Jan. 15, 1946. H. J. DOELL 2,392,842

METHOD OF MAKING COILED STRUCTURES

Filed June 10, 1943

Fig. 1.

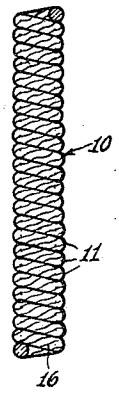


Fig. 2.

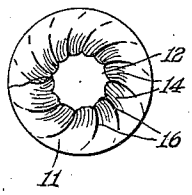
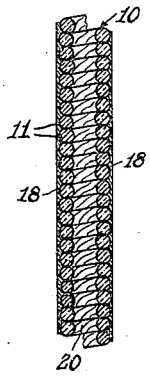


Fig. 3.



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Patented Jan. 15, 1946

2,392,842

UNITED STATES PATENT OFFICE

2,392,842

METHOD OF MAKING COILED STRUCTURES

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Application June 10, 1943, Serial No. 490,319

19 Claims. (Cl. 57—157)

This invention relates to new coiled structures and the method of making the same. More particularly, the invention relates to new coiled structures of nylon capable of numerous uses and to the method of making the same.

Although this invention relates to the formation of springs and spring-like structures from many synthetic linear polymeric materials capable of producing large filaments, it will be discussed for convenience in terms of nylon.

Coiled springs formed of a metal wire are usually produced by winding of a wire about a mandrel. Twisting of a metal wire upon itself will not produce a coiled structure. In attempting to produce a coiled structure by twisting a metal wire upon itself, when one or two kinks are produced, the wire twists off. The torsional cold working also produces a harder, more brittle wire which refuses to coil. So far as the prior art is concerned, no coiled spring structures have been made by twisting without the use of a mandrel. It has now been found that nylon or similar material can be twist-coiled (twisted about itself) to form coiled spring-like structures capable of various uses.

It is an object of this invention to provide new coiled spring-like structures which can be adapted to a large variety of uses. It is a further object to produce new coiled structures or springs of nylon suitable for many diverse uses, including the use as textile elements. It is a still further object to provide an entirely new and unobvious process of producing the previously-mentioned coiled or spring-like structures. Other objects will appear hereinafter.

The objects are accomplished by twisting one end of a nylon monofil held in a straightened position under tension and while the opposite end is held stationary. After a certain amount of twisting and under appropriate tension, a coil lying approximately normal to the length of the structure forms, and upon further twisting successive coils are thereafter laid side by side. The coiled structure may be subjected to a setting treatment, with or without prior release of the tension under which the monofil was twist-coiled and with or without prior extension of the coiled structure. Depending on the ultimate use, the resulting coiled structure may be coated with an elastic coating to form a closed elastic cylinder.

In order to more fully explain the invention, reference will now be made to the drawing forming a part of this specification and wherein:

Figure 1 is an elevation of a coiled or spring-like structure of a nylon monofil;

Figure 2 is an enlarged end view of the structure shown in Figure 1; and

Figure 3 is a vertical section of a coated coiled or spring-like structure.

Referring now to the drawing, wherein like reference numerals designate like parts, the reference numeral 10 designates a coiled spring-like structure comprising a plurality of coils 11 and a bore 12. The coiled structure 10 is formed of a nylon monofil which has been twist-coiled (twisted about itself), as will be more fully explained hereinafter. As shown in Figure 2, the nylon monofil in the coiled structure contains spiral striations 14 and creases 16. When it is desired to conceal the coils 11, the exterior surface of the structure 10 is provided with a coating 18 of an elastic material or composition to produce a hollow elastic cylinder 20.

