Jan. 2, 1951 T. A. FEILD, JR., ET AL 2,536,163

ELASTIC COMPOSITE FABRICS AND PROCESS FOR MAKING SAME

Filed Oct. 15, 1947

Fig. 1.

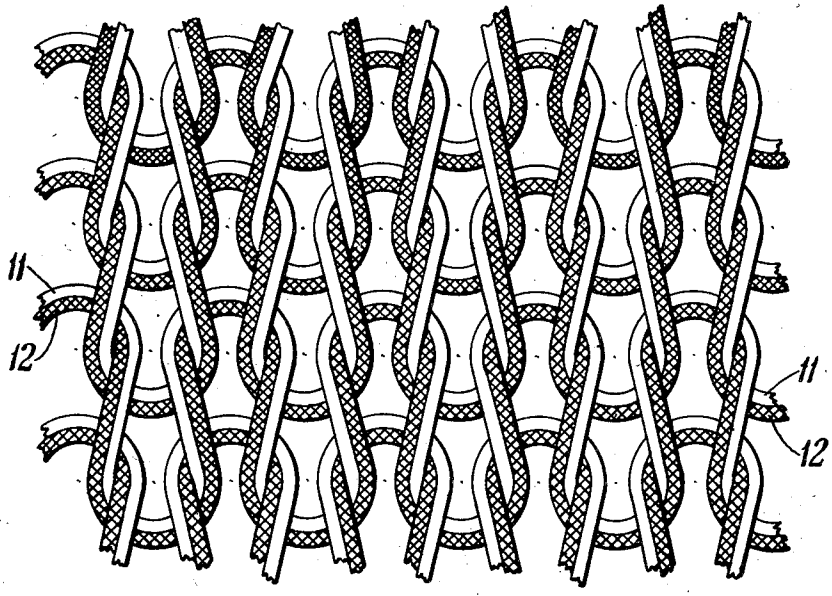


Fig. 2.

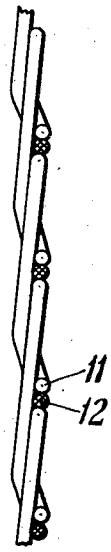


Fig. 3.

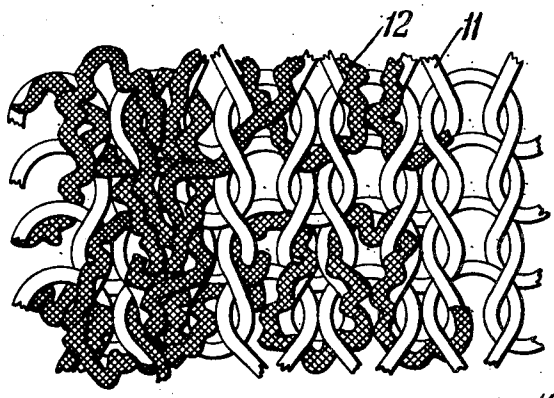


Fig. 4.

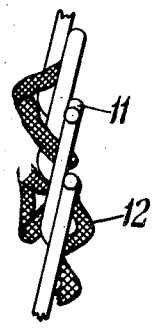
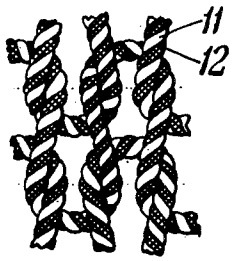


Fig. 5.



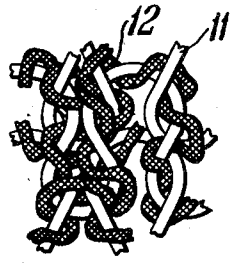


Fig. 6.

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2,536,163

ELASTIC COMPOSITE FABRICS AND PROCESS FOR MAKING SAME

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Application October 15, 1947, Serial No. 779,960

18 Claims. (Cl. 28—73)

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This invention relates to the production of strong, elastic fabrics having a soft dry hand, and comprising filaments and yarns made from certain vinyl resins associated with one or more yarns made from another type of synthetic thermoplastic materials or from natural textile materials, and to a novel process for the production of such fabrics. Knitted fabrics of the invention are run-resistant. The invention has especial utility for the production of strong, elastic composite fabrics comprising yarns made from copolymers of a vinyl halide with a vinyl ester of an aliphatic acid, which fabrics are substantially free from the clammy feel of the usual types of elastic fabrics made from elasticized vinyl resins.

Fabrics having some degree of extensibility in length may be prepared from yarns of cotton, rayon or other textile materials by a knitting operation. When very high extensibility is desired in a knitted or woven fabric, together with good recovery upon release of stretching tension, yarns made from rubber commonly are used in both woven and knitted constructions. The manufacture of these yarns and the preparation of the yarns for knitting and weaving operations relate to a specialized art, and usually require special equipment and methods of handling which are radically different than those utilized for making standard, woven or knitted textile fabrics. The complicated procedures heretofore required for producing and for subsequently processing elastic yarns have had a retarding effect upon the commercial exploitation of elastic fabrics made from synthetic resinous materials.

It is a primary object of this invention to produce a highly extensible elastic fabric by weaving, knitting or otherwise compositing at least two kinds of yarns, each of which possesses textile properties adapting it for use with standard weaving or knitting equipment and without the need for high or special yarn twists.

Among other important objects of the invention are the following: the production in novel manner of a run-resistant knitted fabric; the production in novel manner of strong, highly extensible and elastic knitted, woven, braided and other composite fabrics; the production of elastic textile fabrics comprising vinyl resin yarns, which fabrics have a soft hand, and are free from the moist clammy feel of the elastic fabrics made wholly from plasticized vinyl resins; to provide a novel composite textile fabric comprising an elastic vinyl resin yarn in association with a substantially unplasticized reinforcing and stretch-limiting textile yarn, which fabrics may be dyed at temperatures as high as 100° C. without substantial shrinkage of or injury to the fabric; and the production of highly extensible elastic composite fabrics comprising elastic yarns made

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from polymers of one or more vinyl compounds including a vinyl halide plied or otherwise associated with a stretch-limiting textile yarn, but wherein the vinyl resin yarns are not bonded to the said other yarn. Other objects will be apparent as the following description proceeds.

