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(54) **CONTROLLED AIR PERMEABILITY COMPOSITE FABRIC ARTICLES HAVING ENHANCED SURFACE DURABILITY**

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(60) Provisional application No. 60/493,275, filed on Aug. 7, 2003. Provisional application No. 60/626,027, filed on Nov. 8, 2004. Provisional application No. 60/674,535, filed on Apr. 25, 2005.

**Publication Classification**

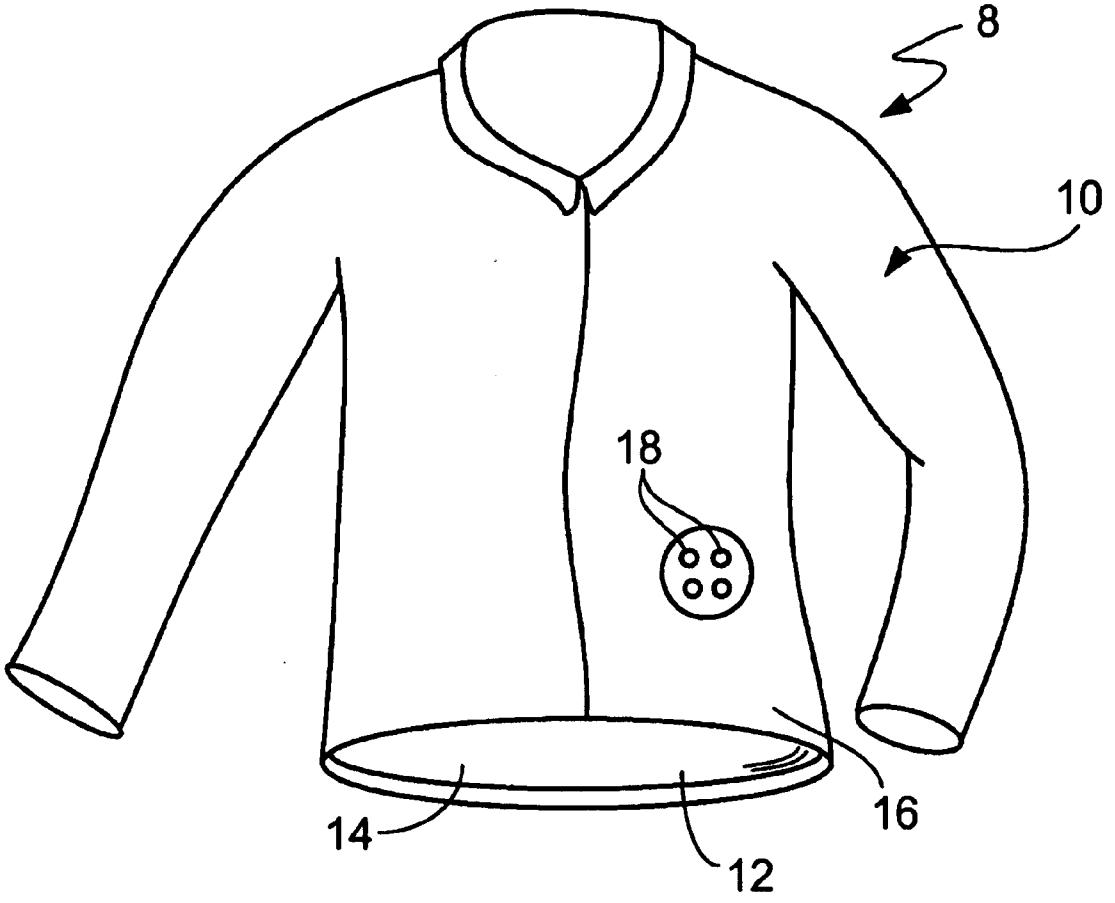
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| ***D04B 21/00*** | (2006.01) |

(52) **U.S. Cl.** ..... **428/85**; 442/304; 428/95

(57) **ABSTRACT**

A fabric article of knitted or woven construction with multi-filament, interlaced yarns has at least one pile or raised or fleece region on its inner surface and at least one discontinuous coating region of binder material on its outer surface. The binder material provides improved durability against pilling and fraying without substantial adverse effect on characteristics of the base fabric. The same or different binders and/or the same or different densities of binders may be applied to one or more selected regions of the fabric surface using engineered printing technology, the binder regions resisting napping to create predetermined non-raised or non-fleece regions of contrasting thermal insulation and/or breatheability conforming to needs of underlying corresponding regions of the wearer's body. Methods of forming the fabric articles are also described.



