April 3, 1962 S. J. GOLUB 3,028,109

METHOD OF MAKING SELF-SUPPORTING RAW SILK PACKAGE

Original Filed April 7, 1959

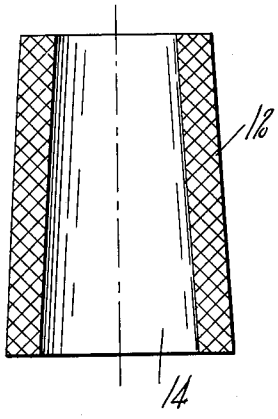


Fig. 1.

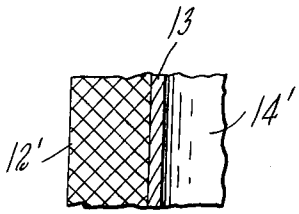


Fig. 4.

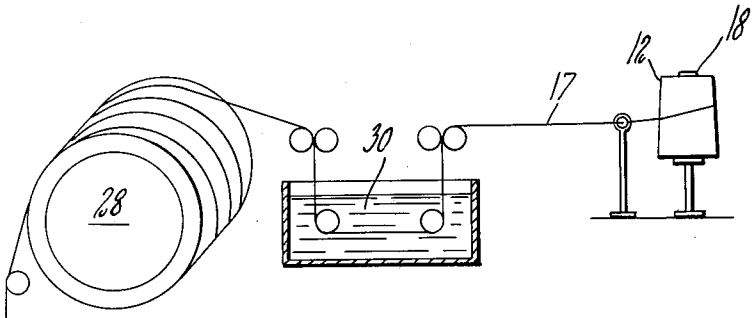
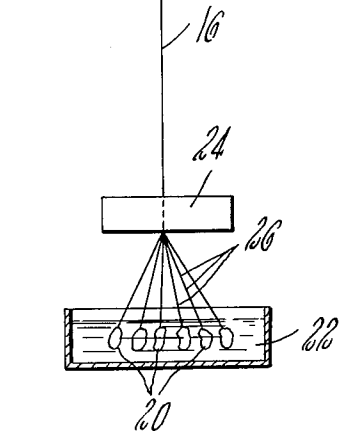


Fig. 2.



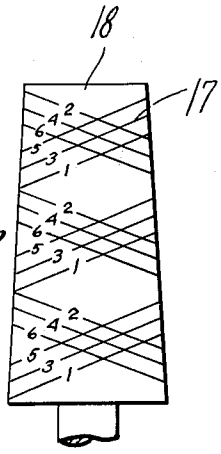


Fig. 3.

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METHOD OF MAKING SELF-SUPPORTING RAW SILK PACKAGE

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2 Claims. (Cl. 242—18)

This invention relates to a novel method of making a self-supporting raw silk package and is a division of my co-pending application Serial No. 804,726, filed April 7, 1959, now abandoned.

For many years, raw silk has been packaged by reeling a continuous multiple filament simultaneously from a number, conventionally at least 10, of suitably treated cultivated silkworm cocoons (*Bombyx mori*) to form a free limp skein of raw silk in the form of parallel adjoining multiple filaments. Such a skein is extremely difficult to handle in further necessary processing. Not only does it tend to snarl readily, but it also tends to snag and break because of the accumulation of so-called "gum-spots" binding a number of adjacent parallel coils of the multiple raw silk filament to one another so that they cannot readily be unwound from one another. Often, skeins must be soaked in a special solution to soften the "gum spots" so as to permit unwinding. As a result, the process of unwinding from the conventional skein is a slow and tedious operation, and one requiring great skill on the part of the operator.

Furthermore, the use of skeins as the beginning package in the process of preparing silk threads or the like which can be knitted or woven into cloth has other disadvantages. In the first place, because of the nature of such a skein and the inevitable gum spots thereon, the multiple filament thereof is subject to filament breakage. Such breaks must be repaired by tying filaments together, and the knots so formed cause trouble at later stages of the operation. Even if the skein does not break, its relatively short length is a serious limitation, since it cannot be wound up into a package of large size and free of knots. Thus, because of the necessity of utilizing skeins as the original package, it has been impossible to provide large packages of knot-free raw silk filament. This in turn has been a serious economic detriment to the silk industry, since the inability to provide large packages unwindable at high speed has made it impossible to utilize large package high speed spinning and twisting machinery such as is employed in the cotton and synthetic fiber industries.

