April 9, 1957 L. J. RENAUD 2,788,023

TEXTILE FABRICS

Filed June 12, 1953

Fig. 1

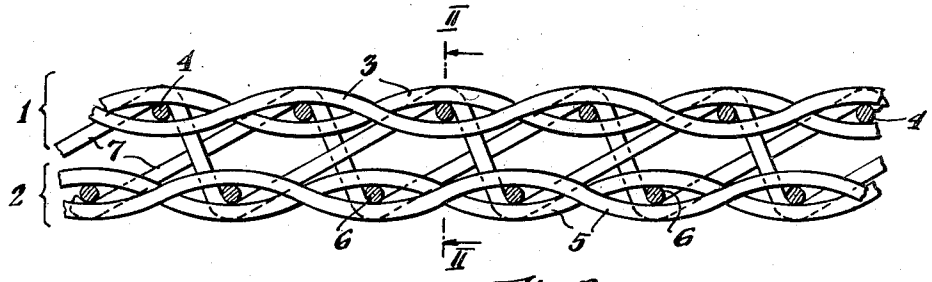


Fig. 2

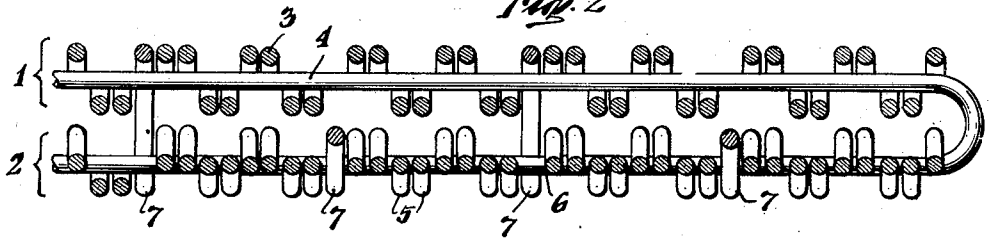


Fig. 3

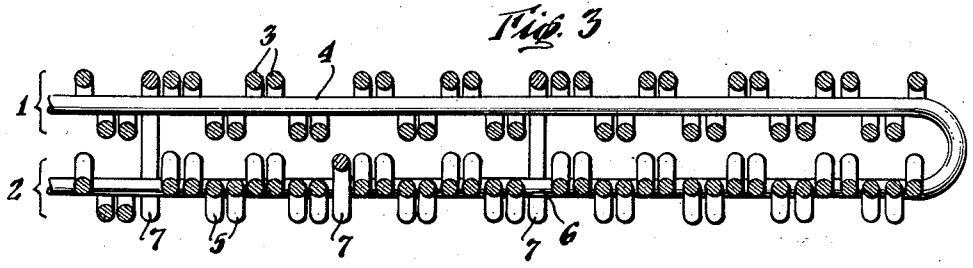


Fig. 4

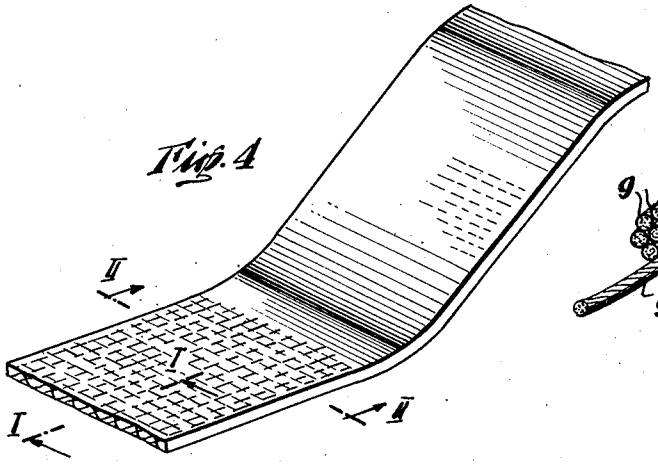
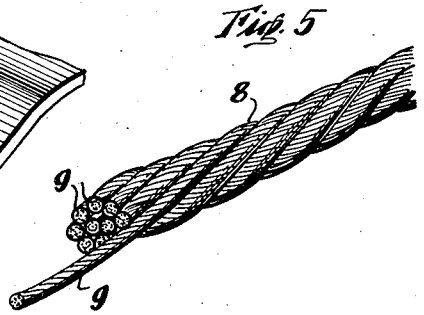