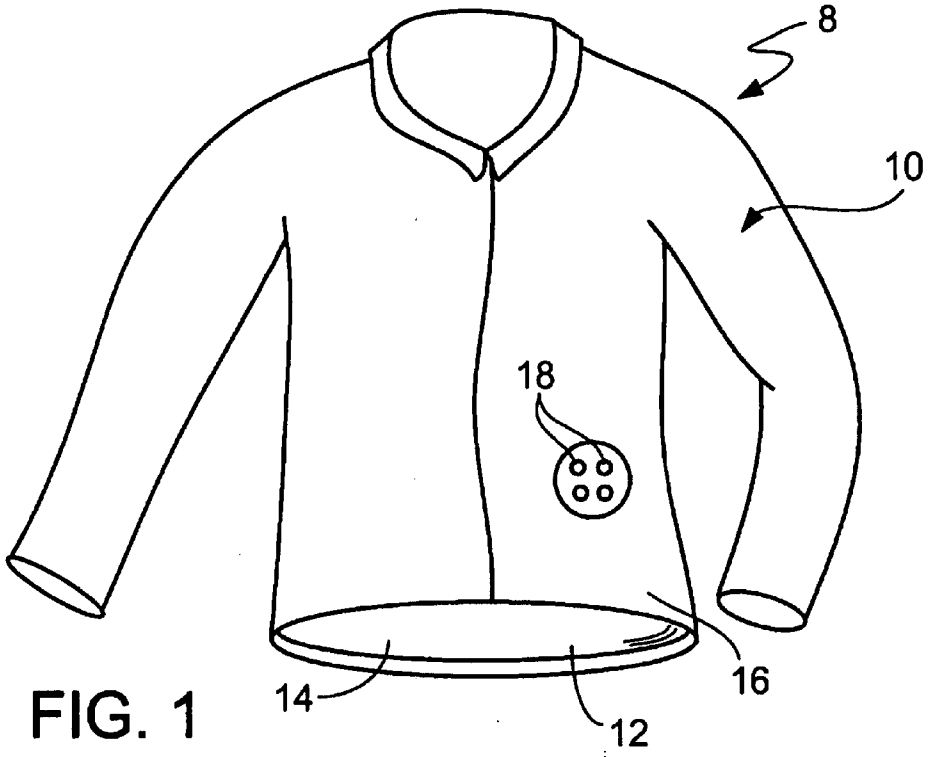



FIG. 1

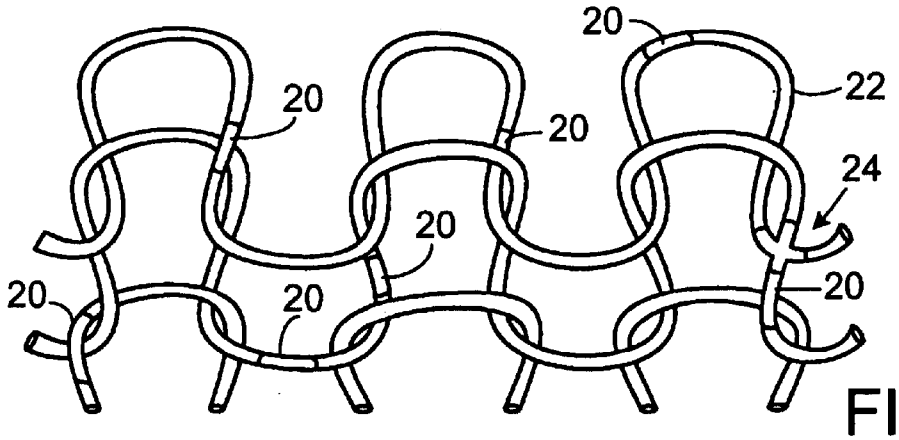



FIG. 2

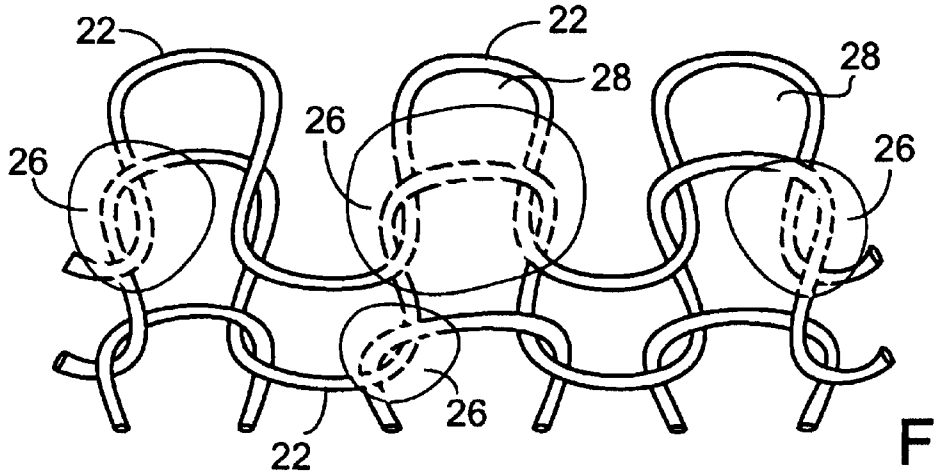



FIG. 3

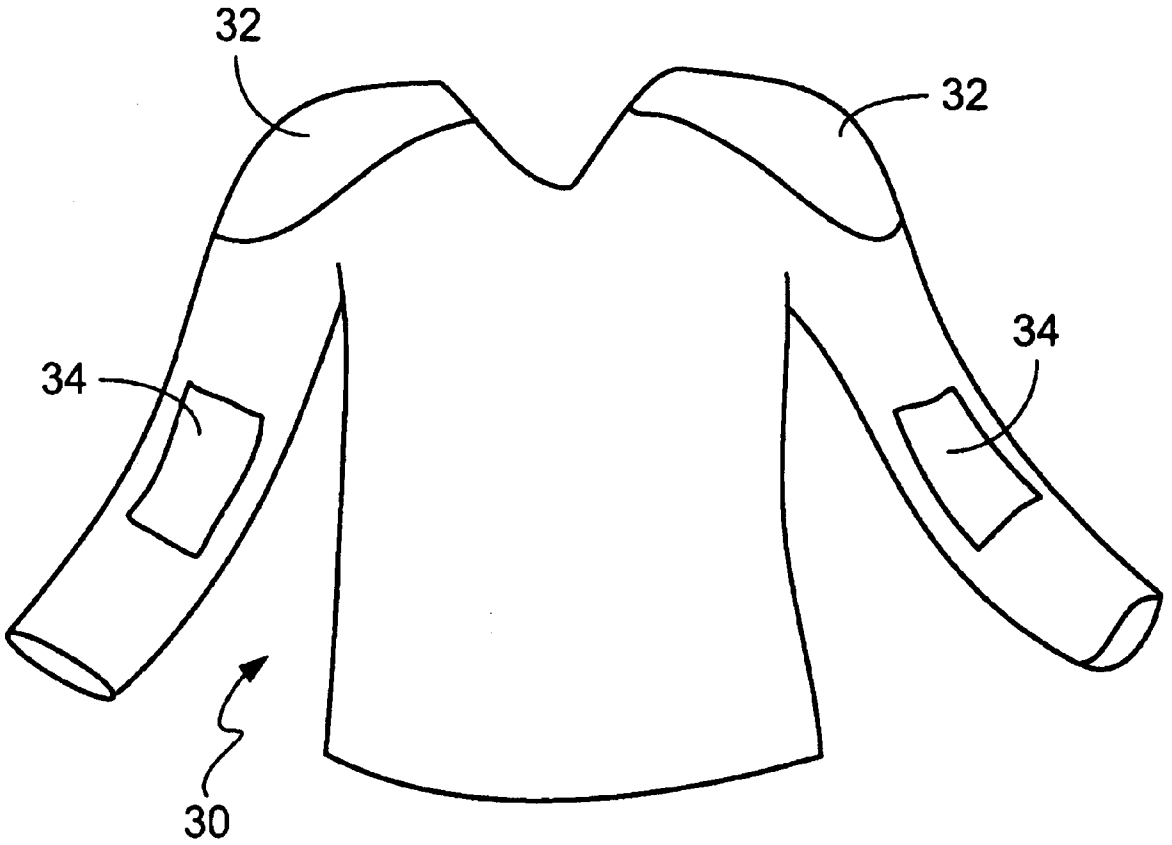



FIG. 4

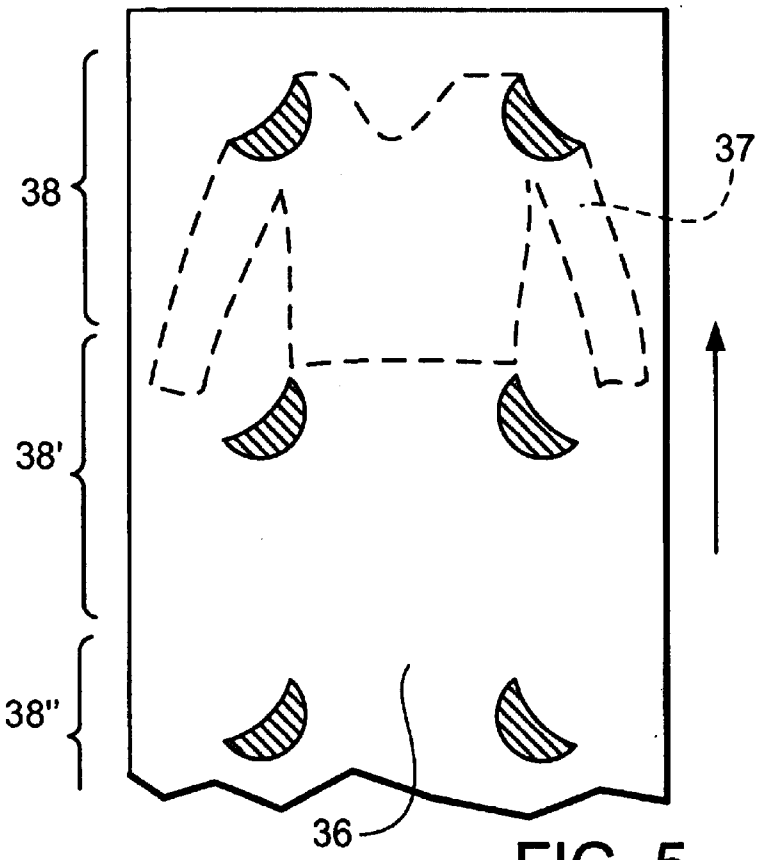



FIG. 5

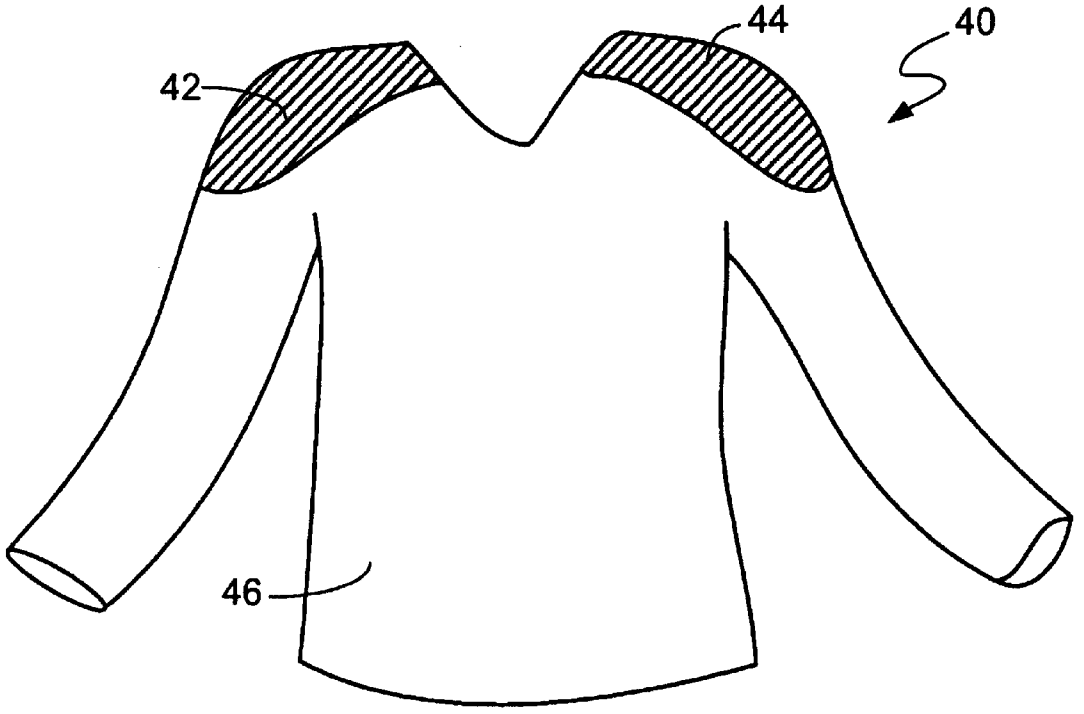



FIG. 6

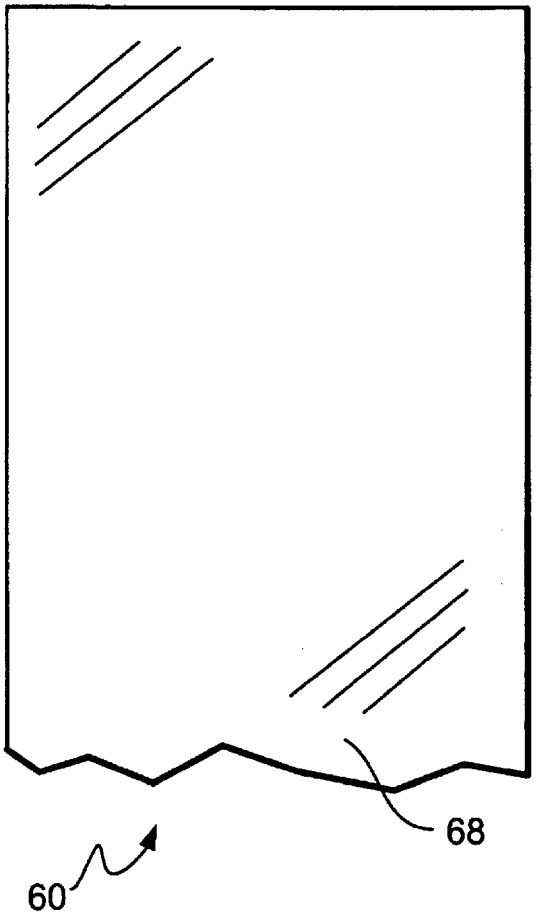



FIG. 7

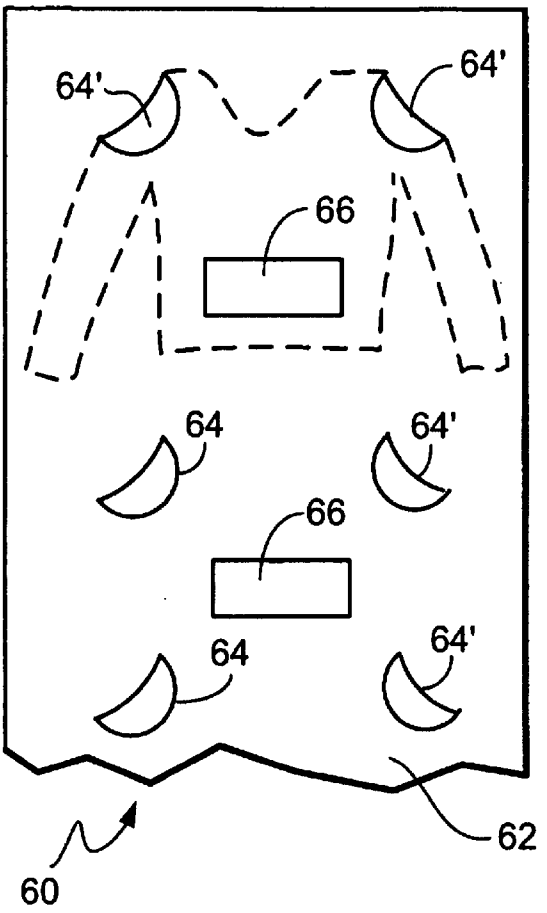



FIG. 8

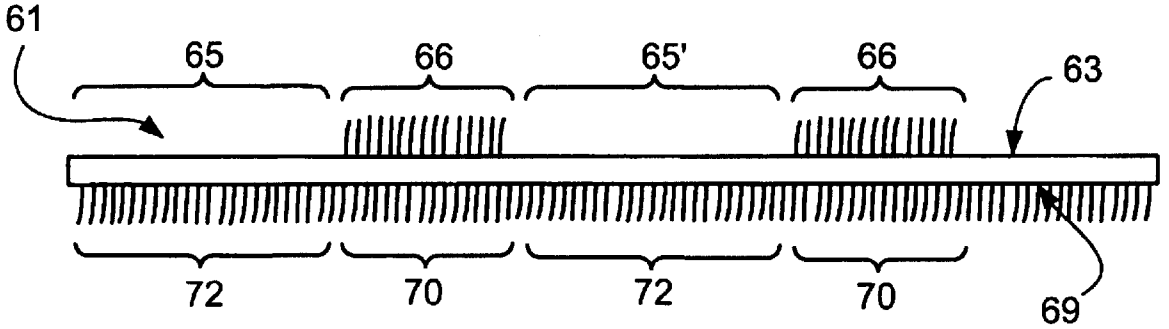



FIG. 9

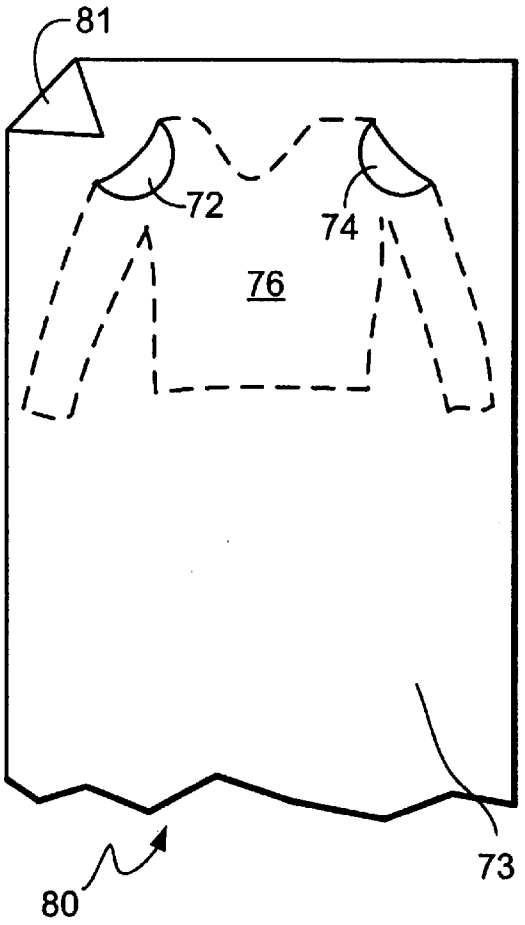



FIG. 10

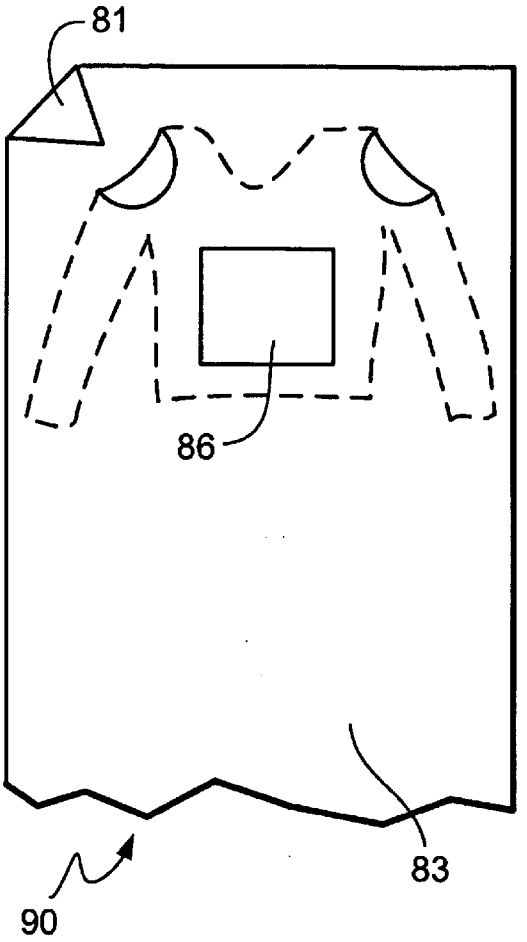



FIG. 11

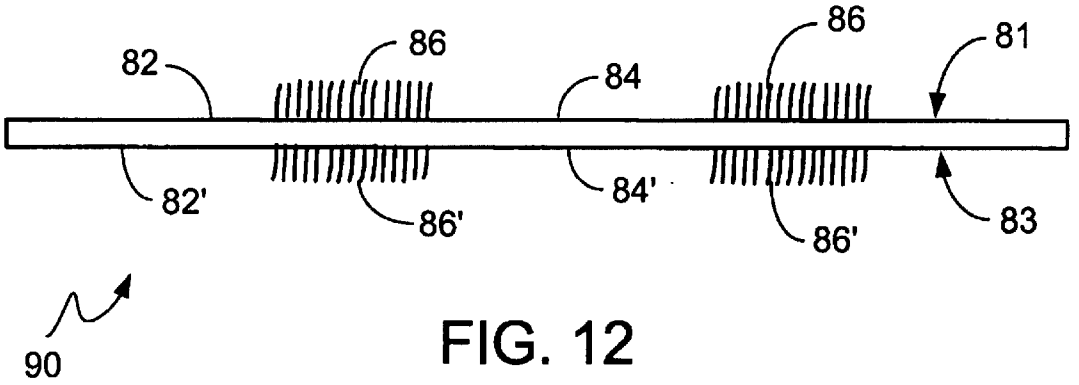



FIG. 12

# CONTROLLED AIR PERMEABILITY COMPOSITE FABRIC ARTICLES HAVING ENHANCED SURFACE DURABILITY

## TECHNICAL FIELD

[0001] This application is a continuation-in-part