area of each drum will be contacted by filaments passed thereover and led from one drum to another.

Each of the filaments 24 (see Fig. 1) is stripped from the forming wheel 12 by the drum 14 and passed around the drum 14 in its respective groove. The distance between the drums 12 and 14 is made as small as conveniently possible so that the length of the run of the filaments between the forming wheel 12 and the drum 14 will be as small as possible. Thus a minimum length of elastic filament is suspended between adjacent drums and the forming wheel and the first drum. This has been illustrated in Fig. 5 on an enlarged scale wherein the length of filament suspended between drums 14 and 16 is illustrated as extending between the arrows A and B.

It has been found that drums having a diameter of nineteen (19) inches can be placed with about three sixteenths ($\frac{3}{16}$) inch between their peripheries and still leave ample room for threading the filaments over the drums at the beginning of a run. The same distance may be used between the forming wheel and the first drum. By mounting the drums so that their axes are adjustable in the vertical plane, this distance can be materially reduced since the drums can be moved apart for starting.

By driving the drum 14 at a greater peripheral speed than the forming wheel 12 and by driving each succeeding drum at a different speed from the preceding drum, it is possible to impart any desired amount of stretch in any desired order to each short length of filament A—B suspended between each pair of drums in the series. Since the length of the section A—B is very short and since those portions of the filament which are supported by the drums do not undergo stretching but are existing in what might be called supporting, advancing and drying zones, the filaments are substantially uniformly stretched. This is so because the portions undergoing stretch are made small and there is not sufficient space for a weak or thin section of any size to occur in the suspended area with a strong section and thereby absorb all of the stretch and become abnormally reduced in size while leaving the stronger section unreduced in size, but on the contrary each successive increment of the thread is stretched a substantially uniform amount. The smaller the drying drums in diameter the shorter will be the section A—B for a given clearance between the drums.

The amount of heat supplied to each drying drum may be regulated in any suitable well known manner so as to vary the amount of drying which the thread undergoes on each drum. That is, the drying heat may be so regulated that the thread is dried predominantly at any point in the stretching process. It has been found that the modulus of elasticity of a filament will be affected inversely in proportion to the amount of moisture it contains during stretching. This means that a relatively wet filament can be stretched a greater amount without affecting the modulus of elasticity than a drier filament and that the modulus can be greatly varied by stretching a relatively dry filament a small amount. Thus by suitably proportioning the amount of stretch which the filament undergoes between any pair of consecutive drums of the series and by suitably controlling the temperature of each drum, an elastic filament can be stretched a maximum amount for a given rubber composition without affecting its modulus of elasticity, or with a given rubber composition the resultant elastic filament can be made to have any desired modulus of elasticity within wide limits. This is of outstanding importance since it makes it possible to produce elastic filaments having different moduli of elasticity from the same latex composition by merely adjusting the relative speeds of the drying drums and/or the temperatures of the drums.

The speeds of the drums may be adjusted by driving each drum through any well known type of change speed mechanism.

By way of illustration but not in limitation of the invention, the following table will be given to represent a set of typical values for an operation in accordance with the invention wherein it was desired to produce a maximum amount of stretch in an elastic filament made from a given latex composition without materially affecting the modulus of elasticity of the filament prior to stretching.

	Position				
	Between forming wheel and 1st drum	Between 1st and 2nd drum	Between 2nd and 3rd drum	Between 3rd and 4th drum	Leaving 4th drum
Moisture content	*Per cent* 15.1	*Per cent* 6.8	*Per cent* 4.6	*Per cent* 3.6	*Per cent* 3.1
Amount of stretch	80	40	10	10	00

It has been found that by stretching in small increments in accordance with the present invention a much higher stretch can be imparted to the filament without varying its normal modulus of elasticity. For example, a filament made from a given latex compound may be stretched as high as 250% in accordance with the present invention without altering the modulus, whereas about 125% was the maximum stretch which could be so applied heretofore. This may be at least in part due to the manner in which the filaments are dried. That is, the filaments are first heated on one side on the forming wheel **12** and then on the other side on the drum **14** and so on throughout the series. This causes the filaments to be more uniformly dried and to have thereby a more homogeneous structure during stretching. This alternate drying on opposite sides of the filament also prevents any tendency toward curling and kinking on the part of the filament after drying.

