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PLIED YARN AND CORDS AND PROCESS OF
PRODUCING THE SAME

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This invention relates in general to plied yarns or cords and in particular to cords of high tensile strength and heat resistance for use in tires, brake linings, belts and the like.

According to the accepted standard practice, tires are built up of a number of plies of fabrics composed of cotton cords, either weftless or with a light filler thread. Although tires constructed of such cotton cords or fabrics have given good results, they have certain inherent limitations. Increases in the operating load and speed of a tire will subject various parts of it to stresses of increased magnitude and frequency, tending to develop weaknesses which are manifested particularly in the larger sizes of tires, such as those which are used on passenger buses, commercial trucks, trailers and the like. One of these difficulties arises from excessive heat generated within the tire carcass by friction between the cotton and rubber, as well as actual friction between the fibers, due to the extreme and rapid flexing of the tire in operation. This ultimately results in a weakening of the cord, breaking of individual filaments and threads, the separation of the rubber from the cord fabric and the general weakening of the tire.

It is a general object of the present invention to provide a plied yarn or cord which has a high heat resistance, a high tensile strength, high insulation against heat transfer and at the same time is highly flexible and resistant to suddenly applied loads and to rapid bending and flexing, and which further shows a strong adherence to rubber.

It is another general object of the present invention to overcome the above mentioned objectionable features and limitations of the prior art by providing a cord and fabric made therewith which possesses characteristics superior to those heretofore known.

It is a specific object of this invention to provide a tire cord having an increased tensile strength, resilience, abrasion resistance, scorch resistance, and at the same time retaining the advantageous characteristics of natural fibers such as the original fiber length within the cord.

It is a further object of this invention to lay the nap, prevent untwisting, retain the moisture content and provide a cord more resistant to heat during vulcanization.

Another object of this invention is to produce a plied yarn or cord which will have a low internal friction. It is well known that the internal friction generated within a cord or similar structure by the slippage of the individual fila-

ments upon each other produces a great amount of heat. This causes a scorch and dehydration within the cord causing it eventually to weaken and ultimately to break.

A still further object is to control the elasticity and expansibility of tire cords and at the same time provide for more compactness of the cord.

According to the present invention there is provided a plied yarn or cord by mixing together, before the completion of the spinning, non-adhesive textile fibers or filaments and at least one type of potentially adhesive fibers or filaments, spinning the mixture of fibers or filaments into a singles yarn and thereafter fabricating the singles yarn into a plied yarn or cord in a known manner. The singles yarn or the plied yarn or cord formed therewith is then subjected to an activating treatment sufficient to cause the fibers or filaments of the yarn to adhere to each other. In the now preferred embodiment the yarn treated by the above described process is, at some point in the course of manufacture, subjected to a stretching operation, preferably while the potentially adhesive fibers or filaments are in an adhesive condition, and the stretched condition is then set by the deactivation of the adhesive to produce a yarn or cord having superior properties.

For the textile fibers and for the potentially adhesive fibers used in the fabrication of the plied yarn or cord there may be employed any of the classes of such fibers as described in my parent application Serial No. 201,851, filed April 13, 1938, now Patent No. 2,252,999, in so far as the fibers or filaments described therein are suitable for attaining the objects of the present invention. However, due to the particular physical and thermal characteristics of cotton and viscose rayon, it is to be understood that in the preferred embodiment the textile fibers, that is the non-adhesive fibers, comprise cotton or viscose rayon or a mixture thereof.

Among the classes of potentially adhesive fibers which are especially advantageous for attaining the objects of the present invention are the following:

Cellulose derivatives, such as the esters, the ethers, whether soluble in alkali or organic solvents, mixed cellulose ester-ethers, hydroxy-alkyl and carboxy-alkyl ethers of cellulose and xanthates of the cellulose ethers, cellulose thiourethanes, cellulose xantho-fatty acids which can be rendered adhesive by treatment with appropriate solvents. For example, a fiber made of an alkali-soluble, water-insoluble cellulose ether

can be rendered adhesive by treatment with alkali.