Conventionally, then, because of these and other difficulties in handling skeined silk, the process of transferring skeined silk onto a package suitable for use on high speed yarn making machinery is carried on in special factories (with trained personnel) known as silk throwing factories, and the cost of this process approximates one-third of the total manufacturing cost of converting skeined raw silk into silk yarn.

Accordingly, it is an object of the invention to provide a method of making a self-supporting novel raw silk package which may be of any desired size and may be the original package on which the multiple raw silk is wound directly from the cocoon.

It is another object of the invention to provide a novel method of making a self-supporting raw silk package in which the coils thereof are cohesively attached to a controlled degree to one another.

It is yet another object of the invention to provide a novel method of making a raw silk package having a hard rigid hollow inner portion composed entirely of integrated raw silk.

It is a further object of the invention to provide novel methods for continuously treating raw silk, especially in multi-filament form.

In order to accomplish this novel result, advantage is taken of the natural sericin or silk gum coating present on the raw silk as it comes from the cocoon. By so doing, packages composed entirely of multi-filament raw silk, and having any desired length of such silk thereon entirely free from knots may be readily prepared. This is because knotless multiple filament is readily produced from an assembly of treated cocoons. For example, if one cocoon double strand breaks or runs out, another double strand may readily be cemented thereto by the sericin present, and without affecting the other double strands which make up the multiple filament of the raw silk of commerce.

Accordingly, by treating the sericin present on the multi-filament raw silk as it comes from the cocoons to contol its degree of plasticization, the invention may provide a self-supporting package having a carefully controlled cohesiveness between coils of the multiple raw silk filament to produce a rigid package providing resistance to unwinding of the multiple filament from such package substantially less than the tensile strength of the filament so that breakage is avoided during unwinding operations even with continuously operating high speed machines. This has been done not only by controlling the plasticization of the sericin, but also by winding the package of the invention to space parallel coil portions from one another and to provide substantial crossing angles of contacting adjacent coils of multiple filament so that said coils throughout the package are prevented from lying parallel and adjacent to one another. The minute cohesive areas so provided at crossing junctions are entirely adequate to provide a unique coreless self-supporting package composed solely of raw silk, yet they are easily successively destroyed during the unwinding process. Thus, it is apparent that the unique packages and methods of the invention for the first time permit significant increases in the speed and economy of handling raw silk, as well as greatly increased lengths thereof so that for the first time, handling on modern equipment becomes possible. The packages of the invention can be used directly on high speed silk throwing machinery, thus greatly reducing throwing costs.

Alternatively, if the sericin be originally plasticized to a higher degree while the initial layers are being wound on the package, a solid integrated unwindable rigid hollow inner portion may be provided, with layers thereafter wound thereon having a lesser degree of plasticization so that a self-supporting package having readily unwound coils of raw silk on a solid unwindable raw silk inner portion may be provided.

The methods of the invention are preferably carried out by continuously and successively treating the continuous multiple raw silk filament to produce a uniform degree of plasticization of the sericin thereon followed by immediately winding the so-treated sericin into a package. This may best be accomplished by treating a substantially dry multiple raw silk filament as by passing it through a hot water bath for a predetermined time to plasticize the outer layers of sericin on the filament and then directly and promptly winding said plasticized filament into a helically coiled package. The package may thereafter be dried to a further extent, although the winding process itself will tend to dry the treated filament to a substantial degree. It is also contemplated that a separate plasticization step may not be needed, but that the degree of plasticization of the sericin may be controlled by partial drying to a desired degree upon removal of the raw silk directly from the treated cocoons. In either case, the treatment of the invention, particularly if the

subsequent water bath treatment be used, causes integralization of the multiple raw silk filament by uniform distribution and plasticization of the natural sericin thereof, so that a better integrated, more uniform multiple filament entirely free of gum spots is provided.

For the purpose of more fully explaining the preferred products and processes of the invention, reference is now made to the following drawings, wherein:

FIG. 1 is a cross-sectional view of a novel raw silk package of the invention;

FIG. 2 is a diagrammatic view of a process for manufacturing the package of FIG. 1 according to the present invention;

FIG. 3 is a view of an arbor partially wound in the manufacture of a raw silk package according to the invention; and

FIG. 4 is an enlarged cross-sectional view of a novel raw silk package of the invention modified from that of FIG. 1.