of U.S. application Ser. No. 10/911,855, filed Aug. 5, 2004, now pending, which claims benefit from U.S. Provisional Application No. 60/493,275, filed Aug. 7, 2003, now expired. This application also claims benefit from U.S. Provisional Application No. 60/626,027, filed Nov. 8, 2004, now pending, and from U.S. Provisional Application No. 60/674,535, filed Apr. 25, 2005, now pending.

[0002] This document relates to composite fabric articles.

## BACKGROUND

[0003] Fabric articles, such as jackets and other outer wear, with qualities desired for use during exercise or exertion, especially warmth and breatheability, may be formed, e.g., by circular knit plaited construction or circular knit reverse plaited construction with a relatively smooth outer surface (the "technical face") and an inner surface (the "technical back") that can be raised, e.g. by processes such as napping, brushing, sanding, etc., to form an insulating layer of fleece. Unfortunately, in both knit constructions, the durability of the smooth technical face is inferior to many woven constructions, limiting use of the knit constructions in articles intended for harsher outdoor sports. In particular, the fuzziness of the smooth technical face will often have an inferior aesthetic look, as well as poor technical features. The smooth face also tends to fuzz out as the surface picks up snow, which it will not shed easily, to fuzz out during rock climbing, and to fuzz out in specific areas of a garment, e.g. at the elbows or at the shoulders, under the straps of a backpack.