In the now preferred embodiment the potentially adhesive fiber is a thermoplastic synthetic resinous material or a thermoplastic non-fibrous cellulosic material capable of being formed into fibers which have an inherent tackiness upon heating to a temperature below that at which any textile fibers present are damaged or rendered tacky and which are non-tacky at room temperature such, for example, as the resins formed by the polymerization of various organic compounds such as cumarone, indene hydrocarbons, vinyl, styrene, sterol aldehyde, furfural ketone, urea, thiourea, phenol-aldehyde resins, either alone or modified with oils, urea-aldehyde resins, amine-aldehyde resins, sulfonamide-aldehyde resins, polyhydric alcohol-polybasic acid resins, drying oil-modified alkyd resins, resins formed from acrylic acid, its homologues and their derivatives, sulfur-olefine resins, resins formed from dicarboxylic acids and diamines (nylon type); fibers formed from synthetic or artificial rubber such, for example, as polymerized butadiene, olefine-polysulfides, e. g. "Thiokol," isobutylene polymers, chloroprene polymers and polyvinyl-halides, e. g. "Koroseal"; fibers formed from a resin comprising the product of copolymerizing two or more resins, such, for example, as copolymers of vinyl halide and vinyl acetate, copolymers of vinyl halide and an acrylic acid derivative, copolymers of vinyl compound and styrol compound; and also fibers formed from a mixture of resins, such for example as a mixture of vinyl resins and acrylic acid resins or methacrylate resins, a mixture of polyolefine resins and phenol-aldehyde resins, or a mixture of two or more resins from the different classes just named.

The thermoplastic resins above mentioned may be classified as:

(a) Heat non-convertible resins such for example as glycol polybasic acid resins, vinyl resins and the acid type phenol-aldehyde resins, and the like.

(b) Heat-convertible resins such for example as a glycerol-polybasic acid resin, polyolefine resins, phenol-aldehyde resins and the like.

(c) An element-convertible resin (which becomes infusible through the action of certain elements, such as oxygen and sulfur) such for example as glycerol-polybasic acid-drying oil resins and olefine sulfur resins.

In addition to the synthetic resins, there may be employed for the potentially adhesive fiber, a fiber formed from a thermoplastic cellulose derivative, such for example as a cellulose ester, a cellulose ether, a mixed cellulose ester-ether, a mixed cellulose ether, a hydroxy-alkyl or carboxy-alkyl ether of cellulose, a cellulose ether xanthate, or a cellulose thiourethane. In particular, the thermoplastic cellulose derivative fiber may be a fiber of cellulose acetate, cellulose nitrate or an organic soluble cellulose ethyl ether, and the like; also fibers formed from a mixture of cellulose derivatives and resins, such for example as a fiber formed by extruding a mixture of cellulose nitrate and an oil soluble phenol-aldehyde resin, or a cellulose acetate and an acrylic acid resin, or an organic soluble cellulose ether and a vinyl resin; also fibers formed from resins such as those formed from polybasic acids and aliphatic diamines (nylon type), either unstretched or pre-stretched; and fibers formed from a natural or synthetic rubber and rubber derivatives.

For the thermoplastic fiber, it is preferred to employ a resin fiber because such fibers, as compared to the cellulose derivative fibers, are tougher and harder, become tacky at lower temperatures and cool to form tough or pliable products. Moreover, the resin fibers are inert to acids, alkalies and dry cleaning fluids, and are not water swelling. This latter property prevents distortion of the adhesive bond, tends to stabilize the twist and shrinkage of the fabric, and the adhesive is more permanent so that the wet and dry tensile strength of the adhesive bond will be substantially the same. Finally, the resin fibers exhibit, particularly when plasticized, a high tensile and a true elasticity, practically as great as that of natural silk.

The non-adhesive textile fibers and/or the potentially adhesive fibers may be prestretched fibers or filaments. In such cases the shrinking treatment advantageously includes treatment with a suitable chemical reagent or heat to effect a shrinkage of the prestretched fiber. The resulting fiber-shortening will produce yarn shrinkage and augment the decrease in fabric dimension.

The articles of the invention are fabricated from yarns comprising at least two dissimilar types of fibers at least one of which type is potentially adhesive.

The mixing of the textile fibers with the potentially adhesive fibers may be carried out in a suitable manner such, for example, as by blending suitable quantities of at least two types of fibers before, during and/or after carding, combing, drafting or spinning; and before and/or during twisting, doubling and other yarn-forming operations. Thus the two types of fibers are mixed and fed together into a carding machine, or slivers are made from each type independently and the slivers combined by spinning into a yarn. Mixing includes also forming the potentially adhesive fibers in situ.