In order that the method of producing the coiled spring-like structure may be fully explained, there are hereafter set forth several illustrative procedures:

Example I

One end of an oriented polyhexamethylene adipamide monofil, 11 mils in diameter, was suspended from a vertical rotary shaft and the opposite end was secured to a weight of 235 grams which was restricted from rotary motion. The rotary shaft was motor-driven at a speed of 200 R. P. M. until the monofil was twisted approximately 23 turns per inch, at which time the tension was preferably momentarily released to permit a kink to form in the filament, after which 16 more turns per inch would form a coil. The twisting was continued until about 81 tight, uniform spirals per inch were formed. A total of about 210 turns was necessary to produce one inch of coil. The coiled structure so formed was subjected to a short setting treatment by steaming at 10 pounds per square inch before the tension was released to render the coils more permanent and lasting. The diameter of the coil was 26 mils. When the coil was relieved of tension prior to the steam treatment, the structure relaxed about 13% and had a stable coil diameter of 33 mils. The steam setting gave to the coils a desirable longitudinal resilience. Twist-coiled nylon springs reached their yield point by the straightening out of a small number of coils, leaving the remainder of the structure a spring. Setting also raised the yield point, which was the point at which tension would cause some of the coils to straighten out. A load of 300 grams was necessary to effect 100% elongation, while the yield point was found to be 400 grams. When coils so produced were used as elastic members in the tops of men's socks, it was found that a highly satisfactory garment was produced.

Example II

A coiled structure, prepared as in Example I, was coated with a 5% solution of N-methoxymethyl polyhexamethylene adipamide (8% meth-

oxymethyl groups) in ethanol to form a closed elastic cylinder. The coating, when applied, was baked at 120° C. for 2 minutes. The closed cylinders so formed were very elastic since the film stretched and returned to position in harmony with the spring coil. The closed cylinder may be used in a number of ways; for example, a very satisfactory shock cord was made by enclosing a bundle of these closed cylinders within a suitable surface braiding or wrapping. The film prevented interference between adjacent springs and also supported the surface covering while preventing that covering from being pulled between the individual coils of the outside springs when the springs were in an extended position.

Example III

Four spring coils were made according to an alternative process, using oriented polyhexamethylene adipamide monofils of 4, 11, 16 and 25 mils diameter. In this process a standard Suter twist counter was used. The following table illustrates the specifications for making the coiled structures and the results of using larger and smaller diameters, as compared with the monofil of Example I:

Monofil, diameter.....mils..	4	11	16	25
Twisting tension in grams:				
Minimum (to avoid lateral kinks).....	10	70	130	330
Optimum.....	20	100	160	350
Maximum (to avoid breaks).....	20	130	200	370
Turns per inch before coiling starts.....	50	23	14	10
Turns per inch of original fiber to form coil...	98	39	24	16
Turns to produce one inch of relaxed spring coil.....	520	210	140	110
Number of coils per inch of spring coil.....	184	81	54	30
Per cent coil length to original fiber length....	19	19	17	15
Per cent elastic twist in coils.....	16	13	11	6
Diameter of coils; untreated.....mils..	12	33	51	80
Load to obtain 100% elongation.....grams..	60	300	500	1,200
Yield point.....grams..	60	400	850	1,800
Diameter of coils; steam-treated.....mils..	10	26	40	67

As indicated, the 25-mil monofil was capable of withstanding a load up to 1200 grams before it was 100% elongated.

Example IV

A coiled structure was made of 25-mil diameter polyhexamethylene adipamide monofil, in accordance with the procedure of Example III. The coiled structure, when formed, was removed from the twisting mechanism and was extended to 200% of its original length and set in an extended position with aqueous phenol, as is well known in the art. The spring had approximately the same resistance to compression as the comparable spring of Example III had to tension and proved to be useful in a mechanical capacity where light compression springs are useful.

While a preference has been shown for polyhexamethylene adipamide in producing the filaments according to the foregoing examples, the invention is not to be so limited. The monofils of the invention may be made from any fiber-forming synthetic polymeric material known to the art, which has good tenacity and especially shear strength, and which is cold-drawable. The monofils are preferably made from such fiber-forming synthetic linear polymers of the classes described in U. S. Patents Nos. 2,071,250, 2,071,251, 2,071,253, 2,130,523 and 2,130,948, as well as from the interpolymers of U. S. Patents Nos. 2,252,554 and 2,252,555. In other words, the invention is intended to include, for the preparation of the filaments, all such water-insoluble and fiber-forming linear superpolymers and interpolymers.

