

Aug. 5, 1941.

R. A. CLAWSON
ARTICLE OF MANUFACTURE
Filed April 6, 1940

2,251,268

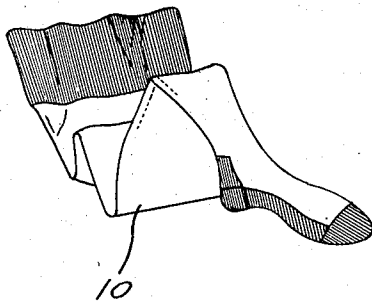


Fig. 1

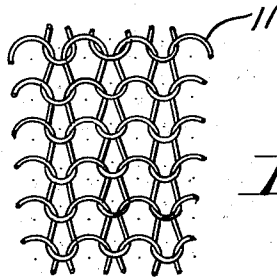


Fig. 2

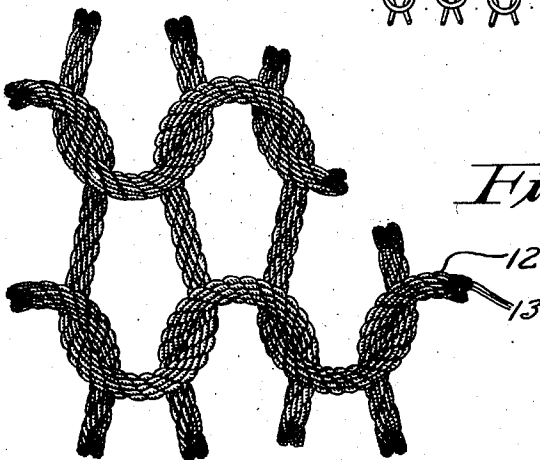


Fig. 3

13 *Robert Arthur Clawson*
INVENTOR

BY *Louis A. Wiebe*
ATTORNEY

UNITED STATES PATENT OFFICE

2,251,268

ARTICLE OF MANUFACTURE

Robert Arthur Clawson, Wilmington, Del., assignor to E. I. du Pont de Nemours & Company, Wilmington, Del., a corporation of Delaware

Application April 6, 1940, Serial No. 328,179

7 Claims. (Cl. 66-178)

This invention relates to sheer, knit fabrics, such as ladies' sheer, knit hose, and more particularly it relates to new and improved sheer, knit articles and fabrics which have been knit from single, artificial filaments, or so-called "mono-fils."

For a long time silk has dominated the field of ladies' fine hosiery. Recently rayon has come into use to a limited extent and quite recently a new synthetic yarn, made from the material known as a synthetic linear polyamide and as disclosed in United States Letters Patent Nos. 2,071,250, 2,071,251, 2,071,253 and 2,130,948 has been used for such purposes. Silk yarn is necessarily a multifilament yarn since each filament is fine and relatively weak. It has been necessary to make hosiery from silk in the gum to the end that the silk gum may protect the filaments until the stocking is ready to be dyed. It has also been the custom to twist the silk filaments together to protect them during processing and use. Twisting imparts to the silk filaments a greater snag resistance; it produces a sheerer stocking; and it modifies the luster of the silk yarn. To impart mechanical elasticity it has been the custom to twist silk further; and since twisting results in a poorly balanced yarn resort has been made to doubling such twisted yarns to produce a balanced thread. Substantially the same procedure has been followed with rayon and other synthetic yarns, although these yarns have found little use in sheer full-fashioned ladies' hosiery. In the production of sheer, knit stockings from yarns comprised of artificial filaments, it has been considered essential, heretofore, to use multifilament yarns in order to obtain the necessary flexibility and softness. Consequently, since hosiery yarns comprised of artificial filaments have always been multifilament yarns, it has been the practice to twist such yarns to accomplish the same general results as for silk yarns.

Prior to the present invention, therefore, all sheer, knit hosiery, and similar sheer, knit structures have been constructed from multifilament, twisted yarn. In spite of the twisting, the strength of the yarn is still a function of the strength of the filaments; and since these are in themselves fine and delicate, the individual filaments are easily broken and produce an undesirable fuzzy appearance. As one or more filaments in a yarn become broken, additional strain is placed on the remaining filaments and quite frequently these, in turn, become broken result-

ing in the failure of the yarn, thus causing runs in the stockings. Not only is such previously known hosiery highly susceptible to damage as stated, but these susceptibilities also exist in the course of producing the hosiery with the result that the finished article is expensive by reason of the number of units of the article discarded as inferior.