The invention involves the compositing of two types of yarn, one of which types is an oriented vinyl resin yarn of the aforesaid type, and the other of which is a stretch-limiting and reinforcing yarn resistant to attack by plasticizers for the vinyl resin. Prior to the knitting or weaving operation the two yarns may be plied on standard textile twisting equipment with any normal twist capable of being run on the knitting machine or weaving machine used, or the two types of yarn may be disposed in parallel in the knitted, woven, or other structure. At some stage prior to, during or subsequent to the production of the fabric, at least the plasticizable vinyl resin yarn is treated with a plasticizer therefor under conditions such that neither type of yarn is penetrated or substantially softened by said plasticizer. The fabric then is subjected to a novel elasticizing treatment hereinafter described under conditions such that the fabric shrinks at least 50% in area, and the plasticized vinyl resin yarns, but not the reinforcing yarns, are slowly converted to the elastic form.

The fabrics made by the practice of this invention are characterized by their high rubber-like extensibilities under tension. These range up to 100% or more in one or more directions for woven, knitted and other fabrics. The fabrics exhibit almost instant recovery from these extensions when the plasticizer content is in the range of from around 70% to around 95%, based upon the dry weight of the plasticizable vinyl resin yarn. A slower recovery occurs when the plasticizer content ranges from around 30% to around 50% of the weight of the plasticizable yarn component.

These fabrics generally do not exhibit the powerful recovery from extension characteristic of rubber fabrics. Thus, they are admirably suited for many medical and personal garment uses where a close fit and a mild pressure are desired. The knitted fabrics are completely run-resistant, even when made on standard circular or flat knitting machines, and may be cut into strips as narrow as one-half inch without fraying or unraveling. Indeed, these novel fabrics represent a fabric within a fabric. Thus, although the original knitted fabric before elasticization is a single system knit structure, the final elastic fabric is composed of a relatively large loosely arranged knitted structure of untensioned reinforcing yarn superimposed upon but not bonded to a smaller knitted structure composed of elastic yarns.

The plasticizable vinyl resin yarns required for the practice of the invention essentially are multifilament oriented yarns that are capable after elasticization of shrinking in boiling water at least 50% and preferably 75% or more. They have the fabricating qualities of a normal textile yarn. Those oriented yarns that have been stretched 50% in their manufacture usually have boiling water shrinkage around 75%, while those stretched less than this have still lower shrinkages. Fabrics made from yarns capable of shrinking 50% in boiling water can shrink in total area this minimum amount during the activation treatment where the shrinkage is not resisted. For fabrics made from yarns capable of shrinking 75% or 80%, a fabric construction that allows a free shrinkage of only 50% in area during activation still permits the major contractile forces to be dissipated without harm to the fabric. The desired openness of structure is readily obtained in knitted fabrics. In the case of woven fabrics the required looseness of construction may be controlled by the number of picks per inch for the filling and the number of ends per inch used in the warp. As the yarn size increases, the number of ends per inch is decreased to allow the production of a fabric capable of shrinking at least 50% in area in boiling water. In some woven composite fabrics of the invention the elasticizable yarn is used only as the filling yarn, or only as the warp yarn, in association with non-elastic yarns to provide a fabric having a one-way stretch. In such cases the warp ends or the fillings yarns are so disposed as to allow for the required transverse shrinkage.

Each filament of the yarn should have a denier no higher than 20; and those having deniers around 1 to 3 are prefered. The filament size is very important since, the larger the filament, the more the surface thereof tends to become overgelatinized when treated with plasticizers, thus making it impracticable to obtain uniform elasticization of the filament throughout its cross-section in any reasonable length of time. By "fabricating qualities of a normal textile yarn" we mean that the oriented vinyl resin yarns shall have sufficient strength, resilience and flexibility to be readily knitted or woven on standard textile equipment. The yarn may be in the form of continuous filaments or of yarn spun from staple fibers cut from an oriented yarn. Vinyl resin yarns eminently suitable for use with the invention are those made from copolymers of vinyl chloride and vinyl acetate having between 80% and 95% of the chloride in the polymer, and having average macromolecular weights of at least 15,000, described in the E. W. Rugeley, T. A. Feild, Jr., and J. F. Conlon, United States Patent No. 2,161,766. (Molecular weights referred to herein are those calculated by means of Staudinger's formula from viscosity determinations of solutions of the resins.)

While the following description is directed particularly to the use, as the elasticity-imparting textile component, of filaments, fibers and yarns made from copolymers of vinyl chloride and vinyl acetate, it will be understood that one can employ other vinyl resins capable of being rendered more or less elastic by the use of non-solvent plasticizers under the conditions herein described, such as the polyvinyl chloride resins; and copolymers of vinyl chloride with other vinyl esters of lower aliphatic acids having from two to four carbon atoms, and with acrylic and methacrylic esters such as methyl and ethyl acrylates and methacrylates.

The stretch-limiting and reinforcing secondary yarn may be any normal textile yarn of suitable denier or count which is not attacked nor weakened by the plasticizer under the temperature and other conditions employed in the process. Among such normal textile yarns are those made from natural fibers such as cotton, silk, wool or linen, and those made from such synthetics as viscose rayon; acetate rayon; nylon; and copolymers of vinyl chloride and acrylonitrile, particularly those having between about 45% and about 80% of the chloride in the polymer and having specific viscosities at 20° C. between 0.2 and 0.6, described in the E. W. Rugeley, T. A. Feild, Jr., and J. L. Petrokubi, United States Patent No. 2,420,565, and capable of fabrication on standard textile equipment.

It has been found that the looseness of the construction of the knitted, woven or other fabric to be processed plays an important part in determining the ultimate properties of the elastic fabric. The more closely woven is the fabric structure treated by this process, the lower the degree of elasticity imparted to the finished fabric, since the shrinkage during elasticization of the vinyl resin filaments serves further to tighten the construction. Where an open construction is used, the vinyl resin filaments are free to contract the requisite amount, thereby producing a substantial reserve of untensioned stretch-limiting secondary yarn in the finished fabric when the latter is in relaxed condition. When tension is applied to the fabric, the elasticized vinyl resin yarn yields, permitting extension of the fabric until the slack in the secondary yarn is taken up, whereupon the full strength of the latter yarn comes into play, protecting the elasticized vinyl resin yarn from injury under tension. Upon release of the tension the extended fabric recovers its original size due to the elastic recovery of the elasticized vinyl resin yarn.