The relative proportion of the non-adhesive textile fibers and potentially adhesive fibers may be varied in accordance with their properties; the nature of treatment; the intended use of the finished product and the characteristics desired therein. In a preferred embodiment, the non-adhesive fibers constitute the major portion and the potentially adhesive fibers the minor proportion. For most cords, the potentially adhesive fibers comprise preferably from 2% to 25% by weight of the mixture, without limiting the invention by this range.

The nature and extent of the activating treatment will depend, inter alia, upon the nature of the potentially adhesive fiber, upon its proportion in the textile and upon the properties and characteristics desired in the product. Among the methods which may be used for activation are the following, taken singly or together in appropriate combinations, without limiting the invention to these samples.

(1) By applying to the yarn, or cord a solvent or swelling agent or mixture thereof with diluents, under such conditions of concentration and temperature as to render the fibers adhesive. For example, fibers of cellulosic materials may be rendered adhesive by the use of inorganic alkalies, in particular, quaternary ammonium bases, solutions of cuprammonium, zinc chloride, alkali metal perchlorates, alkali metal thiocyanates, and the like.

(2) By the use of chemical agents which convert the potentially adhesive fibers into an ad-

hesive condition. For example, by appropriate treatment, cellulose fibers may be converted to an ester, a xanthate and other derivatives which are adhesive in their swollen freshly formed state.

(3) When the potentially adhesive fibers are thermoplastic, they may be activated by heat and/or irradiation, especially ultra-violet and infra-red. For example, a textile made of yarns containing non-adhesive fibers and pure rubber fibers is subjected to ultra-violet irradiation to render the fibers adhesive.

(4) A latent activating agent may be combined with the potentially adhesive fibers and/or with the non-adhesive fibers by impregnating them prior to mixing the fibers. Such agent may be rendered active by a subsequent treatment, such as chemical agents and/or heat, thus producing a simultaneous activation of the fibers. For example, fibers may be impregnated with a liquid which, at room temperature, is a non-solvent therefor but which, at a higher or lower temperature, is a solvent sufficiently active to render the fibers adhesive.

The singles yarns may be activated on a warp beam or in hanks or while wound upon a spool or bobbin, whereas the plied strand or cord may be activated on the warp beam or in form of the weftless fabric or during vulcanization.

While the fibers are in an adhesive condition, the yarns or cords may be subjected to a compacting treatment to bring the fibers into more intimate contact and promote a partial or complete adhesion and/or fusion of the associated fibers at their points of contact and, if desired, of the plies in the cord. For example, mechanically applied pressure may be exerted on the yarn or cord during and/or after activation, or deactivation. Compacting may be accomplished by twisting the yarns, threads, cords and the like and with or without application of additional external pressure and/or tension or centrifugal force. For example, an activated yarn or cord may be wound under tension upon a spool or core. A tire fabric may be passed between pressure rolls to compress the mixed fibers. The step of compacting is optional, depending upon the properties and finish desired in the product. The twisting and doubling of the yarns may be carried out during and/or after activation while the fibers are in an adhesive condition, thus improving the adherence and bonding of the fibers and/or of the yarns to one another. It is preferred to activate, compact and deactivate (if necessary) the singles yarns before plying or doubling them so as not to decrease substantially the flexibility of the plied thread or cord.

Simultaneous with or subsequent to compacting, the textile may be treated to deactivate the adhesive, that is, to render the adhesive non-tacky so as to fix the new relationship of the fibers. If activation has been accomplished by heat, deactivation may be accomplished by heating to a higher temperature or by cooling; if by chemical agents, deactivation may involve evaporation, extraction, neutralization or coagulation of the chemical agent, fixing, precipitation, decomposition and transformation to a non-adhesive condition; and if partly or completely dissolved by a solvent, deactivation may involve extraction of the solvent as by washing, evaporation, decomposition and/or coagulation.

The invention may be embodied in a pneumatic tire of standard form, such tire having a carcass built up of the improved fabric plies having their

side edges tied in with circular reinforcing beads, flipper strips and chafing strips. In some cases, a central circumferential breaker strip, rubber side walls and tread complete the assemblage. As will be recognized by those skilled in this art, the number of fabric plies employed and the specific method of tying in the beads may vary for different sizes and grades of tires, these being features of tire design with which this invention is not particularly concerned.

The invention is not limited in this respect, but the standard tire constructions are preferred because they make possible the immediate practice of the invention without any radical changes in present manufacturing methods and machinery.