Fig. 5



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TEXTILE FABRICS

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Application June 12, 1953, Serial No. 361,290

1 Claim. (Cl. 139—410)

This application is a continuation-in-part of my co-pending application Serial No. 322,501, filed November 25, 1952, now abandoned.

The present invention relates to woven fabrics and particularly to fabrics woven from continuous artificially polymerized synthetic filaments and intended for use where they may be subject to repeated abrasion.

The invention will be described herein as applied to nylon webbing for a parachute harness. It will be readily understood by those skilled in the art that the invention is applicable to fabrics intended for different purposes which involve similar conditions of use. Also, it has been found that the invention is applicable to other continuous artificially polymerized synthetic fibers.

The natural fibers commonly used in weaving have a short individual length or staple, usually less than one inch. In order to form such short fibers into a continuous thread, they are twisted together by spinning, which is one of the oldest arts known to man. The twisting or spinning of the fibers together holds them frictionally so that they cannot move lengthwise with respect to each other, and forms them into a continuous thread.

Artifically polymerized synthetic fibers such as nylon and the like are formed as continuous filaments. Since the filaments are continuous, there is no need to spin or twist bundles of such filaments tightly together in order to form a continuous thread. However, it is commonly desired to make a thread from a multiplicity of such filaments. For that purpose, it is usual to give each thread formed from a continuous filament yarn a slight twist, sometimes termed a "twist of convenience," just enough to hold the filaments of that thread together laterally for convenience in handling. In some cases, where threads may be subjected to unusually rough handling, e. g., sewing threads, it has also been proposed to use somewhat higher twists to keep the thread components from separating laterally. It has been proposed, in situations where special ornamental effects are desired, to twist continuous filament yarns in preparing threads for weaving. An example of such a twist is found in the very high twist used to produce the kinking of the threads which is characteristic of crepe fabrics.

It has been found that woven fabrics of nylon and other continuous artificially polymerized synthetic fibers are weakened when subjected to severe abrasion, if such fibers are formed into threads and woven by conventional methods. This weakening is usually accompanied, at least according to my observation, by the formation of loops in the surface filaments, which loops project above the normal surface of the fabric, giving it a fuzzy appearance.

It is also now believed that each such loop is attended by a lengthwise sliding movement of a part of the fiber of which it is formed. This apparent lengthwise sliding movement may be accompanied either by a breaking of the looped filament at some point spaced from the loop or by a stretching or drawing of the looped filament, or by a tightening of another part of the looped filament relative to other filaments of the thread.

In order to improve the abrasion resisting qualities of nylon webbing, it has been proposed to treat the webbing with a suitable binder material, usually a resinous compound, for example, polyvinyl butyral. The binder holds the filaments of each thread together so that they cannot move lengthwise relative to one another and thereby prevents the formation of loops when the surface of the fabric is abraded. Although some of the filaments may be broken by the abrasion, they cannot pull lengthwise because of the action of the binder material, and the break decreases the strength of the thread only in the immediate neighborhood of the break. The strength of the thread at points spaced from the break is not affected, since all the filaments of the thread at such points are held against relative movement by the binder material, and act together as a single body.

The use of such binder material increases the stiffness of the fabric and the stiffness increases with decreasing temperature. In the case of parachute harness, which must sometimes be used at very low temperatures, the webbing fabric may become quite rigid, so that it impedes the movements of the wearer and its edges tend to cut the wearer.