In the case of knitted fabrics the character of the fabric construction similarly controls the ultimate extensibility and elastic recovery of the fabric. Thus, tightly knitted composite fabrics processed in accordance with the invention have excellent recovery after extension, but cannot be extended as far as those made from loosely knit structures. For the foregoing reason it is highly desirable in the case of a woven construction, to use one sufficiently open that the fabric is capable of freely shrinking at least 50% in total area during the activation step. In the case of knitted fabrics the deniers of the threads being knitted and the cut of the knitting machine principally determine the tightness of the fabric. With a 34-cut circular knitting machine using two yarns having a total denier of 75, the knitting of 18 stitches per linear inch provides a highly extensible fabric, while the knitting of 48 courses per inch provides a tight fabric construction. The extent of shrinkage of the plasticized vinyl resin yarn during the activation is an important factor in determining the maximum extensibility of the fabric under stress.

The plasticizers useful in the practice of this invention include any of the well-known plasticizers for these vinyl resins which are not plasticizers for the reinforcing yarn under the conditions of the process. Those plasticizers having the greatest permanence are preferred in order to insure permanent rubber-like elasticity. Preferably the plasticizer is one which is a non-sol-

vent for the plasticizable vinyl resin at temperatures around 25° C. and below. Among plasticizers found particularly useful in the process are the higher alkyl and aryl esters of dicarboxylic acids wherein each alkyl or aryl group contains at least four carbon atoms, such as dibutyl phthalate, di 2-(ethylhexyl) phthalate, phenyl phthalate, butoxyglycol phthalate, dibutyl sebacate, dibutyl suberate, dibutyl pimelate and dibutyl adipate; alkyl and aryl phosphates such as tributyl phosphate, triphenyl phosphate and tricresyl phosphate; glycollate esters such as ethyl phthalyl ethyl glycollate; and polyglycol esters of monocarboxylic acids, which acids have from six to eight carbon atoms in the molecule, such as triglycol di-2-ethylbutyrate and triglycol di-2-ethylhexoate.

The plasticizer may be applied by many known methods, and at various stages in the production of the elastic fabric. Thus, the plasticizer may be applied to the finished composite fabric made from the two or more types of yarns; or the plasticizer may be applied to the plasticizable vinyl resin yarn alone, or to a composite yarn made by plying the vinyl resin multi-filament yarn with a yarn of the secondary textile material. The finished fabric may be run through a plasticizer bath, and the treated fabric squeezed or centrifuged to remove excess plasticizer; or the fabric may be dipped in a solution or suspension of the plasticizer in a diluent that is a non-solvent for the resin, or treated in other known manner.

In one preferred modification of the invention the plasticizer is applied to the composite yarn formed by plying ends of the two types of yarn by passing the composite yarn over a winding machine coating roll applicator during a winding operation prior to the formation of the composite fabric. In each instance the amount of plasticizer applied, and the conditions employed in such application and in the removal of excess plasticizer are such as to cause the vinyl resin filaments to absorb, during the subsequent elasticizing treatment, between about 30% and about 95% of the plasticizer, based upon the weight of the plasticizable vinyl resin yarn component. While the lower limit of 30% is not necessarily critical, it has been found that when less than 30% of the plasticizer is introduced into the vinyl resin yarn the resultant fabric requires considerable stress for stretching the same, while its recovery from extension is extremely slow. Plasticizer contents above 95% give no further improvement in fabric elasticizing, while the vinyl resin yarns become unduly weakened and fragile. Plasticizer contents in the range between 30% and 50% preferably are used when it is desired to produce a strong fabric having a medium extensibilty with slow recovery; and plasticizer contents in the range between 70% and 95% preferably are employed for the production of fabrics having high extensibility and prompt recovery from extension.

After applying the plasticizer to the composite fabric, or to the plasticizable vinyl resin yarn, alone or composited with the secondary reinforcing textile yarn, the fabric is subjected to heat under conditions which elasticize such vinyl resin yarn, while preserving the original properties of the reinforcing yarn. This is one of the most important steps in the process and requires the exercise of care to insure the desired results. During this step several major changes occur. The fabric area is reduced at least 50% by the

elasticizing step, while the vinyl resin yarn often increases in denier to nearly twice that of the original yarn, and changes from a normal textile yarn having an extensibility usually of less than 35% to a highly elastic rubber-like yarn having an extensibility well in excess of 100%, with a very high rate of recovery from such an extension. The reinforcing yarn in the fabric structure changes from a primary component of the original fabric to that of a loose, relatively untensioned, unbonded yarn which (1) separates the vinyl resin yarns from each other in the shrunken fabric, (2) limits the extent to which the elastic threads may be stretched; and (3) protects the yarns from rupture due to undue stretching.

The elasticization of the vinyl resin yarn component may be accomplished in various ways, using either moist or dry heat, all involving the application to the fabric at a controlled rate of heat in amount sufficient to cause impregnation of the resin yarn by the plasticizer and to fix the latter within the yarn while preventing bonding of that yarn with the reinforcing yarn.

The elasticization usually is initiated by heating the coated fabric to temperatures around 50° C. to 60° C. more or less rapidly, and then raising the temperature of the fabric gradually as it approaches the strain-release temperature of the vinyl resin in order to insure the uniform penetration of each of the filaments of the plasticizable vinyl resin component by the plasticizer at temperatures below that at which ripid shrinkage of the fabric occurs. The application of higher temperatures around the strain-release temperature of the vinyl resin at the outset causes such rapid shrinkage of the plasticizable vinyl resin yarn that the plasticizer is forced from between the individual filaments thereof. Unduly rapid shrinkage also causes frequent breakage of the vinyl resin yarn.