There has been a long established wish on the part of the public for more durable, sheer hosiery; and in spite of very persistent study of the problem, it has not been solved.

Contrary to all prior art operation and practice, it has now been discovered that sheer, knit hose, and similar sheer, knit goods can be constructed of mono-fils, which knit goods will have a flexibility, softness and elasticity that for all practical purposes and usage is hardly distinguishable from previously known multifilament sheer, knit goods of equal strength and durability. The sheerness and durability of mono-fil sheer, knit goods exceed that of multifilament sheer, knit goods.

It is therefore an object of the present invention to produce new and improved sheer, knit articles and fabrics, such as sheer, knit hose and hosiery fabrics, from artificial mono-fils, which articles and fabrics have great sheerness, strength, elasticity, exceptional durability, and very satisfactory flexibility, softness, and appearance.

It is the specific object of the present invention to produce new and improved sheer, knit articles and fabrics, such as sheer, knit hose and hosiery fabrics from artificial mono-fils of synthetic linear polyamides, which articles and fabrics have great sheerness, strength, elasticity, exceptional durability, and very satisfactory flexibility, softness, and appearance.

Other objects of the invention will appear hereinafter.

In its broad aspects, the objects of the invention may be accomplished by knitting sheer stockings, and similar articles and fabrics from mono-fils, which have the proper characteristics of denier, tenacity, modulus of elasticity, and

Tenacity
Modulus of elasticity

as hereinafter more fully described.

The more specific objects of the invention may best be accomplished by knitting sheer stockings and similar articles and fabrics from mono-fils of synthetic linear polyamides which have the

proper characteristics of denier, tenacity, modulus of elasticity, and

Tenacity
Modulus of elasticity

as hereinafter described.

The details of construction of the sheer knit structure of the present invention will be more clearly apparent by reference to the following description taken in connection with the accompanying illustrations in which:

Figure 1 is a side-elevational view showing generally the construction of ladies' sheer knit hosiery.

Figure 2 is a magnified view of a small section of a sheer knit structure knitted from single filaments, or mono-fils.

Figure 3 is a very highly magnified view of a small section of a sheer knit structure knitted in the conventional construction from a multifilament yarn.

Referring to the drawing, reference numeral 10 designates a sheer knit ladies' stocking. Numeral 11 designates a mono-fil, i. e., a single filament, knitted to form a sheer knit structure. Numeral 12 designates the previously known, conventional form of multifilament yarn in a sheer knit construction. The individual fine filaments 13 are twisted to form a highly twisted thread. Three of the highly twisted threads are then twisted together to form the three-thread yarn 12 as illustrated in Figure 3.

The following examples are illustrative of specific methods for the production of sheer, knit stockings from mono-fils in accordance with the present invention. The invention is, of course, not to be limited by the specific details of these examples.

Example I

Polyhexamethylene adipamide was spun from melt in a manner known to the art to produce mono-fils of 60 denier. These mono-fils were cold drawn approximately 400% (ratio drawn; undrawn 4:1) to produce an oriented mono-fil of 15 denier. The mono-fil had a dry tenacity at 75° F. and a relative humidity of 85% of 4.8 grams per denier, a residual elongation of 34%, a modulus of elasticity of 0.25 gram per denier for a 1% stretch, and a

Tenacity
Modulus of elasticity

factor of 19.2. This mono-fil was knit into a 45-gauge full-fashioned stocking fabric, looped and seamed. The stocking was pre-set by a pre-boarding process such as is described in United States Letters Patent No. 2,157,119, dyed in a conventional manner, and finally reboarded to finish the stocking.

Example II

A 17-denier drawn mono-fil with a dry tenacity at 75° F. and a relative humidity of 65% of 4.8 grams per denier, a residual elongation of 34%, a modulus of elasticity of 0.25 gram per denier for a 1% stretch, and a

Tenacity
Modulus of elasticity

factor of 19.2, prepared from polyhexamethylene adipamide as in Example I, was knit into a 45-gauge seamless stocking. The stocking was pre-set by a pre-boarding process, dyed, and finally reboarded.