[0004] Composite fabric articles are achieved by joining at least one material to a fabric body to attain desirable properties that cannot be attained by the fabric body alone. Laminar composites, e.g. having multiple layers joined by an adhesive, are sometimes employed to increase the thermal resistance of a fabric body. However, the feel (e.g., drapability, hand tactile, etc.) of a fabric is often substantially decreased by laminating one or more additional layers of material to the fabric body.

## SUMMARY

[0005] According to one aspect, a fabric article with knitted or woven construction of multi-filament, interlaced yarns has an inner surface and an outer surface. The inner surface has at least one region of pile or raised fibers or fleece formed thereupon and the outer surface has at least one region of a non-continuous coating of binder material adhered to yarns and to yarn fibers, e.g. at least at interlacing intersections, for enhanced durability of the outer surface against pilling or fraying during use.

[0006] Preferred implementations of this aspect may include one or more of the following additional features. The fabric article has construction selected from the group consisting of a plaited circular knit construction, reverse plaited circular knit construction, woven construction, and warp knit construction. The fabric article is an article of wearing apparel. The multi-filament yarns are textured or flat. The multi-filament yarns comprise fibers formed of materials selected from the group consisting of: polyester, nylon and polypropylene. The multi-filament yarns comprise spun yarns formed of materials selected from the group consisting of: natural fibers, synthetic fibers, and blends thereof. The multi-filament yarns of the outer surface comprise spandex. Fibers of the multi-filament yarns are highly intermingled at over at least about 10 tucks per meter (TPM), preferably at over about 60 TPM, and more preferably at over about 100 TPM, or more, or there may be little or no intermingling. The binder material adheres to yarn fibers in a manner to substantially avoid restriction of air permeability through the fabric article. Alternatively, the binder material comprises a film extending into interstitial air passageways through the fabric article in a manner to reduce air permeability. The region of non-continuous coating of binder material is without substantial adverse effect on drapability and hand of the fabric article. The region of non-continuous coating comprises one or more first regions of enhanced surface durability due to relatively greater density of binder or binder dots per unit area, and/or due to relatively greater durability of a first binder material, applied by engineered pattern printing technology to a fabric web. Preferably the one or more first regions comprises at least shoulder or elbow regions. The outer surface of the fabric article further comprises one or more second regions of relatively lesser surface durability due to relatively lesser density, including no or negligible density, of binder or binder dots per unit area, and/or due to relatively lesser durability of a second binder material, applied by engineered pattern printing technology to a fabric web. Preferably, the one or more second regions comprises at least body regions. One or more of the second other regions of relatively lesser surface durability have no or only negligible density of second binder material per unit area. Preferably, one or more of the second other regions of the outer surface comprises regions of pile or raised fibers or fleece and one or more of the first regions of the outer surface remains non-raised or smooth face. More preferably, the one or more second other regions comprises at least body regions of the fabric article.

[0007] According to another aspect, a method of forming a fabric article comprises the steps of: interlacing yarns comprising multi-filament fibers to form a fabric body of knit or woven construction, forming one or more raised or fleece regions upon an inner surface of the fabric body; and, thereafter, applying binder material to one or more regions of the outer surface of the fabric article to form a discontinuous coating of binder material upon yarn fibers, e.g. at least at interlacing intersections, on at least the outer surface of the fabric article, to resist pilling and fraying of yarn fibers at the outer surface.

[0008] Preferred implementations of this aspect may include one or more of the following additional features. The step of applying binder material comprises applying binder material by standard printing technology, e.g., selected from the group consisting of: rotary screen roll printing, gravure roll printing, and ink jet printing. The step of applying binder material comprises applying the binder material with a kiss roll. The method further comprises removing binder material in liquid state from interstitial spaces of the fabric body in a manner to control reduction of air permeability. The step of removing binder material comprises blowing air through the interstitial spaces or drawing air by suction through the

interstitial spaces. The step of applying binder material comprises applying one or more binder materials in one or more forms selected from the group consisting of: resin, latex, polymer emulsion, polymer dispersion, and plastisol system. Preferably, the binder material is selected from the group consisting of: melamine, acrylate, polyurethane, silicon, poly vinyl chloride, epoxy, and blends thereof. The step of applying binder material to one or more regions of an outer surface comprises the steps of: applying first binder material to one or more regions by screen printing techniques in a first pattern, and applying second binder material different from the first binder material to one or more regions by screen printing techniques in a second pattern not overprinting the first pattern. The step of applying binder material comprises applying binder material in a liquid carrier and allowing the liquid carrier to evaporate leaving the binder material or applying binder material in a foam liquid carrier and allowing the foam carrier to collapse leaving the binder material. The step of applying binder material comprises applying binder material by engineered pattern printing technology to a fabric web. Preferably, binder material is applied by engineered pattern printing techniques to form one or more first regions of enhanced surface durability by applying a first pattern of binder material with relatively greater density of binder or binder dots per unit area, e.g. to shoulder regions and/or to elbow regions, and to form one or more second other regions of relatively lesser surface durability by applying a second pattern of binder material with relatively lesser density of binder or binder dots per unit area, e.g. to body regions. The step of applying binder material by engineered printing technology to a fabric web comprises the steps of: forming one or more first regions of enhanced surface durability by applying a first pattern with relatively greater density of binder or binder dots per unit area, and forming one or more second other regions of relatively lesser surface durability by applying no or only negligible density of binder or binder dots per unit area. The step of forming one or more first regions of enhanced surface durability comprises applying the first pattern of binder material to each first region, the binder material and/or the pattern being the same or different from region to region, with relatively greater density of binder or binder dots per unit area upon, e.g., shoulder regions and/or elbow regions. The step of forming one or more second other regions of relatively lesser surface durability comprises forming second other regions upon, e.g., body regions. The method comprises a further step performed after applying binder to the one or more first regions of enhanced surface durability, the further step comprising raising or napping the one or more second regions bearing little or only negligible density of binder or binder dots per unit area to form fleece or velour. The method comprises the steps of, prior to forming a raised or fleece region upon an inner surface of the fabric body, applying binder material to one or more predetermined regions of the inner surface by engineered printing technology, and generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing. The method comprises the further step of forming the fabric body by plaited knit construction. Preferably, the fabric body is circular knit with terry sinker loop. Applying binder material to one or more regions of an inner surface of the fabric body is synchronized with wet printing in other regions.

[0009] According to another aspect, a method of forming a fabric article comprises the steps of: interlacing yarns comprising multi-filament fibers to form a fabric body of knit or woven construction, forming one or more raised or fleece regions upon an outer surface of the fabric body, applying binder material to one or more regions of an inner surface of the fabric body to form a discontinuous coating of binder material upon yarns fibers, e.g. at least at interlacing intersections, on at least the inner surface of the fabric body, and generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing.