Raw silk, used to make up the novel self-supporting package of the present invention, is the fiber from the cocoon spun by the larvae of the mulberry silk worm (*Bombyx mori*). In spinning the cocoon the worm secretes a viscous fluid, the fibroin from two tube-like glands in its body. The two tubes join into a common exit in the head of the worm, over and around which another secretion from another portion of the same glands flows, the sericin or silk gum, which cements the two fibroin filaments together. Unpierced cultivated cocoons yield from 400 to 700 yards of usable silk, which is commercially obtained by combining a number of double filaments from suitably treated individual cocoons to produce a continuous multiple untwisted filament, the raw silk of commerce. (See, for example, "The Textile Fiber Atlas" [1942], plate XIII.)

The sericin or silk gum present on the surface of the raw silk filament and cementing the double filaments together as well as sticking the entire group of double filaments to one another amounts to 18–27 percent of the total fiber weight. It is readily plasticized to a flowable condition, usually as a result of cocoon treatment to permit unwinding and is responsible for so-called "gum spots" in skeins under certain conditions. It can be and is conventionally removed from the silk filament at a later processing stage but it is necessary that it be retained on the multiple raw silk filament until a number of such multiple filaments have been twisted together to provide a thread of sufficient strength to maintain its integrity after removal of the sericin. The continuous multiple raw silk filament of commerce is substantially untwisted and maintains its integrity mainly because of the sericin which sticks the filaments together.

According to the present invention, the continuous multiple raw silk filament of commerce may be wound to produce a hollow, tubular, rigid, self-supporting package **12** having an axial bore **14** (FIG. 1) and composed solely of raw silk by uniquely utilizing the properties of the natural sericin thereon to cohesively bind together the coils of multiple filament making up the package as well as to more uniformly bind together the double filaments making up the multiple filament itself and so integralize it. Preferably, in order best to accomplish this result, the integralized filament is helically wound about an axial center with its parallel surface portions of adjacent coils spaced from one another to avoid contact and its contacting surface portions of adjacent coils at a substantial crossing angle. This is because undesirable intercoil sticking or cohesive bonding requires parallel juxtaposition for at least about $\frac{1}{16}$" so that crossed coils produce such a small sticking point that the coils can be readily separated with no danger of breaking the multiple raw silk filament upon unwinding. This may be accomplished by helically winding to produce an open wind, such as is illustrated in FIG. 3, wherein six initial turns of a continuous multiple raw silk filament **17** are shown wound on a suitable arbor **18**. In such figure each successive three turn helix of filament is numbered from 1 . . . 6 inclusive. It will be seen that each of the generally parallel coil portions 1, 3, 5 and 2, 4, 6 are spaced from one another and each of the contacting filament portions are disposed at a substantial crossing angle. With the coils of the filament so disposed and cohesively bonded to one another at their crossings, the unique package of the invention is normally self-supporting yet readily unwound with the cohesively bonded coils of multiple raw silk filament providing a resistance to unwinding and sloughing by axial movement of the coils relatively to one another.

A continuous process for manufacturing the above described package is best shown in FIG. 2, in which figure, the silkworm cocoons **20** in a suitable treating solution **22** are unwound by conventional means **24**, either manually or automatically, into double filaments **26** which are combined into a multiple raw silk filament **16**. The multiple raw silk filament is then preferably dried to harden the sericin thereon by passing it for one or more turns around a heated drying drum **28**. Alternatively, already dried skeins of multiple raw silk filament may be used. Thereafter, the multiple raw silk filament is treated according to the invention to integralize it by treating the sericin to plasticize it to a predetermined degree by passing the raw silk multiple filament continuously and sequentially through a hot water bath **30** for a limited time. This serves to redistribute the sericin to provide a move uniform multiple raw silk filament as well as to plasticize the sericin thereof. The so integralized sericin raw silk filament **17**, preferably still plasticized, is then helically wound on an arbor **18** to produce the package **12** of the invention.