The rate of heating of the coated fabric at temperatures below 60° C. may vary rather widely. However, the period of time during which the fabric being heated is at temperatures below 70° C. must be sufficient to fix within the yarn forming the fabric the required amount of the plasticizer. For best results, during the period that the fabric being heated is at temperatures within the range between 60° C. and around 70° C. (temperatures near but below those at which major shrinkage of the unplasticized oriented resin yarn in the fabric occurs), the heat is regulated to provide a rate of temperature rise between 0.1° C. and 2° C. per minute, and preferably one of between 0.33° C. and 1.0° C. per minute. If desired, fixation of the plasticizer may be effected by heating the coated fabric at a selected elevated temperature below 70° C. for the required length of time. The fabric is finally heated to a temperature within the range between 90° C. and 100° C., and preferably to 100° C., to facilitate further shrinkage of the fabric and to remove unfixed plasticizer. This is effected conveniently by scouring the fabric in a dilute solution of a detergent such as a water-soluble soap. The rate of heating in th's higher temperature range is not critical.

The following examples serve to illustrate the invention:

Example I

A 35 denier 40 filament oriented vinyl resin yarn made from a vinyl chloride-vinyl acetate

copolymer resin having a vinyl chloride content of 90% and a macromolecular weight of about 20,000, and having a tenacity of 3.46 grams per denier, an extensibility of 19.8%, and a shrinkage in boiling water of 81.4% was plied 5 turns per in., S, with one end of 120's/2 cotton yarn (89 denier). The above composite yarn was knitted on a 3¾ inch cylinder 34 cut knitting machine to produce a composite fabric having 26 stitches per linear inch. The knitted fabric was immersed for five minutes in dibutyl sebacate, removed from the bath and then centrifuged to a weight gain of 27%. The treated fabric then was placed in an 0.10% aqueous soap solution at 50° C. and slowly agitated while the temperature of the solution gradually was raised to 70° C. over a 30 minute period, corresponding to a rise rate of about 0.67° C. per minute. The bath temperature then was raised to 90° C. over an additional 30 minute period, after which the fabric was scoured at a boil with an 0.25% aqueous soap solution. A portion of the scoured fabric was dyed with 2% of its weight of a direct type blue dye in water to yield an attractive uniformly dyed blue fabric. The air dried elasticized fabric showed a total gain in weight of 25.5% which is equivalent to a plasticizer content of 90.5%, based upon the dry weight of the original vinyl resin yarn. The treated fabric had a soft dry hand, was strong, and had shrunk 47% in length and 15.8% in width. Other fabric changes resulting from the treatment are as follows:

	Original	Treated
Extensibility in length	20%	130%.
Recovery from extension	Rapid	92% recovery rapid. Balance slow but complete.
Extensibility in width	142%	150%.
Recovery from extension	66% rapid	91.5% recovery rapid.
Resistance to runs	Not resistant	Resistant.

Example II

A composite yarn was made by twisting 2½ turns per in. 12's/1 (450 denier) cotton yarn with one end of a 300 denier, 300 filament oriented yarn made from a vinyl chloride-vinyl acetate copolymer resin having 90% of vinyl chloride in the polymer and a macromolecular weight of about 25,000, the said vinyl resin yarn having a tenacity of 2.54 grams per denier, an extensibility of 25.2%, and a shrinkage in boiling water of 90.2%.

This composite yarn was woven to yield a plain fabric having a filling count of 18 and a warp count of 20. The fabric then was immersed in a 50% isopropanol solution of dioctyl phthalate, was centrifuged to remove excess plasticizer, and was air dried to remove the isopropanol. The treated fabric was activated by placing it in a water bath at 60° C. containing 0.25% of a soap, and the temperature of the bath was slowly raised to 70° C. over a thirty minute period, and from thence to 80° C. over a 30 minute period. The fabric then was scoured in a boiling 0.5% aqueous soap solution to remove any unfixed plasticizer and to complete the fabric shrinkage, and then was rinsed in water and dried.

The resultant fabric contained 35.7% of the plasticizer, which is equivalent to 93% of the plasticizer, based upon the dry weight of the vinyl resin yarn. In the process the fabric had shrunk 43.9% in the direction of the filling and 45.9% in the warp direction. The fabric had a soft dry hand, and also the following characteristics:

	Original	Treated
Extensibility in warp direction.	None	75%.
Recovery from extension		95% recovery rapid. Balance slow but complete.
Extensibility in the filling direction.	None	75%.
Recovery from extension		95% recovery rapid. Balance recovery slow.

Example III

A continuous multi-filament oriented 40 denier 20 filament vinyl resin yarn having a tenacity of 2.86 grams per denier, an extensibility of 23%, and a shrinkage in boiling water of 76%, and made from a vinyl chloride-vinyl acetate copolymer resin having a vinyl chloride content of 90%, was knit on a 34 cut circular knitting machine simultaneously with an end of a 35 denier 40 filament yarn made from a vinyl chloride-acrylonitrile copolymer resin having a vinyl chloride content of 55.0%, and a specific viscosity at 20° C. of 0.31. The fabric had 48 stitches per linear inch. It was immersed for five minutes in a 50% isopropanol solution of dioctyl phthalate, and then was centrifuged and air dried to provide a plasticizer pick-up of 44.5%. The fabric then was placed in an 0.25% aqueous soap solution at 50° C., and the temperature gradually raised to 70° C. over a 30 minute period, and maintained at this temperature for 15 minutes. The elasticized fabric finally was scoured in a boiling 0.5% aqueous soap solution for 10 minutes, rinsed with water and dried to yield a fabric having a weight gain of 44.5%, corresponding to a plasticizer content of 83.5%, based upon the weight of the original vinyl chloride-vinyl acetate copolymer resin yarn. The vinyl chloride-acrylonitrile resin yarn did not absorb this plasticizer and remained unplasticized. During the treatment the fabric shrunk 59.5% in length and 36.8% in width. It had a good ultimate tenacity and a soft dry hand. As a result of the treatment the following changes also were noted in the fabric characteristics:

	Original	Treated
Extensibility in length	25%	150%.
Recovery from extension	Rapid	95% recovery rapid. Balance slow but complete.
Extensibility in width	144%	200%.
Recovery from extension	Very slow partial recovery.	95% recovery rapid. Balance slow but complete.
Resistance to runs	Not resistant	Totally run-resistant.