The stockings of the examples had a surpris-

ingly good hand and softness, were quite sheer, presented a good appearance, and were very snag resistant. They had good elastic properties, high wet strength, great resistance to the action of water, great heat resistance, and good recovery after deformation while wet or dry because of the ability of the fabric to be set by steam treatment.

Stockings produced in accordance with the examples given above were more sheer than stockings knit from 15 denier or 17 denier multifilament yarns, respectively; for the compact structure of the mono-fil produces a more sheer appearing fabric than does a multifil of the same denier.

These stockings, furthermore, even though they were constructed of mono-fils of only 15 or 17 denier, had a snag resistance as great or greater than that of a stocking knit in a similar manner from a 30 denier multifilament yarn. Furthermore, it was found that when a filament did break, it was more difficult for a run to start. The great strength of the synthetic polyamide mono-fil is such that when it is snagged, the mono-fil is pulled out to such an extent as to cause a tightening of the stitches around the pulled mono-fil before breakage of the mono-fil occurs. This prevents the loose ends from slipping back and permitting a run to occur. This is especially true of synthetic polyamide stocking fabrics which have been pre-set in accordance with the method described in United States Letters Patent No. 2,157,119. By such a process, the stocking is pre-set by subjecting it to a hot, wet treatment to set the polyamide filaments in the desired shape and loop arrangement preferably by fitting the stocking on a boarding form and treating it with steam. This procedure introduces a set into the multifilament yarn, or, in accordance with the present invention in the mono-fil, which is permanent for all practical purposes, for the usual processes of dyeing, laundering, etc., do not remove the set.

Stockings produced in accordance with the examples present a good appearance. They have good clinging quality and very good elastic properties, especially in view of the fact that the mono-fil is not twisted. But, most surprising of all, these stockings have a remarkably soft hand. One would expect that a stocking made from mono-fils would be very stiff, for mono-fils have been used heretofore for purposes requiring stiffness; e. g., in the manufacture of toothbrush bristles, paint brush bristles, and bristles for other types of brushes. Despite this generally recognized, inherent characteristic of mono-fils, the mono-fil sheer stocking fabrics of the examples have a surprisingly desirable soft hand, great snag resistance, and exceeding sheerness.

Although in the above examples, the stocking fabrics were made of mono-fils of 15 and 17 denier, it is to be understood that use may be made of mono-fils of other denier values, preferably within the limits of 5 to 30 denier, and particularly good results are obtained with mono-fils of denier values between 10 and 20.

The examples disclose the use of mono-fils having a dry tenacity at 75° F. and 65% R. H. of 4.8 grams per denier. However, it is to be understood that yarns of other tenacities may be used, preferably those having a dry tenacity at 75° F. and 65% R. H. of at least 2 grams per denier, and particularly good results are obtained with yarns having a similar tenacity of at least 4 grams per denier. Throughout the specification

reference to "tenacity" means dry tenacity at 75° F. and 65° R. H.

The modulus of elasticity of the mono-fils described in the examples was stated to be 0.25 gram per denier for 1% stretch. Although modulus of elasticity is usually expressed in terms of pounds per square inch or kilograms per square centimeter required to produce unit elongation, it has been found to be more convenient, when referring to yarns, to define modulus of elasticity as the number of grams per denier required to stretch the yarn 1% in length. It is to be understood that use may be made of mono-fils having other values for the modulus of elasticity than that used in the examples, preferably not to exceed 0.6 gram per denier for 1% stretch. For example, excellent hose can be prepared from mono-fils spun from aminocaproic acid polymer having a modulus of elasticity of about 0.2 gram per denier for 1% stretch. Good hose can be prepared from mono-fils spun from polydecamethylene sebacamide (modulus of elasticity about 0.3 gram per denier for 1% stretch), or from the polymer derived from para-beta-amino-diethyl amino-benzene and sebacic acid (modulus of elasticity about 0.4 gram per denier for 1% stretch), or from the interpolymer prepared by conjointly polymerizing vinyl chloride and vinyl acetate in such a manner as to produce a polymer containing 87% of the chloride (modulus of elasticity about 0.4 gram per denier for 1% stretch). On the other hand, mono-fils spun from a blend of polyhexamethylene adipamide and 10% para-tertiary butyl phenol formaldehyde resin (a composition more particularly described in copending application Serial No. 309,898, filed December 18, 1939, in the name of Vaala) are somewhat stiffer (modulus of elasticity about 0.5 gram per denier for 1% stretch) and should be spun in finer deniers and are less satisfactory for mono-fil hose. The best results are obtained with filamentary materials having moduli of elasticity not greater than 0.30 gram per denier for 1% stretch. The determinations of values for modulus of elasticity, as used in this specification, should be made at 50° R. H. and 75° F. using a dynamometer of the type manufactured by Ste. Amedes Etablissements Jules Richard, 25 Rue Melingue, Paris, France, with a rate of loading of 3.7 grams per minute per denier.