As pointed out above, further drying of the sericin of the multiple raw silk filament will take place sequentially after the filament passes from the water bath **30** until it is wound up onto its own coils, so that the degree of drying so provided must be taken into account determining the effective degree of sericin plasticization. Thus, if the preferred self-supporting package of the invention is to be provided, the sericin plasticized filament at the point of its winding up should be at a state best described as tacky, rather than flowable as may be its condition in the hot water bath for best redistribution to provide the uniform integralized multiple raw silk filament characteristic of the invention. A flowable condition of the sericin-plasticized filament at the point of its winding up will result in the coils of raw silk multiple filament sticking together to provide an unwindable body. This may be desirable in the initial winding stages in order to provide a rigid inner portion **13** as is shown in FIG. 4, with the coils of multiple raw silk filament thereafter wound being plasticized to a lesser degree, preferably to the tacky stage wherein slight inter-coil cohesiveness is provided.

Any of a number of suitable winding machines well known to the art may be used to provide the desired winding pattern.

The conditions of sericin plasticization and winding are critical in order to produce the desired degree of tackiness in order to wind the cohesively bonded self-supporting package of the invention. Thus, it has been found that for the preferred degree of sericin plasticization beginning with a multiple raw silk filament with the sericin thereof completely dried, the water bath **30** should be at a temperature of about 180° F. to 210° F. with the filament remaining in said bath for about 0.10 to 0.01 second, although lower water temperatures, even room temperature with longer immersion times can be used. The filament is then immediately wound up, say within a few seconds, so that it does not become overdried beyond the desired tack point necessary to produce the preferred self-supporting package of the invention. The conditions of plasticization of the sericin may be altered so that higher or lower bath temperatures may be used, or longer or

shorter immersion times, by the use of suitable chemicals in the bath. Thus, for example, formalin or various metal salts reduce the stickiness o. sericin, allowing the use of higher temperatures or longer immersion periods, and alcohols or other sericin solvents or plasticizers may enhance sericin stickiness and permit shorter immersion periods or lower bath temperatures. Low winding tensions are preferably utilized because of the high degree of shrinkage of the wet silk filament, preferably of the order of about 2 to no more than about 10 grams, more preferably 5 grams. Winder bail pressures are less important, but should be low in terms of bail pressure adjustments on conventional winding machines.

With higher temperatures of water bath **30**, say boiling water at 212° F,. and somewhat longer treatment times of the multiple raw silk filament therein, usually upwards of 0.10 second, the sericin may be plasticized to a flowable condition to produce the solid inner portion **13** of FIGURE 4. With the so plasticized filament wound up immediately while its sericin remains in flowable condition, a strong rigid inner portion **13** which cannot be unwound will be produced about a central bore **14'**. After the solid inner portion **13** is wound to a desired degree, say ⅛ inch thick for a typical package of about 3 to 5 inch diameter with a 1½ to 3 inch axial bore and 3 to 6 inch length, the oncoming filament may be removed from its boiling water bath to reduce the degree of sericin plasticization so that further coils wound thereon may be unwound therefrom, although a degree of treatment thereof is still desirable to provide the integralized filament characteristic of the invention as well as a small degree of cohesiveness. This can be accomplished by providing an auxiliary water bath operating at a lower temperature.

Thus it will be seen that the invention provides novel self-supporting raw silk packages composed solely of multiple raw silk filament, as well as novel methods of manufacturing same and producing an improved raw silk filament by means of integralization. Various modifications of the invention will be apparent to those skilled in this art. As to the package, for example, it is contemplated that only portions thereof may be cohered according to the invention, preferably either the inside or outside portions thereof, or both. As to the process, the plasticization of the sericin may be achieved in various ways other than specifically set forth herein, as for example, by application of direct steam, or treatment in an autoclave, by use of a water spray or mist instead of a bath, or by alternate means which plasticize the sericin by processes of water and/or chemical absorption or reaction. Also, the sericin may be plasticized to the desired degree other than as explained above, for example, it is contemplated that the assembled multiple raw silk filament may be but partially dried after unwinding from the cocoons so that the desired degree of tackiness of the sericin is achieved to permit winding of the raw silk package of the invention.

I claim:

1. A method of making a self-supporting raw silk package comprising plasticizing the natural sericin of said silk to a predetermined degree of tackiness by passing the raw silk through a heated water bath, winding said plasticized sericin raw silk on a supporting core to form a coiled cross-wound package wherein the cross-wound coils are at a substantial angle, said coils being cohesively bonded together at said crossings, drying the coiled cross-wound package and removing the package from the core.

2. A method as claimed in claim 1 wherein said water bath is at a temperature of about 180–210° F. with said silk remaining in said bath for about 0.10 to 0.01 second.

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