In another treatment of this fabric under identical conditions excepting that the elasticized fabric contained 18% of the plasticizer, corresponding to 33.7% of the original weight of the vinyl chloride-vinyl acetate yarn, the fabric shrunk 64% in length and 38.8% in width during the treatment; and the treated fabric had an extensibility in length of 100% and an extensibility in width of 108%, the recovery of the fabric from extension being substantially 95% complete immediately after release of tension in the direction of length, and 85% complete immediately after tension release in the direction of width. The fabric was totally run-resistant.

Example IV

A continuous 35 denier 40 filament oriented vinyl resin yarn having a tenacity of 3.46 grams per denier, an extensibility of 19.8%, and a shrinkage in boiling water of 81.4%, and made from a vinyl chloride-vinyl acetate copolymer resin having a vinyl chloride content of 90%, was plied 5 turns per in., S, with one end of 40 denier 13 filament nylon. The resultant composite yarn was knit on a 3¾ inch cylinder 34-cut knitting machine to yield a fabric having 26 stitches per linear inch. The knitted fabric then was immersed in a body of tricresyl phosphate, and the fabric then was removed and centrifuged to a weight gain of 35%. It then was activated by being placed in a 0.1% aqueous soap solution at 50° C. and gently agitated while the temperature gradually was raised to 70° C. over a 30-minute period; and then was slowly heated to 90° C. over an additional 30-minute period. The fabric then was scoured in a boiling 0.25% aqueous soap solution to complete the shrinkage of the fabric and remove excess plasticizer. A portion of the fabric then was dyed with 2% of its weight of an acetate type blue dyestuff to yield a uniformly dyed blue fabric. The elasticized fabric had a soft dry hand although having a plasticizer content of 66%, based upon the dry weight of the original vinyl resin yarn. During the treatment the fabric shrunk 69% in length and 36% in width. The following fabric changes resulting from the treatment also were observed:

	Original	Treated
Extensibility in length	25%	150%.
Recovery from extension	Rapid	95% recovery rapid. Balance slow but complete.
Extensibility in width	191%	186%.
Recovery from extension	67% rapid. Incomplete total recovery.	93% recovery rapid. Balance slow but complete.
Resistance to runs	Not resistant	Resistant.

Example V

The same vinyl resin yarn described in Example IV was plied in the same manner with one end of 50 denier 18 filament viscose rayon. The resultant composite yarn was knitted in the manner described in Example IV to produce a fabric having 28 stitches per linear inch. The knitted fabric was soaked in a 50% isopropanol solution of dioctyl phthalate for 5 minutes, and then was removed, air dried and centrifuged to a weight gain of 35%. The fabric then was activated by heat treatment and scoured in the manner described in Example IV. A portion of the treated fabric was dyed with 2% of its weight of a direct type red dyestuff to yield a uniformly dyed attractive red fabric. The finished fabric had a soft dry hand. It had a plasticizer content of 72.2%, based upon the weight of the original vinyl resin yarn. During activation the fabric shrunk 71% in length and 36.4% in width. As a result of the treatment the following changes in the fabric characteristics were noted:

	Original	Treated
Extensibility in length	16.6%	167%.
Recovery from extension	Rapid	95% recovery rapid. Balance slow but complete.
Extensibility in width	172%	183%.
Recovery from extension	63% rapid. Incomplete total recovery.	85% recovery rapid. Balance slow but complete.
Resistance to runs	Not resistant	Resistant.

Example VI

The plied vinyl resin-viscose rayon yarn described in Example V was treated with dioctyl phthalate by coning the composite yarn over an emulsion roll of a Universal winding machine rotating at a speed of 12 revolutions per minute. During the winding the yarn picked up a coating of the plasticizer. The resultant coned yarn was knitted on a 3¾ inch cylinder 34-cut machine to produce a fabric having 36 stitches per linear inch. The fabric was activated and scoured in the manner described in Example IV. The activated fabric had a plasticizer content of 22.9% based on the weight of the composite yarn, which is equivalent to 55.7%, based upon the weight of the vinyl resin yarn component. The fabric thus prepared had a soft dry hand. It was uniformly activated; and the following changes in the properties of the original fabric were noted:

	Original	Treated
Extensibility in length	16.6%	100%.
Recovery from extension	Rapid	83.4% recovery rapid. Balance slow but complete.
Extensibility in width	183%	100%.
Recovery from extension	83.4% rapid. Recovery not complete.	83% recovery rapid. Balance slow but complete.

Example VII

A continuous 35 denier 40 filament oriented vinyl resin yarn having a tenacity of 2.04 grams per denier, an extensibly of 19%, and a shrinkage in boiling water of 82.5%, made from a vinyl chloride-vinyl acetate copolymer resin having a vinyl chloride content of 90%, was plied 5 turns per in., S, with one end of 45 denier 14 filament cellulose acetate rayon. The resultant composite yarn was knitted in the manner described in Example IV to yield a fabric having 28 stitches per linear inch.

The knitted fabric was soaked in triglycol di-2-ethylbutyrate plasticizer after which excess plasticizer was extracted by centrifuging. The thus treated fabric then was activated and scoured in the manner described in Example IV. The activated fabric had a soft dry hand. It showed a weight gain of 31.8%, corresponding to a plasticizer content of 72.6%, based upon the weight of the original vinyl resin yarn component. The fabric shrunk 74% in length and 45.5% in width during the activation. The following important changes in the properties of the fabric resulted from the treatment:

	Original	Treated
Extensibility in length	16.6%	150%.
Recovery from extension	Rapid	89% recovery rapid. Balance slow but complete.
Extensibility in width	17.2%	167%.
Recovery from extension	53% rapid. Recovery not complete.	90% recovery rapid. Balance slow but complete.
Resistance to runs	Not resistant	Run resistant.