As above indicated, mono-fils suitable for use in the production of sheer knit goods should have a tenacity of at least 2 grams per denier, a denier of between 5 and 30, and a modulus of elasticity not to exceed 0.6 gram per denier for 1% stretch. The

Tenacity Modulus of elasticity

factor of a mono-fil is of further great importance. In order to obtain sheer knit goods of great sheerness, strength, elasticity, and durability, and exhibiting very desirable flexibility, softness, and appearance by the use of mono-fils, the latter should have a

Tenacity Modulus of elasticity

factor of at least 6, and, to secure the most desirable results, the factor should preferably be at least 10.

In the examples, the invention has been illustrated by the use of mono-fils of polyhexamethylene adipamide. Mono-fils of other syn-

thetic linear polyamides can be used equally as well in accordance with this invention if they possess the proper characteristics of denier, tenacity, modulus of elasticity and

Tenacity Modulus of elasticity

Although mono-fils prepared from synthetic linear polyamides are preferred, mono-fils of synthetic linear polyesters, synthetic linear polyethers, synthetic linear polyacetals, synthetic linear vinyl polymers, interpolymers of vinyl chloride and vinyl acetate, interpolymers of unsymmetrical dichloroethylene; e. g., with vinyl esters, acrylic and methacrylic acid esters, and styrene, and other types of synthetic linear polymers and interpolymers may also be used for the production of desirable sheer knit goods. It is also within the scope of this invention to prepare sheer stockings and similar sheer knit goods from mono-fils composed of any filament-forming composition so long as the mono-fils have a denier of between 5 and 30, a strength of at least 2 grams per denier, a modulus of elasticity not to exceed 0.6 gram per denier for 1% stretch and a

Tenacity Modulus of elasticity

factor of at least 6.

When using synthetic linear polyamide mono-fils, the mono-fils may be drawn to whatever extent, is desired within the possible limits of drawing of the mono-fils, although they are preferably drawn between 150% (1.5:1 ratio of drawn to undrawn yarn) and 500% (5:1 ratio).

In the examples, no step of sizing the mono-fils was referred to. It is preferred not to size the mono-fils, but it is to be understood that a size or finish may be applied to the mono-fils if desired.

Either wet or dry mono-fils may be used in the preparation of the stockings of this invention. Wet knitting of unsized yarn gives a more desirable stocking fabric, for it prevents a distortion of the stitches sometimes known as "laci-ness."

The setting of the synthetic linear polyamide stockings of this invention, though preferably accomplished in accordance with the method described in United States Letters Patent No. 2,157,119, may be accomplished in other ways; e. g., hanging the stockings in a container and exposing them to steam. However, the invention is not limited to stockings or other sheer knit fabrics that have been set.