[0010] Preferred implementations of this aspect may include one or more of the following additional features. The method further comprises the steps of: applying binder material to the inner surface of the fabric body in a manner to cause the binder material to penetrate to the outer surface of the fabric body, and generating, upon the outer surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the outer surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing. The method further comprises the step of: generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing, one or more raised or fleece regions of the inner surface of the fabric body being in registration with one or more raised or fleece regions of the outer surface of the fabric body. The method comprises the further step of forming the fabric body by reverse plaited knit construction. Preferably, the fabric body is circular knit with terry sinker loop. Applying binder material to one or more regions of an inner surface of the fabric body is synchronized with wet printing in other regions.

[0011] There is thus provided a composite fabric article that overcomes the recognized deficiencies of fabrics of knit construction, discussed above, in particular when used in garments and other articles for harsher outdoor sports, without detracting significantly from qualities of the original form of the fabric found highly desirable for use during exercise or exertion, e.g., warmth, breatheability, drapability, MVT, hand tactile, etc. Furthermore, improved fabric articles have a predetermined, controlled, i.e., limited, degree of air permeability or breatheability and/or thermal insulation performance may be formed according to the described methods.

[0012] The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

## DESCRIPTION OF DRAWINGS

[0013] **FIG. 1** is a somewhat diagrammatic front plan view of an example of a fabric article or garment, here, a jacket, with an insulating layer of fleece on one or more regions of the inner surface and a non-continuous coating of binder material on one or more regions of the outer surface, for enhanced surface durability.

[0014] **FIG. 2** is a somewhat diagrammatic plan view of the outer surface of a fabric body with a non-continuous coating of binder material for enhanced surface durability against fraying and pilling adhered to yarns and yarns fibers about an interstitial space; and

[0015] **FIG. 3** is a somewhat diagrammatic plan view of the outer surface of a fabric body with a non-continuous coating of binder material for enhanced surface durability against abrasion, fraying and pilling adhered to yarns and yarns fibers and also extending into interstitial spaces for increased wind resistance.

[0016] **FIG. 4** is a rear plan view of an example of a fabric article or garment formed in part of an element of a fabric web and having enhanced durability regions, e.g., at the shoulder and at the elbows.

[0017] **FIG. 5** is a plan view of a fabric web printed with a series of predetermined patterns of binder material applied in a non-continuous coating by engineered pattern printing technology to form fabric article elements with regions of enhanced surface durability; and

[0018] **FIG. 6** is a plan view of an example of a fabric garment, here, a shirt, formed in part of an element cut from the fabric web of **FIG. 5** and having enhanced surface durability regions, e.g., at the shoulders.

[0019] **FIG. 7** is a first plan view of a fabric web of plaited knit construction; and **FIG. 8** is a second, opposite plan view of the fabric web of **FIG. 7** printed with a series of predetermined patterns of binder material applied by engineered pattern printing technology to form predetermined raised or fleece regions among contrasting non-raised or non-fleece regions for enhanced thermal insulation and/or breatheability performance.

[0020] **FIG. 9** is a somewhat diagrammatic side section view of a fabric article cut from a fabric web of reverse plaited knit construction, with an engineered pattern ("body mapping") of predetermined regions of double face raised or fleece fabric and predetermined regions of single face raised or fleece fabric with an opposite surface that was napped prior to application of the binder material.

[0021] **FIG. 10** is a plan view of a fabric web printed with a series of predetermined patterns of binder material applied by engineered pattern printing technology to form regions of raised or fleece fabric and contrasting regions of non-raised or non-fleece fabric upon one face of a fabric web, the opposite face being napped.

[0022] **FIG. 11** is a plan view of a fabric web printed with a series of predetermined patterns of binder material applied by engineered pattern printing technology to form regions an engineered pattern ("body mapping") with regions of raised or fleece fabric and regions of non-raised or non-fleece fabric in register upon both faces of a fabric web.

[0023] **FIG. 12** is a somewhat diagrammatic side section view of a fabric article cut from the fabric web of **FIG. 1** with an engineered pattern ("body mapping") with regions of raised or fleece fabric and contrasting regions of non-raised or non-fleece fabric in register upon both faces of a fabric web.

[0024] Like reference symbols in the various drawings indicate like elements.

## DETAILED DESCRIPTION

[0025] Referring to **FIG. 1**, a fabric article of wearing apparel **8**, in this case, by way of example only, a jacket, is formed of an improved composite fabric **10**. The fabric has an inner surface **12**, upon which is formed at least one insulating region of fleece **14**, and an outer surface **16**, upon which is adhered a discontinuous coating **18** of binder or coagulant material, e.g., as used herein including latex, polymer or resin in emulsion, dispersion or plastisol, for enhanced surface durability, e.g. against pilling and fraying. Referring also to **FIG. 2**, in a preferred implementation, regions **20** of binder or coagulant material are adhered primarily to yarn fibers **22** and at interlacing intersections of yarns **24**, thereby allowing the fabric to retain its original form and characteristics, including good drapability and hand, and allowing through-passage of air to a predetermined degree (MVT and breatheability), but also providing an outer surface of enhanced durability, e.g. against pilling and wear, e.g. during exercise and harsher outdoor sports.

[0026] Referring to **FIG. 3**, in other implementations, as described more fully below, the binder material forms a film **26** that constricts (but preferably does not block) interstitial spaces **28** between yarns **22**, thereby to reduce air-permeability and provide increased insulation and warmth, for use in particular under colder and windier conditions.

[0027] In a first example of a fabric article to be provided with an outer surface of enhanced durability, the fabric has a plaited circular knit construction, e.g., as described in *Knitting Technology*, by David J. Spencer (Woodhead Publishing Limited, 2nd edition, 1996), the entire disclosure of which is incorporated herein by reference, with a smooth outer surface (technical face) and a raised inner surface (technical back). The stitch yarn forming the technical face is preferably a filament yarn of textured filaments formed of synthetic material, e.g. polyester, nylon or polypropylene, the yarn fibers or filaments having a high level of intermingling, e.g. over at least about 10 tucks per meter, preferably over about 60 tucks per meter, and more preferably over about 100 tucks per meter, to reduce the tendency of individual fibers to fray or catch and later on to pill. In preferred implementations, the yarn has a fineness of 0.2 to 3.0 denier per filament (dpf). Fraying is a particular concern in multi-fiber yarns, especially with yarns of fine dpf, e.g. 0.2 to 1.5.

[0028] In a second example of a fabric article to be provided with the outer surface of enhanced durability, the fabric has a reverse plaited circular knit construction, where the raised surface can be formed on the loop yarn, either on

the loop side (technical back), which is preferred, or on the smooth side (technical face). The technical back can be any of a variety of constructions, e.g., knit and/or knit-tuck and/or knit-welt and/or knit-tuck-welt in a variety of combinations.

[0029] To avoid restricting or reducing the capability of maximizing the bulk of the raised or fleece surface at the technical back, the fabric articles of knit construction are preferably finished before application of the binder material to the outer surface.

[0030] In yet another example, the fabric has a woven construction of synthetic, multi-filament, textured yarn. Spandex is incorporated into the yarn, e.g. in air tuck, cover or core spun position, to provide the fabric with two-way or one-way stretch.