Example VIII

The vinyl resin yarn described in Example IV was plied 5 turns per in., S with one end of 45 denier 14 filament cellulose acetate rayon. A 34-cut 3¾ inch cylinder circular knitting machine was equipped with a container for holding a plasticizer, and suitable guides and means for

passing a thread through the plasticizer during a knitting operation. Using this equipment the plied composite yarn was treated with dioctyl phthalate as the yarn moved to the knitting operation. The knitted fabric had 36 stitches per linear inch and had a plasticizer content of 40.3%. The treated fabric was activated in the manner described in Example IV, and was thereafter scoured in the manner therein indicated. The activated fabric contained 37.7% of the plasticizer, corresponding to a plasticizer content of 86.2%, based upon the dry weight of the original vinyl resin yarn.

During the activation the fabric shrunk 60% in length and 33.3% in width. The activated fabric had a uniform texture and a soft dry hand, and possessed elastic properties, also differing from a similar fabric not thus plasticized and activated in the following respects:

	Original	Activated
Extensibility in length	16.6%	117%.
Recovery from extension	Rapid	93% recovery rapid. Balance slow but complete.
Extensibility in width	133.4%	117%.
Recovery from extension	83.4% rapid. Incomplete.	85.5% recovery rapid. Balance slow but complete.
Resistance to runs	Not resistant	Resistant.

Example IX

A continuous 120 denier 84 filament oriented vinyl resin yarn, having a shrinkage in boiling water of over 60%, and made from a vinyl chloride-vinyl acetate copolymer resin having a vinyl chloride content of 90%, was plied 5 turns per in., with one end of 100 denier 100 filament viscose rayon. The resultant composite yarn was treated with dioctyl phthalate during a winding operation to provide the yarn with a plasticizer content of 40%, based upon the weight of the unoiled yarn. The winding machine roll applicator for the plasticizer operated at 20 revolutions per minute, and the yarn was wound at a rate of 250 revolutions per minute. The plasticizer-treated composite yarn then was knitted on a 4½ inch cylinder, 28-cut, circular knitting machine to provide a fabric having 28 stitches per linear inch. The knitted fabric then was activated by heating the same in dry heat, beginning at a temperature of 55° C. and gradually progressing to 70° C. during a 30 minute period. After holding at 70° C. for 10 minutes the temperature was slowly raised to 80° C. and held there for 10 minutes. The resultant fabric was scoured in a 0.5% boiling aqueous soap solution to remove any unfixed plasticizer. The finished fabric was highly elastic, had a soft dry hand, and contained plasticizer in an amount equivalent to 59.2% of the dry weight of the vinyl resin yarn present therein.

Example X

A continuous 100 denier 120 filament oriented vinyl resin yarn having a shrinkage in boiling water of over 60%, and made from a vinyl chloride-vinyl acetate copolymer resin having a vinyl chloride content of 90%, was plied 5 turns per in., with one end of a continuous 70 denier 80 filament yarn that was dimensionally stable in boiling water, and was made from a copolymer of vinyl chloride and acrylonitrile having a vinyl chloride content of 59.4%, and a specific viscosity at 20° C. of 0.421.

The resultant composite yarn was wound on a coning machine. On its passage to the take-up package the yarn contacted an emulsion roll revolving in a trough containing dibutyl sebacate. The composite yarn thereby picked up 55% of its weight of this plasticizer.

The thus-treated yarn then was knitted on a two feed 1¼ inch cylinder 12 gauge knitting machine to produce a fabric having 14 stitches per linear inch. The knitted fabric was activated by immersing in an aqueous 0.13% soap solution at 50° C. and gradually raising the temperature of the solution to 90° C. over a 60-minute period. The thus activated fabric was scoured in a boiling 0.25% aqueous soap solution to remove any excess plasticizer, and then was rinsed with water.

The resultant highly elastic fabric contained plasticizer in amount corresponding to 87.3% of the dry weight of the vinyl chloride-vinyl acetate resin yarn in the fabric.

During the activation the fabric shrunk 76.7% in length and 25% in width. The activated fabric was uniform in texture. Its properties compared with those of the unactivated fabric as follows:

	Original	Activated
Extensibility in length	20%	220.0%.
Recovery from extension	Rapid	Rapid.
Extensibility in width	250%	233%.
Recovery from extension	60% rapid. Incomplete.	86% rapid. Balance slow but complete.
Resistance to runs	Not resistant	Resistant.

In the accompanying drawing, which illustrates one form of a knitted composite fabric embodying the invention, Figs. 1 and 2, respectively, are a side view and a longitudinal sectional view, on an enlarged scale, of a composite knitted fabric made from parallel yarns of the two types, prior to the activation treatment; and Figs. 3 and 4 respectively are a corresponding side view and a longitudinal sectional view of the elasticized fabric. Figs. 5 and 6, respectively, are fragmentary side views, on an enlarged scale, of an element of a composite fabric made from twisted yarns of the two types, before and after the activation step. In the drawing numeral 11 designates a yarn made from an elasticizable vinyl resin yarn, and numeral 12 designates a stretch-limiting, reinforcing yarn.

Among useful articles that can be made from elastic fabrics produced in accordance with the invention are bathing suits, ladies girdles, belts, surgical stockings and bandages, men's sock tops, fabric for shoe uppers, elastic cords, knitted and woven upholstery fabrics, drapery materials, gloves, garters, crepe fabrics, lining materials, elastic adhesion tapes, and numerous other articles. The articles may have one-way or two-way stretch, as desired.

By the use of the invention it is now possible to fabricate, using standard textile processes and equipment, and employing yarns with normal textile properties, sturdy finished fabrics which possess valuable elastic properties, while preserving therein an attractive appearance and a soft dry hand.

The term "stretch-limiting yarn," and similar expressions used in the claims, are intended to designate not only yarns made from such natural fibers as cotton, silk, wool, linen and the like, but also yarns made from synthetic base materials such as organic derivatives of cellulose, e. g., cellulose acetate and viscose rayons; nylon; copolymers of vinyl chloride with acryonitrile; and

other synthetic resins capable of being formed into filaments and yarns that can be knitted or woven on standard textile machines, and which yarns are resistant to attack by plasticizers for the elasticizable vinyl resin yarn component at temperatures up to around 100° C.

The invention is susceptible of modification within the scope of the appended claims.