The tire cord of the invention is a composite structure comprising a plurality of singles yarns. The shingles yarn may be produced in any suitable manner by carding, with or without combing the fibers and spinning them into a yarn as well known in the art. In accordance with the standard practice of the art the singles yarn may be twisted upon themselves to form a plied yarn and two or more of the plied yarns may then be twisted upon themselves to form a strand, and several of such strands may be twisted together to form the cord. It is to be understood that the number of singles yarns used, the number of twists present each in the singles yarn, the number of plied yarn or strands used, the number of twists of the plied yarn, the number of plied yarn used, and the number of twists of the plied yarn employed to produce the cable or cord may vary for different cords in accordance with the established principles of cord design and having regard for the kind of pneumatic tire in which the cord will be employed. Further, the directions of the twists of the several components of the twists and the relation of the twists to each other in the component yarns may be varied in accordance with the established practice of the art. By way of illustrating but not by way of limiting the invention, a tire cord may comprise a three-ply cable, the cable comprising three twisted strands, each formed of five twisted singles yarns of size 23. According to the terminology now current in the trade, such a tire cord would be referred to as a 23/5/3 cord. It is to be understood that the cord may be formed into a tire fabric of any suitable construction such for example, as a weftless fabric or coarse woven or woven with a light filler thread and two or more such fabric plies may be employed to build up the pneumatic tire carcass.

In the now preferred embodiment the yarns, strands or cords are stretched to control the elongation and expansibility of the finished product, and in the present invention such stretching takes place while the potentially adhesive fibers are in a tacky condition. To promote such stretching there may be employed lubricants and softening agents of known type. It is understood that this stretching increases also the compactness of the yarn and reduces the gauge both of which are definite advantages in tire cords.

After the manufacture of the cord, it is impregnated and coated with rubber in a known manner by dipping, spraying, pressure padding, and the like, preferably by passing the finished cord through the bath of rubber and drying the cord on a heated roll. To promote the adhesion of the rubber to cords comprising rayon fibers or filaments, the cords may be pre-treated before the application of the rubber, with a bonding

agent of known type, such for example as a mixture of protein and latex as in U. S. Patent No. 2,129,623, or with synthetic resin as in U. S. Patents No. 2,128,635 and No. 2,128,229. The cord may be thereafter coated with rubber or rubber latex to which has been added the usual fillings, vulcanizing agents, pigments, accelerators, and the like.

The cord may be treated with various optional agents for softening and improving the heat resistance and rot resistance. By way of illustration but not by way of limiting the invention there will be given the following specific example:

A singles yarn is spun from a mixture of 85% viscose staple rayon which has been pre-stretched during manufacture, with 15% of fiber formed from a copolymer of vinyl acetate and vinyl chloride in a picker and the mixture carded, and spun into a 23's singles yarn, five of such yarns are twisted together to make a strand and three of such strands are twisted to make a cord. The cord is then subjected to heat sufficient to render said resin fibers adhesive and while said fibers are in an adhesive condition the cord is subjected to longitudinal tension and the cord then allowed to cool without relaxing the tension until the resin fibers are thus again non-adhesive. The fibers in the singles yarns are thus bound together but the plies are not bound together in the strands or cords thus giving a compact cord which has a higher scorch resistance, decreased stretch, decreased internal heat generated and a higher tensile strength than a similar cord which has not been activated.

The articles of the invention have uses other than in tire cords, for example the ply yarns may be made into cordage of all kinds and in the manufacture of belts, brake linings, journal packings, conveyor bands, shoe soles, and for fire, steam, and air hose. The ply yarns and cords of the present invention have many advantages over many similar articles made of identical textile fibers but not containing the activated adhesive fibers. In particular, the tire cords of the present invention are in general lighter, cooler, and stronger than the cords heretofore known. The present process requires less twist in the singles yarns so that there is a gain in tensile strength. Activation of the potentially adhesive fibers sets the position of the textile fibers, prevents movement of such fibers relative to each other during the flexing of the tire cord and thus decreases the internal heat generated in use. The activation also sets the twist in the strand and cable and thus gives a relaxed balanced cord free from a tendency to curl or crimp.