From the last drum **20** the elastic filaments may be passed through a suitable talcing mechanism **26** and then between guide rollers **28** and **29** to a suitable reel **30**. It has been found that the present invention makes it possible to produce elastic filaments by using a minimum quantity of talc since the filament is in a very dry condition before it is passed through the talc and thereby takes up a smaller quantity of the talc than when it is wet.

The grooves **22** of the drying stretching and shaping drums may be suitably shaped to compress the filaments and form them into any desired shape within wide limits. Since a round filament is usually desired for uses where the projecting fins **20** are not desirable, grooves **22** are usually rounded at the bottom. As the filament **24** passes into the groove **22** of the first drum **14** the bottom side of the filament passes into contact with the rounded groove and the fins **20** are folded back against the body portion **19** and substantially made a part thereof. While the fins and the bottom of the filament are thus compressed the filament is dried by the heat emanating from the drum **14** and the stresses existing in the rubber filament due to stretching and folding the fins in compressing the filament are relieved by the heat which causes the filament to retain the shape and length existing while it is on the drum **14**.

As the filament **24** passes on to the second drying drum **16** its position in the groove **22** is reversed so that the top side of the filament comes in contact with the curvature of the groove and this side of the filament and the fins are further compressed toward the center of the filament to further shape the filament. Drying of the filament while it is thus compressed and held in further stretched condition relieves the stresses existing in the filament and causes it to retain the shape and length existing on the drum **16**. When further drums are used in the series these actions may be repeated.

The number of drums used are dependent on the amount of stretch to be imparted to the filament as well as the point in the drying of the filament where the major portion of the stretch should be applied to the filament. Thus, if it is desired to stretch the filament a maximum amount without varying the normal modulus of elasticity for the latex compound being used, the majority of the stretch will be applied to the filament between the forming wheel and the first drum and between the first and second drums, or at the points where the filament contains the most moisture.

In the case where it is desired to appreciably modify the normal modulus of elasticity the predominant amount of stretching may be caused to take place between drums toward the end of the series so as to stretch the thread predominantly while it is relatively dry to thereby vary the modulus of elasticity. The diameter and clearance of the drying drums will be varied as desired to vary the length of the section to be stretched.

The apparatus of the present invention is exceedingly compact and thereby saves plant space which has not been the case heretofore when belts and similar apparatus had been used to stretch elastic filaments.

The process of the present invention makes it possible to rapidly and effectively stretch elastic filaments to the proper size, shape them to the proper shape, and produce the desired strength and modulus of elasticity in the completed filament, all without necessitating a change in the original latex composition. These features of the invention have greatly reduced the cost of manufacture and extended the uses of the rubber filaments.

Since certain changes may be made in carrying out the above process without departing from the scope of the invention it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. The process of making elastic filaments comprising continuously collecting latex by means of surface tension and capillary attraction in the groove of a continuous collecting member moving adjacent to but spaced from the surface of a body of latex, coagulating the latex in the groove to form a coherent deposit having a main body portion and laterally-extending elements, stripping the deposit from said groove by a second member moving closely adjacent to the first member and having a continuous groove which receives the filament and is shaped to compress the said laterally-extending elements against the body portion, the second continuous member being moved at a relatively greater speed than the first member to impart a predetermined stretch to the short length of filament between the two

members, and applying heat to the filament in the groove of the second member to dry it in stretched and shaped condition.

2. The process of making elastic filaments comprising continuously collecting latex by means of surface tension and capillary attraction in the groove of a continuous collecting member moving adjacent to but spaced from the surface of a body of latex, coagulating the latex in the groove to form a coherent deposit having a main body portion and laterally-extending elements, stripping the deposit from said groove by a second member moving closely adjacent to the first member and having a continuous groove which receives the filament and is shaped to compress the said laterally-extending elements against the body portion, the second continuous member being moved at a relatively greater speed than the first member to impart a predetermined stretch to the short length of filament between the two members, applying heat to the filament in the groove of the second member to partially dry it in stretched and shaped condition, passing the filament from the second to a third member moving closely adjacent to the first continuous member and having a continuous groove which receives the filament and is shaped to further compress the said laterally-extending elements against the body portion, the third member being moved at a relatively greater speed than the second member to impart a predetermined stretch to the short length of filament between the second and third members, and applying heat to the filament in the groove of the third member to further dry it in stretched and shaped condition.