We claim:

1. Process for producing an elastic composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises gradually heating to a temperature around 100° C. a composite open fabric comprising oriented vinyl resin multi-filament yarns having a shrinkage in boiling water of at least 50% associated with strong stretch-limiting yarns, at least said vinyl resin yarns being coated with a plasticizer for such resin which is a non-solvent for the resin at temperatures around 25° C., and which does not substantially plasticize the stretch-limiting yarns at temperatures as high as 100° C., the total time of heating such fabric at temperatures up to 70° C. being sufficient to fix the plasticizer within the oriented vinyl resin yarns of the fabric, thereby fixing the plasticizer in said vinyl resin yarns and reducing the area of the fabric at least 50%, and removing any unfixed plasticizer from the fabric, thereby producing a run-resistant composite elastic fabric having an extensibility under tension of at least 100% in at least one direction and a recovery of at least 85% of the original length rapidly upon release of such tension and a slow recovery of the balance thereof.

2. Process for producing an elastic composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises heating to about 100° C. a composite non-elastic open fabric comprising an oriented vinyl resin yarn laid in parallel and knitted with an end of a reinforcing, stretch-limiting yarn, at least said vinyl resin yarn having a shrinkage in boiling water of at least 50% and being coated with a plasticizer for such resin which is a non-solvent for the resin at temperatures around 25° C., and which does not substantially plasticize the stretch-limiting yarn at temperatures as high as 100° C., the total time of heating such fabric at temperatures below 70° C. being at least sufficient to fix the plasticizer within said vinyl resin yarn, thereby reducing the area of the fabric at least 50% and uniformly plasticizing the vinyl resin yarns, and removing any unfixed plasticizer from the resultant elastic composite fabric having an extensibility under tension of at least 100% in at least one direction and a quick recovery of at least 85% of the original length upon release of such tension and a slow recovery of the balance thereof.

3. Process for producing an elastic run-resistant composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises compositing oriented multi-filament yarn made from a resinous copolymer of vinyl chloride and vinyl acetate with a reinforcing stretch-limiting yarn, at least the filaments of said resin yarn being coated with a plasticizer for such resin which is not a plasticizer for such stretch-limiting yarn at temperatures at least as high as 100° C., said plasticizer being present in amount sufficient to provide the composite yarn with a plasticizer content between around 30% and around 95%, based upon the weight of the vinyl resin yarn component, forming an open fabric from said composite yarn, heating the fabric to around 100° C., for a time sufficient to shrink the fabric at least 50% in area, the total time of heating of such fabric at temperatures below 70° C. being sufficient to fix the plasticizer within said vinyl resin yarn, thereby fixing the plasticizer in said vinyl resin yarn, converting the latter to the elastic form and shrinking the fabric, and thereafter scouring the fabric in an aqueous solution containing a detergent, thereby producing an elastic run-resistant composite fabric having an extensibility of at least 100% in at least one direction under tension, a rapid recovery of at least 85% of the original length upon release of the stretching tension, and a slow recovery of the balance of the original length.

4. Process for producing an elastic run-resistant composite fabric which is strong, resilient, and dimensionally stable in the untensioned state in boiling water, which comprises plying oriented multi-filament yarn made from a resinous copolymer of vinyl chloride and vinyl acetate with a strong stretch-limiting yarn, applying to the surface of the resultant composite yarn sufficient of a plasticizer for the said vinyl resin yarn which does not soften the stretch-limiting yarn at temperatures as high as 100° C. to provide the composite yarn with a plasticizer content between around 30% and around 95%, based upon the weight of said vinyl resin yarn component, forming an open fabric from said treated composite yarn, and heating the fabric to around 100° C. for a period sufficient to shrink the fabric at least 50% in area, the rate of heating of the fabric within the range between 60° C. and 70° C. being between about 0.33° C. and about 1° C. per minute, and scouring the resultant fabric in an aqueous solution of a detergent.

5. Process for producing an elastic composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises impregnating a composite non-elastic open fabric comprising oriented vinyl resin multi-filament yarns associated with strong stretch-limiting yarns with a plasticizer for said vinyl resin which is not a plasticizer for said stretch-limiting yarns at temperatures as high as 100° C., said vinyl resin yarns being made from a resinous copolymer of vinyl chloride and vinyl acetate having between about 80% and about 95% of the chloride in the polymer, being formed from filaments each of which is less than 20 denier, and having a shrinkage in boiling water of at least 50%, activating the impregnated non-elastic composite fabric by heating the same to a temperature around 100° C., the total time of heating such fabric at temperatures up to 70° C. being sufficient to fix the plasticizer within the oriented yarns, continuing the gradual heating of the fabric to around 100° C., thereby reducing the area of the fabric at least 50% and uniformly plasticizing the filaments of the vinyl resin yarns, and removing any excess plasticizer from the fabric, thereby producing a composite elastic fabric having an extensibility of at least 100% in at least one direction under tension, and a rapid recovery of at least 85% of the original length upon release of the stretching tension.

6. Process for producing an elastic composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises impregnating a non-elastic composite open fabric comprising oriented vinyl resin multi-filament yarns associated with

strong stretch-limiting yarns with a plasticizer for said vinyl resin which is not a plasticizer for said stretch-limiting yarns at temperatures as high as 100° C., said vinyl resin yarns being made from a resinous copolymer of vinyl chloride and vinyl acetate having between about 80% and about 95% of the chloride in the polymer, being formed from oriented filaments each of which is less than 20 denier, and having a shrinkage in boiling water of at least 50%, activating the impregnated non-elastic composite fabric by heating the same to around 100° C., the rate of heating of such fabric in the range between 60° C. and 70° C. being between about 0.33° C. and about 1° C. per minute, thereby reducing the area of the fabric at least 50% and fixing the plasticizer within the filaments of said vinyl resin yarns, and removing any unfixed plasticizer from the fabric by scouring the latter in an aqueous solution containing a detergent, thereby producing a composite elastic fabric having an extensibility under tension of at least 100% in at least one direction and a rapid recovery of at least 85% of the original length upon release of the stretching tension, and a slow recovery of the balance of the original length.