Other illustrative polymeric materials are vinylidene chloride-vinyl chloride copolymer, acrylonitrile polymer or copolymers, vinyl chloride-vinyl acetate copolymers, cellulose acetate, cellulose aceto butyrate.

The size of the monofil to be employed will generally fall within the range of 2–100 mils, although larger ones may sometimes be satisfactory.

The optimum tension will be governed by the size, tenacity and flexibility of the monofil being twisted. If the tension is too low, lateral, uncontrollable kinks will be formed in the monofil. If the tension is too high, the structure will be sheared.

The speed and temperature of twisting are not critical within reasonable limits.

The amount of twist and the number of the coils per inch are a function of the size of the monofil in the coil.

The length of monofil to be twist-coiled is obviously variable. While the examples are, for convenience, limited to reasonable lengths, it will be well within the skill of the expert to provide an intermittent or continuous process for producing coils of indefinite length.

While a preference is shown for setting the twist-coiled monofil in steam, as discussed more fully in U. S. Patent No. 2,157,117, the invention is not so limited. Setting may be accomplished by dry heat at 100° C. to 150° C. or by heating in the presence of various liquids, such as aqueous phenol, aqueous formic acid, water, etc., as described in U. S. Patents Nos. 2,197,896 and 2,287,099. Moreover, setting by means of heat and organic non-solvent swelling agents, as described in U. S. Patent No. 2,289,377, is also meant to be included as an alternative method for producing a coil of more desirable longitudinal resilience.

Preference is shown for setting the twist-coiled monofil in steam while still under the twisting tension to produce a coiled structure of more desirable longitudinal resilience. The invention is not, however, so limited. If the twisting tension is released, the twist-coiled monofil will relax about 13% and the coil diameters will increase somewhat. The relaxed coiled structure is, however, stable and somewhat stiffer, i. e., a greater load is required to extend it a given amount, than the coiled structure which was set prior to the release of the twisting tension. Similarly, the relaxed coil can be set with steam or the like and a quite soft coil will result, i. e., it will extend a given amount with a smaller load. Thus, coiled structures suitable for different purposes may be produced by these variations. In general, the amount of steam-setting exerts no pronounced effect on the final product.

Preferably substantially fully drawn monofils, as is well understood in the art, will be employed in this invention. It is, however, entirely practical to use monofils which have not been fully drawn.

It is to be understood that the monofils of this invention may be plasticized by any of the conventional plasticizing agents, as is known in the art.

The invention is intended to include, for producing closed elastic cylinders, any of the conventional coating compositions known to the art which produce well adhering, flexible, elastic and abrasion-resisting coverings, such as synthetic linear polyamides and interpolyamides, polyesters, polyacetals, polyesteramides, polyurethanes, polythioureas, polymeric ethylene, as well as properly plasticized resins, etc. It is to be un-

derstood that the coating can be applied by any of the conventional coating methods.

It has been found that a very unusual coiled structure can be formed by twisting a nylon monofil upon itself. The twist-coiled springs of nylon which are not set exhibit the phenomenon of initial tension, thus requiring an initial load before the start of the elongation with load curve. Setting, however, removes the initial tension and also decreases the modulus of the spring. Twist-coiled springs of nylon have a higher modulus than mandrel-wound springs of nylon. This difference is ascribed to the spiral orientation and the increase in fiber denier resulting from the twisting. As previously mentioned, these twist-coiled springs reach their yield point by straightening out of a small number of coils, leaving the remainder of the structure a spring. When the spring is placed under tension, both ends thereof must be prevented from rotating otherwise the structure will untwist and cease to be a spring. This new coiled structure, which has a remarkable degree of strength, elasticity and durability, can be suitably adapted for use as a textile element or as a small mechanical spring.