3. The process of making elastic filaments comprising continuously collecting latex in the groove of a continuous collecting member, coagulating the latex in the groove to form a coherent deposit having a main body portion and projections thereon, stripping the deposit from said groove by a second member moving closely adjacent to the first member and having a continuous groove which receives the filament and is shaped to compress the projections against the body portion, the second member being moved at a relatively greater speed than the first member to impart a predetermined stretch to the short length of the filament between the two members, and applying heat to the filament in the groove of the second member to dry it in stretched and shaped condition.

4. The process of making elastic filaments comprising continuously collecting latex by means of surface tension and capillary attraction in the groove of a continuous collecting member moving adjacent to but spaced from the surface of a body of latex, coagulating the latex in the groove to form a coherent deposit having a main body portion and laterally-extending elements, leading the deposit from said groove directly into a continuous groove formed in a second member moving closely adjacent to the first member, the groove in the second member being shaped to compress the said laterally-extending elements against the body portion, and applying heat to the filament in the groove of the second member to dry it in shaped condition.

5. The process of making elastic filaments comprising forming liquid latex into a filament, heating the filament while supported on one side to partially dry it, heating the filament while supported on the opposite side to further dry it, stretching the filament so dried and thereafter vulcanizing the filament.

6. The process of making elastic filaments comprising continuously forming liquid latex into a coherent filament having a main body portion and projections thereon, passing the filament from the point of formation and shortly thereafter supporting and advancing the filament while compressing the projections against the body portion, the rate of advance of the filament being greater than the rate of formation whereby a predetermined stretch is applied to the small length of filament suspended between the point of formation and the point of support and advancement, and applying heat to the supported filament to dry it in the stretched and compressed condition.

7. The process of making elastic filaments comprising continuously forming liquid latex into a coherent filament having a main body portion and projections thereon, passing the filament from the forming point and advancing the filament while compressing the projections against the body portion, the rate of advancement of the filament being greater than the rate of formation of the filament whereby the short length of filament suspended between the point of formation and point of advancement is stretched a predetermined amount, applying heat to the supported filament to partially dry it in compressed and stretched condition, passing the filament from the supporting and compressing zone and shortly thereafter again supporting and advancing the filament while further compressing the projections against the body portion, the rate of advancement in the second advancing zone being greater than the advancement in the first advancing zone whereby the short length of suspended filament between the two zones is subjected to a predetermined stretch, and applying heat to the filament in the second advancing zone to further dry it in stretched and compressed condition.

8. The process of making elastic filaments comprising continuously collecting latex by means of surface tension and capillary attraction in the groove of a continuous collecting member moving adjacent to but spaced from the surface of a body of latex, coagulating the latex in the groove to form a coherent deposit having a main body portion and laterally-extending elements, stripping the deposit from said groove and shortly thereafter supporting and advancing the filament while compressing one side of the filament to shape it and simultaneously bend the projections against the body portion, applying heat to the filament to partly dry it in the shaped and compressed condition, passing the filament from the first shaping and compressing zone and compressing the other side of the filament to shape it and simultaneously compress the extensions against the body portion, and applying heat to the filament to further dry it in the shaped and compressed condition.

9. The process of making elastic filaments comprising continuously forming liquid latex into a coherent filament having a main body portion and projections thereon, passing the filament from the point of formation and thereafter supporting and advancing the filament while compressing one side thereof to shape the filament and compress the projections against the body portion, applying heat to the filament to partially dry it in shaped and compressed condition, thereafter supporting and compressing the other side of the filament while compressing the projections against the body portion of the filament.

and applying heat to the filament to further dry it in compressed and shaped condition.