Since in the preferred embodiment the several plied yarns are not bound to each other except by elastic rubber, the strands are able to move substantially relative to one another so that the flexibility of the cord is not materially reduced. Coating and impregnating materials heretofore used have prevented such movement thus causing the generation of internal heat in the cord. In the present invention there is a maximum fiber bonding with a minimum of adhesive material, so that there is no substantial increase in the weight of the tire cord. Finally, the present invention gives a more compact cord and promotes the manufacture of cords of higher strength with smaller gauge thus increasing the amount of rubber and decreasing the thickness of the tire carcass. The present invention permits a careful

control of the extensibility and elongation before a break in the cord occurs.

The present application is a continuation in part of my co-pending application Serial No. 201,851, filed April 13, 1938, now U. S. Patent No. 2,252,999.

What I claim is:

1. In a process for producing a multiply cord, the steps comprising twisting together two or more yarns at least one of which is a singles yarn formed from a mixture of a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, and compacting said plied yarn while the potentially adhesive fibres are in an adhesive condition to produce a flexible plied yarn which is more heat resistant and smaller in gauge than the yarn before said activating and compacting treatments.

2. In a process for producing a multiply cord, the steps comprising twisting together two or more yarns at least one of which is a singles yarn formed from a mixture of a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, treating said plied yarn to activate said potentially adhesive fibers to bind fibers in said yarn, and compacting said plied yarn while the potentially adhesive fibres are in an adhesive condition to produce a flexible plied yarn which is more heat resistant and smaller in gauge than the yarn before said activating and compacting treatments.

3. In a process for producing a multiply cord, the steps comprising twisting together two or more yarns at least one of which is a singles yarn formed from a mixture of a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, treating said plied yarn to activate said potentially adhesive fibers to bind fibers in said yarn, subjecting said plied yarn to tension while the potentially adhesive fibres are in an adhesive condition, and compacting said plied yarn while the potentially adhesive fibres are in an adhesive condition to produce a flexible plied yarn which is more heat resistant and smaller in gauge than the yarn before said activating and compacting treatments.

4. In a process for producing a multiply cord, the steps comprising mixing together, before completion of the spinning, a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, spinning said mixture into a singles yarn and doubling said yarn with another yarn of similar construction and composition, and compacting said plied yarn while the potentially adhesive fibres are in an adhesive condition to produce a flexible plied yarn which is more heat resistant and smaller in gauge than the yarn before said activating and compacting treatments.

5. In a process for producing a multiply cord, the steps comprising mixing together, before completion of the spinning, a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, spinning said mixture into a singles yarn and doubling said yarn with another yarn of similar construction and composition, treating the potentially adhesive fibres in said yarns to render them adhesive, and compacting said plied yarn while the potentially adhesive fibres are in an adhesive condition to produce a flexible plied yarn which is more heat resistant and smaller in gauge than the yarn before said activating and compacting treatments.

6. In a process for producing a multiply cord, the steps comprising mixing together, before com-

pletion of the spinning, a major proportion of textile fibers and a minor proportion of potentially adhesive fibers, spinning said mixture into a singles yarn and doubling said yarn with another yarn of similar construction and composition, treating the potentially adhesive fibers in said yarns to render them adhesive, and compacting said yarns while the potentially adhesive fibers are in an adhesive condition.

7. A multiply cord comprising a singles yarn formed from a mixture of a major proportion of textile fibres and a minor proportion of potentially adhesive fibres, fibres in said singles yarn being bonded together by said potentially adhesive fibres, said multiply cord being characterized by a stabilized twist in said singles yarn and a stabilized multiply configuration in said cord.

8. A multiply cord each ply of which comprises at least one singles yarn formed from a mixture of a major proportion of textile fibres and a minor proportion of potentially adhesive fibres, fibres in said singles yarn being bonded together by said potentially adhesive fibres, said multiply

cord being characterized by a stabilized twist in said singles yarn and a stabilized multiply configuration in said cord.

9. A multiply tire cord comprising a singles yarn formed from a mixture of a major proportion of textile fibres and a minor proportion of potentially adhesive fibres, fibres in said singles yarn being bonded together by said potentially adhesive fibres, said multiply cord being characterized by a stabilized twist in said singles yarn and a stabilized multiply configuration in said cord.

10. A multiply tire cord each ply of which comprises at least one singles yarn formed from a mixture of a major proportion of rayon fibres and a minor proportion of potentially adhesive resin fibres, fibres in said singles yarns being bonded together by said resin fibres, said multiply cord being characterized by a stabilized twist in said singles yarn and a stabilized multiply configuration in said cord.

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