7. Process for producing an elastic composite fabric which is strong, resilient, and dimensionally stable in the untensioned state in boiling water, which comprises applying to a non-elastic composite open fabric, comprising oriented vinyl resin multi-filament yarns plied with reinforcing stretch-limiting yarns, between about 30% and about 95%, based upon the weight of the vinyl resin yarn, of a plasticizer for said vinyl resin which is not a plasticizer for said stretch-limiting yarns at temperatures as high as 100° C., said vinyl resin yarns being made from a resinous copolymer of vinyl chloride and vinyl acetate having between about 80% and about 95% of the chloride in the polymer and an average macromolecular weight of at least 15,000, and being formed from filaments each of which is less than 20 denier, said yarns having a shrinkage in boiling water of at least 50%, said two types of yarns being plied with between one and eight turns per inch twist, heating the impregnated non-elastic composite fabric to a temperature around 100° C., the rate of heating of such fabric in the range between about 60° C. and about 70° C. being between about 0.33° C. and about 1° C. per minute, thereby shrinking the fabric at least 50% in area and fixing the plasticizer in said vinyl resin yarns, and removing unfixed plasticizer from the fabric, thereby producing a run-resistant composite elastic fabric having an extensibility of at least 100% in at least one direction under tension, and a rapid recovery of at least 85% of the original length upon release of the tension.

8. Process for producing an elastic composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises applying to a composite open fabric, comprising oriented vinyl resin multi-filament yarns associated with strong stretch-limiting yarns, between around 30% and around 95%, based upon the dry weight of said vinyl resin yarn component of the fabric, of a plasticizer for said vinyl resin which does not plasticize or weaken said stretch-limiting yarns at temperatures as high as 100° C., said vinyl resin yarns being made from a resinous copolymer of vinyl chloride and vinyl acetate having between about 80% and about 95% of the chloride in the polymer, being formed from filaments each of which is less than 20 denier, and having a residual shrinkage in boiling water of at least 50%, removing excess plasticizer from the fabric, activating the impregnated non-elastic composite fabric by heating the same while untensioned to a temperature around 100° C., the rate of heating of such fabric within the range between 60° C. and 70° C. being between about 0.33 C. and about 1° C. per minute, thereby shrinking the fabric at least 50% in area and elasticizing the filaments of said vinyl resin yarns, and removing any unfixed plasticizer from the fabric at temperatures of at least 80° C., thereby producing a run-resistant composite elastic fabric having an extensibility of at least 100% under tension, and a rapid recovery of at least 85% of the original length upon release of the tension.

9. Process for producing an extensible composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises impregnating a non-elastic composite open fabric comprising oriented vinyl resin multi-filament yarns associated with strong stretch-limiting yarns with a plasticizer for said vinyl resin which is not a plasticizer for said stretch-limiting yarns at temperatures as high as 100° C., said vinyl resin yarn being made from a resinous copolymer of vinyl chloride and vinyl acetate having between about 80% and about 95% of the chloride in the polymer, being formed from filaments each of which is less than 20 denier, and having a shrinkage in boiling water of at least 50%, activating the impregnated non-elastic composite fabric in the absence of tension sufficient to prevent at least 50% shrinkage in area of the fabric by heating the fabric to a temperature around 100° C., the rate of heating of such fabric within the range between around 60° C. and around 70° C. being between about 0.33° C. and 1° C. per minute, thereby shrinking the fabric at least 50% in area and elasticizing said vinyl resin yarns, and removing any unfixed plasticizer from the fabric, thereby producing a run-resistant composite elastic fabric having an extensibility of at least 100% under tension, and a rapid recovery of at least 85% of the original length upon release of the tension.

10. Process for producing an elastic run-resistant composite fabric which is strong, resilient and dimensionally stable in the untensioned state in boiling water, which comprises compositing oriented multi-filament yarn made from a resinous copolymer of vinyl chloride and vinyl acetate with a relatively non-extensible stretch-limiting yarn, at least the filaments of said resin yarn being coated with a plasticizer for such resin which is not a plasticizer for such stretch-limiting yarn at temperatures at least as high as 100° C., forming a fabric from the composite yarn, and heating the fabric to a temperature around 100° C. while free from tension, the rate of heating of the fabric within the range between 60° C. and 70° C. being between about 0.33° C. and about 1° C. per minute, and further heating the fabric to around 100° C., thereby shrinking the fabric at least 50% in area and fixing the plasticizer within the resin yarn, and thereafter scouring the fabric in an aqueous solution of a detergent to remove any unfixed plasticizer.

11. Process as defined in claim 1, wherein said stretch-limiting yarns are made from an organic derivative of cellulose.

12. Process as defined in claim 1, wherein the stretch-limiting yarns are made from nylon.

13. Process as defined in claim 1, wherein the stretch-limiting yarns are made from a copolymer of vinyl chloride and acrylonitrile having between about 45% and about 80% of the chloride in the polymer, and having a specific viscosity at 20° C. between 0.2 and 0.6.

14. Elastic composite fabrics made by the process defined in claim 1.

15. Elastic composite fabrics made by the process defined in claim 3.

16. Elastic composite fabrics made by the process defined in claim 5.

17. Elastic composite fabrics made by the process defined in claim 7.

18. An elastic run-resistant composite fabric which is strong, flexible and dimensionally stable in boiling water, which fabric comprises an elastic yarn made from a vinyl resin formed by the conjoint polymerization of a vinyl halide and a vinyl ester of a lower aliphatic acid and having between 80% and 95% of the halide in the polymer associated with another yarn made from at least one reinforcing stretch-limiting textile material, at least the first-named elastic yarn having been produced in situ in the fabric by conversion of a non-elastic vinyl resin yarn component of the fabric under conditions preventing bonding of such elastic yarn with the stretch-limiting yarn, said elastic yarn containing a plasticizer for said vinyl resin which does not plasticize nor weaken said other yarn at temperatures as high as 100° C., the said fabric being readily extensible at least 100% in at least one direction, and having a rapid recovery from such extension of at least 85% of such extension, with a slow recovery of the balance thereof.

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