10. The process of making elastic filaments comprising forming liquid latex into a coherent filament, thereafter successively alternately stretching and heating the filament, the successive stretching operations being of progressively decreasing magnitude whereby a maximum amount of stretch may be imparted to the filament formed from a given liquid latex composition without altering the modulus of elasticity of the filament.

11. The process of making elastic filaments comprising continuously forming a liquid latex composition into a coherent filament, thereafter successively alternately stretching and partly drying the filament, the stretching operations being varied in magnitude to produce a desired modulus of elasticity in a filament made from a given latex composition.

12. The process of producing elastic filaments comprising forming liquid latex into a coherent filament, thereafter stretching successive lengths of said filament a plurality of times, and heating lengths of the filament between the stretching operations, the heated lengths of filament being greater than the lengths subjected to the stretching.

13. An apparatus for forming filaments comprising a movable filament-forming member, means for positioning a body of rubber-containing liquid in position to deposit rubber upon said filament-forming member, means for coagulating the rubber deposit into a coherent filament, a member having a grooved surface movable closely adjacent to said filament-forming member for receiving the filament in said groove and shaping the filament, means for heating said movable member, a second movable member having a grooved surface movable closely adjacent to the groove of the first movable member for receiving the filament in said groove and further shaping the filament, and means for heating the second movable member.

14. An apparatus for forming filaments comprising means for forming an elastic filament and means for receiving and supporting the elastic filament while advancing the filament so as to stretch the filament between the forming means and the advancing means, the length of filament supported by both the forming means and the advancing means being greater than the length of the filament suspended between said means and the length of filament supported between said means being of the order of three-sixteenths of an inch.

15. The process of making elastic filaments comprising continuously forming a liquid latex into a coherent filament while maintaining one side of the filament in contact with a heated forming means, and removing the filament from the forming means and immediately advancing the filament by a heated advancing means while maintaining the opposite side of the filament in contact with said advancing means.

16. The process of making elastic filaments comprising continuously collecting latex by means of surface tension and capillary attraction in the groove of a continuous collecting member moving adjacent to but spaced from the surface of a body of latex, coagulating the latex in the groove to form a coherent deposit, stripping the deposit from said groove by a second member moving closely adjacent to the first member and having a surface for directly receiving and supporting the filament from the first member, the second continuous member being moved at a relatively greater speed than the first member to impart a predetermined stretch to the length of filament between the two members, and applying heat to the filament carried by the second member to dry it in stretched condition.

17. The process of making elastic filaments comprising continuously forming an elastic filament from liquid latex, coagulating the latex to form a coherent filament, moving a supporting member having a continuous surface closely adjacent to the point of exit of the filament from the coagulating operation so that the member can directly receive the filament and withdraw it from the coagulating operation, the span of the filament between the forming and coagulating operation and the moving member being very small compared to the length of the filament supported by the moving member, moving the member at a greater surface speed than the speed of formation of the filament, whereby the very short span of unsupported filament is subjected to a predetermined stretch, and heating the filament while supported on the moving member to dry the filament in stretched condition.

18. An apparatus for producing elastic filaments comprising a movable filament-forming member, means for positioning a body of rubber-containing liquid in position to deposit rubber upon said filament-forming member, means for coagulating the deposit on the filament-forming member into a coherent filament, a rotatable member having a continuous surface spaced to directly receive and support the filament as it is passed from the filament-forming member, the distance between the periphery of the filament-forming member and the filament-supporting member being small compared to the periphery of the filament supporting member, and means for driving the filament-supporting member at a greater peripheral speed than the filament-forming member, whereby the short span of filament between the two said members is stretched, and means for heating the rotatable member.

19. The process of making elastic filaments comprising continuously forming latex in a zone of formation into a coherent filament having relatively strong and relatively weak sections along its length, passing the filament from the zone of formation onto a supporting and advancing element spaced from said zone of formation a distance insufficient for the short length of filament suspended therebetween to accommodate simultaneously a relatively weak section or a portion thereof and any substantial length of a relatively strong section so as to prevent the relatively weak section from absorbing the stretch intended for the relatively strong section, and advancing the element at a rate greater than the rate of formation of the filament, whereby substantially all of each successive short length of filament suspended between the zone of formation and the element is stretched a predetermined uniform amount.

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