It is therefore an object of the present invention to provide an improved fabric which is resistant to abrasion. A further object is to provide such a fabric in which the improved abrasion resistance is secured without substantially increasing the stiffness of the material.

The foregoing and other objects of the invention are secured, in the fabric described in detail herein by way of example, by giving nylon threads a substantial amount of twist before weaving them into the fabric. For a 210 denier nylon thread, a twist of at least eight turns per inch is required, and it is preferred to use from eighteen to twenty turns per inch. It has been found that fabrics woven from threads so twisted have a very high resistance to abrasion, even though the abrasion may be repeated continuously for a long period. The twisting of the threads holds the continuous filaments tightly together, in the same manner that short staple fibers are held tightly together by spinning. The individual filaments, even when broken, are unable to slide lengthwise with respect to one another. No loops can form, either due to breaking or stretching, and the abrasion resistance of the fabric is substantially improved. Even though individual filaments may be broken during the abrasion, there is no accompanying formation of loops, and the filaments of each thread continue to act as a single body rather than as separate filaments. Even after considerable abrasion, the fabric retains substantially its original appearance and strength. This improvement in the abrasion resisting characteristics of the material is attained without substantially increasing the stiffness of the fabric.

Other objects and advantages of the invention will become apparent from the consideration of the following specification, taken in connection with the accompanying drawings, in which:

Fig. 1 is a fragmentary, expanded, longitudinal sectional view, taken on the line I—I of Fig. 4, looking in the direction of the arrows, of a webbing of conventional weave in connection with which the present invention may be utilized.

Fig. 2 is a lateral, cross-sectional view taken on lines II—II of Figs. 1 and 4 looking in the direction of the arrows.

Fig. 3 is a view similar to Fig. 2 showing a form of weave modified in accordance wtih the present invention.

Fig. 4 is a perspective view, on a smaller scale, of the webbing of Figs. 1 and 2.

Fig. 5 is an enlarged view of one form of a single weaving end constructed in accordance with the invention, showing a number of individually twisted threads cabled together with a cable twist in the opposite direction.

A thread of yarn of nylon or other artificially polymerized synthetic fiber usually consists of a bundle of fine continuous filaments; in the manufacture of such yarn for weaving purposes, the extruded bundle of filaments is commonly given not more than a small twist, sometimes called a "twist of convenience," say 2 to 4 turns per linear inch, to hold the filaments together and thus constitute the bundle as an integrated thread. Sometimes there is no twist, and often a twist of less than 2 turns per inch is used. It is uncommon to have a twist substantially more than 4 turns per inch. Usually there are many fine filaments in each thread; for instance one suitable nylon thread mentioned below as having a denier (in its composite state) of 210, consisted of about 34 filaments. The number of filaments and the individual filament size may vary in various yarns and yarn sizes, it being usual to have at least 10 or 15 such filaments in even the finest threads. The twisting of the present invention contemplates substantial further twisting of the thread in addition to the original twist, conveniently and thus preferably in the same direction as the original twist, although it may be in the opposite direction. In any event the final twisted condition of the thread represents the desired tight twist, numerical values of twist herein representing the net twist which thus characterizes the thread. For example, where a commercial nylon yarn has two turns per inch as manufactured, a net twist of 18 turns per inch in the preferred range mentioned below will be achieved by twisting the yarn 16 turns more per inch, in the same direction as the twist already present. Alternatively, the same condition may be reached by twisting the yarn 20 turns per inch in the direction opposite to the original twist. As will be appreciated, the individual filaments of synthetic material, e. g. nylon, are thus twisted very tightly or firmly together, thereby being prevented from slipping longitudinally with respect to one another.

It has been found that nylon webbing is particularly desirable for use in parachute harnesses because of its high strength and light weight. It is presently common to test such webbing for abrasion resistance by repeatedly rubbing it under tension over a hexagonal or octagonal steel bar. Such a test has been found to simulate satisfactorily the abrasion conditions encountered by the webbing in actual use, which abrasion conditions are due primarily to buckles and other harness fittings.