It is known that elastic fibers or filaments made from rubber are effective and useful for a limited length of time only because of rupture and loss of elasticity. It is also well known that the garment or material into which these elastic fibers are knitted or woven outlive the elastic fibers but are rendered useless and must be discarded because of the loss of the elasticity and effectiveness of the elastic fibers.

This invention provides new and valuable elastic spring-like structures of nylon and similar polymeric material which may be used as textile elements. For example, the twist-coiled monofils may be knitted or woven into the welt of all types of hosiery and socks to form tight-fitting elastic tops. The filaments are also favorably adapted for use as the elastic elements in knitted and woven clothing; for example, for making shirred elastic bodices in dresses and for making foundation garments and like articles of clothing. The elastic closed cylinders, when made according to the invention, also adapt themselves very well to use as elastic yarns in clothing and wearing apparel, such as foundation garments, etc. The coated or uncoated elastic filaments, because of their elasticity, longitudinal resiliency and recovery from elasticity, are also capable of being woven (or knit) either alone or with other types of yarns into fabrics for use as elastic supporters, elastic tapes, etc. In general, the improved elastic filaments of this invention can be used in any or all instances where rubber and rubber-type yarns and threads are employed.

The coiled structure may also be used as a decorative or ornamental textile or material. It may be used as military braid, an edging to simulate piping, etc.

The new springs of the invention can be used to replace light wire springs where corrosion by chemicals and oxidation make the use of wire impractical or troublesome. The new structures may constitute springs to be used by chemists, physicians, photographers, dentists, etc. The springs may be used in a mechanical capacity to replace light-weight wire springs, to dampen vibrations of radio microphones, to support antennae on airplanes, as counter balances (high fatigue-resisting) in testing instruments, and numerous other uses.

Since it is obvious that many changes and modifications can be made in the above-described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited thereto except as set forth in the appended claims.

I claim:

1. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, and subjecting the coiled structure to a setting treatment.

2. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, releasing the tension, and subjecting the coiled structure to a setting treatment.

3. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, and releasing the tension.

4. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, extending the coiled structure, and subjecting the extended coiled structure to a setting treatment.

5. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, and coating the coiled structure with an elastic composition to form an elastic cylinder.

6. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, and coating the coiled structure with an elastic composition to form an elastic cylinder.

7. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, releasing the tension, subjecting the coiled structure to a setting treatment, and coating the coiled structure with an elastic composition to form an elastic cylinder.

8. A method of making coiled structures which comprises twisting one end of a monofil formed of a polymer held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, releasing the tension, and coating the coiled structure with an elastic composition to form an elastic cylinder.

9. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, and continuing the twisting to produce successive coils until the desired number of coils is obtained.

10. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, and further continuing the twisting to produce successive coils until the desired number of coils is obtained.

11. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, and subjecting the coiled structure to a setting treatment.

12. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, releasing the tension, and subjecting the coiled structure to a setting treatment.

13. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, and releasing the tension.

14. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, extending the coiled structure, and subjecting the extended coiled structure to a setting treatment.

15. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until a coil is formed, continuing the twisting to produce successive coils until the desired number of coils is obtained, and coating the final coiled structure with an elastic composition to form an elastic cylinder.

16. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, and coating the final coiled structure with an elastic composition to form an elastic cylinder.

17. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, and coating the final coiled structure with an elastic composition to form an elastic cylinder.

18. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, releasing the tension, subjecting the coiled structure to a setting treatment, and coating the final coiled structure with an elastic composition to form an elastic cylinder.

19. A method of making coiled structures which comprises twisting one end of a nylon monofil held in a straightened position under tension while the other end is held stationary to twist said monofil about itself until momentary release of the tension will produce a kink in the monofil, momentarily releasing the tension to produce a kink in the monofil, continuing the twisting until a coil is formed, further continuing the twisting to produce successive coils until the desired number of coils is obtained, subjecting the coiled structure to a setting treatment, releasing the tension, and coating the final coiled structure with an elastic composition to form an elastic cylinder.

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