[0031] In still another example, the fabric upon which a surface of enhanced durability is to be formed has a warp knit construction, e.g. as described in U.S. Pat. No. 6,196,032, issued Mar. 6, 2001, and in U.S. Pat. No. 6,199,410, issued Mar. 13, 2001, the complete disclosures of which are incorporated herein by reference.

[0032] A fabric article, e.g. from the examples described above, may be treated to provide an outer surface of enhanced durability by applying binder material to reduce fiber fraying and minimize pilling.

[0033] Referring to **FIG. 4**, in a preferred implementation, a chemical binder material for forming a surface region of enhanced durability surface is applied to the smooth outer surface of the fabric article **30** using standard printing technology, e.g. rotary or gravure roll or by ink jet printing. The binder is preferably applied, e.g., to shoulder regions **32** and/or to elbow regions **34**, in a non-continuous coating, e.g. a pattern of separate dots. Any suitable chemical binder material may be employed. Examples of such binders include resin (such as melamine), latex (such as acrylate), polymer emulsions or dispersions (such as silicon, polyurethane, poly vinyl chloride (PVC), or epoxy). The binder is preferably selected to have a dry hand upon curing or drying, i.e. not tacky to the touch, good stretch/recovery, and good bond to textile fibers.

[0034] In another preferred implementation, referring to **FIGS. 5 and 6**, a suitable binder material for forming a region of enhanced surface durability is applied by engineered pattern printing technology to a fabric web **36** (**FIG. 5**). For example, in **FIG. 6**, a shirt **40**, formed with an element **37** cut from fabric web **36**, has surface regions **42**, **44** of enhanced durability at the shoulders, which are more prone to abrasion and wear when carrying a backpack. Other regions of the shirt **40**, e.g., the body region **46**, may also be printed to provide enhanced surface durability. However, regions of less wear, e.g. such as the body region **46**, may be printed in a different pattern with relatively less density of binder or binder dots per unit area.

[0035] Referring again to **FIG. 5**, the predetermined pattern of binder material is applied to the fabric web **36** in a series of shirt piece patterns **38**, **38'**, **38"** of predetermined configuration, using engineered pattern printing technology. In a later cut and sew process (not shown), the printed fabric web **36** is indexed through a cutter where shirt pieces **37** (indicated in dashed line in **FIG. 5**) are cut from the web and then subsequently sewn together in shirts **40** (**FIG. 6**).

[0036] In another implementation, the binder for forming a surface region of enhanced durability surface is applied to the outer surface of the fabric article with a kiss roll. In this implementation, in order to reduce the tendency toward fraying while maintaining a high level of moisture vapor transmission, good drapability, hand and soft touch, deposit of the binder material is preferably limited primarily to the fibers and/or to the intersections of fibers in the yarn segments, and formation of binder film in the interstitial spaces between yarns is minimized, e.g. as seen in **FIG. 2**. The formation of film may particularly be avoided by removal of excess liquid binder from interstitial spaces between yarns shortly following application, e.g. while the binder material is still wet or moist, by air suction or air blowing through the fabric article.

[0037] Preferably, the binder material is applied in a low viscosity system, or in: a system with a relatively low level of binder solids or particulates in a liquid carrier, so that as the system dries, the liquid carrier evaporates (or in a foam system, collapses), leaving the solid binder deposited primarily or only on the yarns or yarn fibers. In this manner, the air permeability level and other characteristics of the base fabric are maintained.

[0038] In other implementations, a binder material of relatively higher viscosity may be employed, to encourage formation of a fine film in the interstitial areas between yarns that will partially or fully maintain its integrity during the drying process, e.g. as seen in **FIG. 3**. In this manner, the fabric article may be provided with increased water repellency and wind resistance, which would be advantageous in cold windy ambient environments. However, a full or continuous film is typically to be avoided, in order to maintain at least a minimum desired degree of moisture vapor transmission necessary for comfort during high energy activities, such as running, skiing, etc.

[0039] Referring again to **FIG. 1**, the garment **8** formed of the fabric article **10** of this implementation thus has an outer surface **16** with a non-continuous binder coating **18** providing weather protection, with high pill resistance, high abrasion resistance, and pick resistance, and an inner surface **12** with a raised insulating region **14** with high bulk and softness. In particular implementations, the fabric article may be provided with water repellence and wind protection.

[0040] In another implementation, a fabric web **60** of plaited knit construction, such as a circular knit with terry sinker loops on the technical back surface **62** may be employed. For example, referring to **FIGS. 7 and 8**, the fabric web **60** has an outer jersey surface **68** (technical face, **FIG. 7**) and an opposite looped surface **62** (technical back, **FIG. 8**). A binder material is applied selectively to the opposite looped surface **62** (technical back) by engineered printing technology to form one or more first regions **64**, **64'** with relatively greater density of binder or binder dots per unit area, and one or more second regions **66**, with no or only negligible density of binder or binder dots per unit area.

[0041] In yet another implementation, referring also to **FIG. 9**, in a fabric web **61** of reverse plaited knit construction, the outer surface **69** (technical face) is napped or raised in regions **70**, **72**. A binder material is thereafter applied selectively to the opposite looped surface **63** (technical back) by engineered printing technology to form one or more first regions **65**, **65'** with relatively greater density of

binder or binder dots per unit area, and one or more second regions **66**, with no or only negligible density of binder or binder dots per unit area. The second fabric regions **66** of the looped surface **63** of the fabric web **61** are then raised or napped to generate double face regions **70** of fleece or velour in the engineered pattern ("body mapping") of the second regions **66**, disposed among smooth and durable regions **72** of single face raised or fleece fabric in the one or more first regions **65**, **65'**. The result is an engineered three-dimensional pattern, with predetermined regions of raised yarn and non-raised yarn on the technical back **63**, e.g., arranged in accordance with thermal insulation and breatheability loads of a typical wearer's body and a plain raised surface on the technical face **69**.

[**0042**] In implementations employing fabric webs of plaited knit construction or reverse plaited knit construction, the smooth surfaces, i.e. the technical face, may also be printed with a binder material for improved durability.

[**0043**] Referring now to **FIG. 10**, for fabric web **80** of reverse plaited knit construction, such as circular knit with terry sinker loop, in a first implementation, the outer, jersey surface **81** (technical face) is pre-napped. The sinker loops of predetermined regions **72**, **74** of the technical back **73** are then printed with binder material in an engineered body mapping pattern as above, e.g., to locally resist raising and/or to improve durability against abrasion. The technical back **73** is then raised in non-coated region **76**. The result is a fabric having an engineered pattern of raised regions **72**, **74** and non-raised region **76** on one side, i.e. the technical back **73**, and a plain raised surface on the other side, i.e. the technical face **81**.

[**0044**] Referring next to **FIGS. 11 and 12**, in a further implementation, the binder material is applied in an engineered printing pattern to predetermined regions **82**, **84** of the sinker loops of the technical back **83** of the fabric web **90**. The binder is applied in a manner to cause binder material to penetrate to the opposite surface **81**, i.e. to the technical face, of the fabric web, thereby to resist raising of corresponding regions **82**, **84** and **82'**, **84'** of the technical back and the technical face, respectively. The printed fabric is then raised in the uncoated regions **86**, **86'** at both surfaces to create a three-dimensional pattern obvious at both surfaces, i.e. to meet different thermal insulation and/or breatheability requirements of the wearer at the predetermined regions.