Sheer knit stockings, or similar sheer knit goods, need not be knitted entirely from mono-fils. It is also within the scope of this invention to use other types of fibers and yarns; e. g., silk, viscose rayon, cellulose acetate rayon, cotton, etc., in combination with the mono-fils of this invention. For example, a stocking may be knitted from mono-fils of a synthetic linear polyamide in the heel and toe and silk in the foot and leg. Or a stocking may be knitted from synthetic linear polyamide mono-fils in the foot and leg and cotton in the heel and toe. Or, a stocking may be knitted from synthetic linear polyamide mono-fils in the foot and leg, silk in the welt, and cotton in the heel and toe. It is also within the scope of this invention to use synthetic linear polyamide mono-fils in one part of the stocking and multi-fil yarns of synthetic linear polyamides or other materials in other parts of the stocking. Also a stocking may be prepared from mono-fils

by knitting several mono-fils in parallel without twisting; such a stocking is less desirable because it is less sheer than the above-described mono-fil stockings. Stockings containing mono-fils in any part thereof lie within the scope of this invention.

The mono-fils used in accordance with this invention may contain modifying agents, such as luster-modifying agents, plasticizers, pigments and dyes, antioxidants, resins, etc.

Inasmuch as mono-fils of the character hereinabove described are suitable for the production of desirable sheer knit structures, they will, of course, be suitable for the production of many soft, flexible woven goods in the production of which only multifilament yarns have heretofore been used.

In view of the surprisingly good elasticity, strength, durability, snag resistance, run resistance, flexibility, softness of hand, and good appearance of the monofilament sheer, knit stockings, and similar sheer, knit goods of this invention, it is apparent that an important step forward has been made in this art. There is less wastage of yarn caused by the breaking of filaments, for a fairly large mono-fil does not snag so easily as do the numerous small filaments (smaller than the mono-fil) of a multifilament yarn. Furthermore, since mono-fils do not require twisting and sizing as do multifilament yarns, a considerable saving in the cost of production of sheer hosiery and other sheer knit goods results from this invention.

The present invention furnishes to the consumer a hosiery product which is substantially better in strength, durability, snag resistance, run resistance, and sheerness than any sheer hosiery made from multifilament yarns available at the present time. These results are accomplished with a yarn of lower denier than yarns at present being used for stockings. While this new type of stocking embodies the above-described improvements, it also has surprisingly good elasticity, flexibility, softness of hand, and appearance.

As it is evident 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 to the details set forth, except as set forth in the appended claims.

I claim:

1. A sheer, knit structure comprising knit loops which consist of mono-fils having a denier of between 5 and 30, a tenacity of at least 2 grams per denier, a modulus of elasticity not to exceed 0.6, and a

Tenacity
Modulus of elasticity

factor of at least 6.

2. A sheer, knit structure comprising knit loops which consist of synthetic linear polyamide mono-fils having a denier of between 5 and 30, a tenacity of at least 4 grams per denier, a modulus of elasticity not to exceed 0.3, and a

Tenacity
Modulus of elasticity

factor of at least 10.

3. A sheer, knit stocking comprising knit loops which consist of mono-fils having a denier of between 5 and 30, a tenacity of at least 2 grams per denier, a modulus of elasticity not to exceed 0.6, and a

Tenacity
Modulus of elasticity

factor of at least 6.

4. A sheer, knit stocking comprising knit loops which consist of synthetic linear polyamide mono-fils having a denier of between 5 and 30, a tenacity of at least 4 grams per denier, a modulus of elasticity not to exceed 0.3, and a

Tenacity
Modulus of elasticity

factor of at least 10.

5. A permanently set, sheer, knit stocking comprising knit loops which consist of synthetic linear polyamide mono-fils having a denier of between 5 and 30, a tenacity of at least 4 grams per denier, a modulus of elasticity not to exceed 0.3 and a

Tenacity
Modulus of elasticity

factor of at least 10.

6. A sheer, knit stocking comprising knit loops which consist of mono-fils of polyhexamethylene adipamide, said mono-fils having a denier of between 5 and 30, a tenacity of at least 4 grams per denier, a modulus of elasticity not to exceed 0.3, and a

Tenacity
Modulus of elasticity

factor of at least 10.

7. A permanently set, sheer, knit stocking comprising knit loops which consist of mono-fils of polyheamethylene adipamide, said mono-fils having a denier of between 5 and 30, a tenacity of at least 4 grams per denier, a modulus of elasticity not to exceed 0.3, and a

Tenacity
Modulus of elasticity

factor of at least 10.

ROBERT ARTHUR CLAWSON.