Webbing formed of nylon twisted and woven in the conventional manner is adversely affected by continued abrasion. The abrasion reduces the strength of the fabric. This reduction in strength is accompanied by the formation in the surface threads of loops which extend above the surface of the fabric, giving it an objectionable fuzzy appearance. As explained above, these loops are accompanied by endwise slipping of individual filaments, occasioned either by breaking, stretching or tightening of those filaments.

In accordance with the present invention, an abrasion resisting nylon fabric is secured without sacrifice of its flexibility by twisting the individual threads substantially more than the twist commonly used for convenience. In a yarn of 210 denier, a twist of at least eight turns per inch is required in order to give satisfactory abrasion resistance and a twist of eighteen to twenty turns per inch is preferred. There seems to be no definite upper limit to the number of turns or twists which is acceptable, but there is no advantage to be gained in increasing the number of turns much beyond twenty-four. The twist should not of course be so high as to cause creping of the fabric.

The threads after being individually twisted may be cabled or plied together in groups for weaving purposes with a reverse "twist of convenience" in the cable, for example, of two turns per linear inch. The cabling of the thread is for convenience in the weaving operation only and is not necessary to the practice of the present invention. The cabling may alternatively be in the same direction as the twist, rather than reverse.

It is not necessary to cable or ply the threads at all, but it is desirable to reduce the number of weaving ends in that manner. If the thread is plied, the ply twist is desirably held to the minimum necessary for convenience in the weaving process. If the ply twist is too great, the surface of the thread takes on a "cord" appearance, with high peaks separated by deep valleys. With such a thread, the wear is concentrated on the filaments at the tops of the peaks. A thread with a low ply twist, on the other hand, presents a much smoother surface, and the wear and abrasion are spread more evenly among the various filaments. For a 210 denier nylon thread, the maximum practical ply twist is about 4.

The cabling or ply twisting of a number of threads together adds or subtracts the twist of the cable to each individual thread in the cable. If the cable twist is in the same direction as the individual twist, each thread is twisted an additional amount. If the cable twist is in the opposite direction, each thread is untwisted by the amount of the cable twist. Unless otherwise specified, figures for twist given in this specification refer to net twist remaining in the individual threads after cabling.

An increase in the number of twists per inch above the preferred range of 18–20 indicated above has the effect of increasing the longitudinal resilience of the thread, and hence of the fabric woven from the thread. While such longitudinal resilience is not desirable in the case of webbing for parachute harnesses, it may be acceptable, or even desirable, in the case of fabrics formed for other purposes.

The twisting of the threads may increase the stiffness of the fabric slightly but this increase in stiffness does not vary with temperature. Furthermore, the stiffness of the edges can be readily reduced, in accordance with a feature of the invention, by omitting certain binding threads from the selvages.

An alternative method of eliminating the slight additional stiffness of the fabric introduced by twisting is to give the finished fabric a heat treatment. For example, in the case of the particular fabric described in detail herein, it has been found that a heat treatment in the neighborhood of 350° F. is sufficient to produce a substantial softening of the finished product, without loss of strength or other detrimental heating effects. The particular temperature to be used in each case should be the setting temperature for that particular filament material. The fabric being treated should be maintained at that temperature for a time long enough for the temperature to penetrate throughout all the threads of the material. In the case of the specific fabric described herein, fifteen or twenty minutes is sufficient. The temperature in the example given above was measured in the air in the heat treatment chamber.

The twisting of the threads is carried out before the weaving process is begun, either as a separate step or in combination with another handling step.

The present invention is applicable to substantially all woven mechanical fabrics, whether narrow fabrics used for mechanical purposes, such as webbing for harnesses, other straps, and components of heavy nets, such as cargo nets, or wide goods such as heavy fabrics for parachute packs, knapsacks and the like. The term "mechanical fabric" as used herein is intended to be generic to all the fabrics specifically mentioned in the preceding sentence. All mechanical fabrics may be identified by the fact that they are intended for use in situations where they may be subject to substantial abrasion. In applying the in-

vention to a fabric, substantially all the threads which form a part of the working surface of the fabric must be twisted in accordance with the invention. By the working surface is meant the surface engaged by a mechanical member with which the fabric may come in contact.

Figs. 1 and 2 illustrate, by way of example, a webbing of conventional weave, intended for use as a parachute harness, in connection with which the present invention has been used. This webbing consists of two plies generally indicated at 1 and 2. The upper ply is a plain weave, consisting of warp threads 3 and weft threads 4. The lower ply 2 is a similar plain weave consisting of warp threads 5 and weft threads 6. The two plies are woven together by means of binder threads 7. The binder threads 7 are woven in a conventional manner referred to as two up and two down, meaning that each binder thread passes over two weft threads and then under the next two weft threads. Each of the individual threads identified by that name in Figs. 1 and 2 may be a composite or plied thread consisting of a number of smaller threads. These smaller threads may be handled and woven as separate ends, but preferably each end consists of a number of smaller threads twisted together in a cable, to reduce the number of ends which must be handled separately in the loom.

A webbing woven as illustrated in Figs. 1 and 2 has been constructed from nylon threads of 210 denier.

In the fabric illustrated in Figs. 1 and 2, the working surface of the finished fabric is formed substantially by the warp threads only. While portions of the weft threads 4 are visible to an observer looking at the fabric, nevertheless those weft threads 4 are recessed below the projecting warp threads and so are not engaged by a surface against which the material rubs. Also, as best seen in Fig. 2, the binder threads 7 appear on the surfaces in groups with warp threads 3 and 5. Since the binder threads are of course maintained under tension during the weaving process, and since each binder thread approaches the working surface from a point further within the interior of the fabric than the adjacent warp threads, the portions of the binder threads nearest the surface tend to be covered by the associated warp threads so that they do not form any substantial part of the working surface of the finished webbing. Consequently, it is not necessary to twist either the weft threads or the binder threads in a webbing woven as shown in Figs. 1 and 2.

While the abrasion resistance in the fabric described is determined for the most part by the twist of the warp threads, it has been found desirable to twist the binding threads and the weft or filler threads also. The binding threads may occasionally be subject to breakage or to formation of loops by abrasion. While the twisting is not so necessary in the case of the filler threads, it is considered to be highly desirable as a precautionary measure.

Fig. 5 shows a composite weaving end 8 comprising a number of component threads 9 cabled together, each of such component threads being provided with the specified twist and each, of course, being constituted of many (in one example, 34) elemental filaments.

Of course, for some purposes, fabrics may be woven with single (uncabled or unplied) threads (and single binder threads if used), or there may be a cable 2, 3 or more twisted threads for each warp or binder; as indicated, parachute harness webbing, being a heavy duty, narrow fabric for mechanical purposes, should have a large number, e. g. 10, of twisted threads to constitute each actual warp "thread" or end.

Fig. 3 shows a modification of the weave of Figs. 1 and 2 which may be used to provide more flexible edges on the webbing. Referring to Fig. 3, it may be seen that it is the same as Fig. 2 except that the binder thread 7 nearest the right-hand selvage edge of the material has been omitted. The binder threads 7, in the particular weave shown, are spaced regularly across the webbing except that adjacent each edge there is a section wider than the regular spacing in which no binder thread is employed. This arrangement makes the edges of the webbing more flexible and compensates for any increased tendency to cut which may be observed as a result of the increased stiffness that accompanies the twisting of the individual threads. If desired, more than one binder thread may be omitted adjacent each edge to give even greater flexibility.

The twist values specified in the foregoing parts of the specification are based on the use of a nylon thread of 210 denier. A change in the weight of the thread will require a change in the twist in order to maintain the same abrasion resisting and other characteristics of the finished fabric. Similarly, a change in the particular material used also necessitates an adjustment in the number of turns of twist per unit length of material.

It has long been customary, in the case of staple fibers, to determine the change of twist required to secure the same fabric characteristics, when shifting from one weight of thread to another, by Kochlin's formula:

$$T=M\sqrt{C}$$

In this formula, T is the number of turns per inch, M is called the twist multiplier and is constant for any given material, and C is the count, or length of thread in a given weight.

In the case of continuous artificially polymerized, synthetic yarns, which are commonly identified in terms of denier (or weight for a given length) instead of count (or length for a given weight), Kochlin's formula must be modified as follows:

$$T=\frac{M}{\sqrt{D}}$$

where T and M have the same significance as before, and D is the denier of the yarn.

This also may be expressed as:

$$M=T\sqrt{D}$$

It has been found that for nylon yarn the preferred range of twist multiplier is between 260 and 290, where the twist is expressed in turns per inch and the denier in its usual dimensions (namely, the weight in grams of 9,000 meters of filament). This preferred range corresponds to the twist range of 18 to 20 turns per inch for 210 denier yarn, as set forth in the example above. In most cases this range may be expanded to 174–348 (corresponding to a twist range of 12–24 for 210 denier nylon). It is possible to use twist multipliers in the range from 116 to 500 (corresponding to 8 to 34 turns per inch for 210 denier nylon) to secure results according to the present invention which will be satisfactory for many purposes. Where it is permissible to have considerable longitudinal resilience, the twist multiplier may be much higher, for example, as high as 1,000.

The twist multiplier ranges given above are for currently available commercial nylon yarn. The criterion to be used in any yarn is to make the twist high enough to prevent substantial lengthwise movement of the filaments, or parts thereof, relative to one another. The maximum twist is that at which creping or other undesired deformation of the fabric begins.

The twist multiplier range for the ply twist, corresponding to a twist range of 0.5 to 4 for 210 denier nylon, is 7 to 58. While some advantage may be realized from the invention with a ply twist (for 210 denier nylon) of up to 6–7 turns per inch (corresponding to a twist multiplier of 87–102), it is usually important that the ply twist be less than 4 turns per inch, for example in the range from 0.5 to 4 turns per inch, representing a twist multiplier of 7.–58. As mentioned above, a ply twist of 1 or 2 turns per inch is preferred.

The foregoing examples and ranges of twist and twist multipliers relate particularly to commercial nylon yarn.

The term "nylon" is now recognized, according to one authority, as "a generic term for any long-chain synthetic polymeric amide which has recurring amide groups as an integral part of the main chain, and which is capable of being formed into a filament in which the structural elements are oriented in the direction of the axis." It may be that some types of nylon coming within this generic term will have twist ranges and twist multiplier ranges somewhat different from those given.

Other yarns formed of continuous artificially polymerized, synthetic filaments have characteristics generally similar to commercial nylon, insofar as the present invention is concerned, but again the ranges of twist and twist multipliers may be somewhat different.

Filaments having rough surfaces, as in those filaments which are shrunken or shriveled by the removal of water therefrom after they are formed, will have a greater coefficient of friction between the filaments, and correspondingly less twist will be required to prevent relatively endwise slipping of the filaments and thereby secure the desired abrasion resisting characteristics.

While I have shown and described certain preferred

embodiments of my invention, it should be understood by those skilled in the art that many modifications may be made without departing from the scope of the invention, and I therefore intend the invention to be limited only by the appended claim.

I claim:

An abrasion resistant mechanical textile fabric comprising woven warp ends and filler ends, each warp end comprising a multiplicity of warp threads plied together with a twist multiplier of 7 to 58, each of said warp threads comprising a multiplicity of continuous nylon filaments having a net twist such that the twist multiplier is at least 116.

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