[**0045**] In each of these implementations, the printed regions may be formed of sub-regions of contrasting thermal insulation, breatheability and/or abrasion resistance performance characteristics by use of different binder materials, densities of application, penetration, etc., thereby to achieve optimum performance requirements for each sub-region of the engineered printing pattern.

[**0046**] The improved surface durability of fabric articles is demonstrated in a severe pilling and abrasion test, such as the modified Martindale abrasion test method of ASTM D 4966. According to this test method, a fabric article to be tested is subjected to repeated rubbing by a strip of the hook element (General Application type, ¾-inch by ½-inch) of a hook-and-loop type fastener element. After 250 rubs, the appearance of the fabric article has been seen to be markedly better, e.g., as compared to untreated fabric articles.

[**0047**] A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, other aesthetic effects may be applied to the face side and/or to the back side, including, e.g., color differentiation and/or patterning on one or both surfaces, including three dimensional effects. As mentioned above, the fabric article may have one-way or two-way stretch, and/or the fabric may be constructed to provide a degree of stretch from any of a broad range, including from very low stretch (very stable) to high stretch or compression power stretch. The binder material may be applied in other fashions as appropriate, e.g. by kiss coating or froth foam application, preferably to the technical face after raising the technical back. In other applications, the binder material may also be deposited, e.g., by pad application or by kiss roll, upon both surfaces of the fabric article, including, e.g., upon a raised or fleece surface. The multi-strand or multi-filament yarn may, e.g., have the form of staple fibers in spun yarn or filaments in continuous yarn, or the fabric may be constructed with a combination of spun yarn, staple fibers and continuous filament yarn. In addition to suction and blowing of air through the fabric article during drying, the degree of film formation may also be controlled, e.g., by crushing the coated fabric between nip rollers.

[**0048**] Also, in other implementations, only selected regions, e.g., shoulders and/or elbows, may be printed to provide enhanced surface durability, and other regions of the shirt, e.g. the body region, may be left untreated to be raised while printed regions remain flat, resisting the napping process, for predetermined thermal insulation and/or breatheability performance effects.

[**0049**] Referring again to **FIGS. 7 and 8**, in other implementations, first regions **64** and first regions **64'** may be printed with the same binder material or with different binder materials and/or in the same density or different densities of binder material and/or in the same number or different numbers of binder dots per unit area. For example, the binder material applied to one or more first regions **64**, **64'** may consist of two or more different binder materials, e.g. a first binder material applied by screen-printing through a first screen pattern and a second binder material applied through a second screen pattern. The first and second screen patterns typically would be different, with no overprint, and the first and second binder materials may have contrasting properties, e.g. of toughness, softness, etc. In one implementation, e.g., a super durable, hard face may be applied to elbow and/or shoulder regions, and a contrasting pill resistant and/or nap resistant material may be applied in one or more other regions of the body.

[**0050**] Also, application of binder material in a predetermined engineered pattern for enhanced surface durability and abrasion resistance may be synchronized with the regular wet printing process, including in other regions of the fabric body.

[**0051**] Accordingly, other embodiments are within the scope of the following claims.

What is claimed is:

**1**. A fabric article of knitted or woven construction of multi-filament, interlaced yarns, the fabric article having an inner surface and an outer surface, the inner surface having at least one region of pile or raised fibers or fleece formed thereupon, and the outer surface having at least one region

of a non-continuous coating of binder material adhered to yarns and to yarn fibers, for durability of the outer surface against pilling or fraying during use.

**2**. The fabric article of claim 1, wherein the non-continuous coating of binder material is adhered to yarns and to yarn fibers at least at interlacing intersections.

**3**. The fabric article of claim 1, wherein the fabric article has construction selected from the group consisting of plaited circular knit construction, reverse plaited circular knit construction, woven construction, and warp knit construction.

**4**. The fabric article of claim 1 in the form of an article of wearing apparel.

**5**. The fabric article of claim 1, wherein the multi-filament yarns are textured.

**6**. The fabric article of claim 1, wherein the multi-filament yarns are flat.

**7**. The fabric article of claim 1, wherein the multi-filament yarns comprises fibers formed of materials selected from the group consisting of: polyester, nylon and polypropylene.

**8**. The fabric article of claim 1, wherein the multi-filament yarns comprises spun yarns formed of materials selected from the group consisting of: natural fibers, synthetic fibers, and blends thereof.

**9**. The fabric article of claim 1, wherein the multi-filament yarns of the outer surface comprise spandex.

**10**. The fabric article of claim 1, wherein fibers of the multi-filament yarns are highly intermingled at over at least about 10 tucks per meter.

**11**. The fabric article of claim 10, wherein fibers of the multi-filament yarns are highly intermingled at over about 60 tucks per meter.

**12**. The fabric article of claim 11, wherein fibers of the multi-filament yarns are highly intermingled at over about 100 tucks per meter.

**13**. The fabric article of claim 1, wherein fibers of the multi-filament yarns have little or no intermingling.

**14**. The fabric article of claim 1, wherein the binder material adheres to yarn fibers in a manner to substantially avoid restriction of air permeability through the fabric article.

**15**. The fabric article of claim 1, wherein the binder material comprises a film extending into interstitial air passageways through the fabric article in a manner to reduce air permeability.

**16**. The fabric article of claim 1, wherein the at least one region of a non-continuous coating of binder material is without substantial adverse effect on drapability and hand of the fabric article.

**17**. The fabric article of claim 1, wherein the at least one region of a non-continuous coating of binder upon the outer surface of the fabric article comprises one or more first regions of enhanced surface durability due to relatively greater density of binder or binder dots per unit area applied by engineered pattern printing technology to a fabric web.

**18**. The fabric article of claim 17, wherein said one or more first regions comprises at least shoulder regions or elbow regions.

**19**. The fabric article of claim 1 or claim 17, wherein the outer surface of the fabric article further comprises one or more second regions of relatively lesser surface durability due to relatively lesser density of binder or binder dots per unit area applied by engineered pattern printing technology to a fabric web.

**20**. The fabric article of claim 19, wherein said one or more second regions comprises at least body regions.

**21**. The fabric article of claim 19, wherein one or more of the second other regions of relatively lesser surface durability have no or only negligible density of binder or binder dots per unit area.

**22**. The fabric article of claim 21, wherein one or more of the second other regions of the outer surface comprises regions of pile or raised fibers or fleece and one or more of the first regions of the outer surface remains non-raised or smooth face.

**23**. The fabric article of claim 22, wherein said one or more second other regions comprises at least body regions of the fabric article.

**24**. The fabric article of claim 1 or claim 17, wherein the at least one region of a non-continuous coating of binder upon the outer surface of the fabric article comprises one or more first regions of enhanced surface durability due to relatively greater durability of a first binder material applied by engineered pattern printing technology to a fabric web.

**25**. The fabric article of claim 24, wherein said one or more first regions comprises at least shoulder regions or elbow regions.

**26**. The fabric article of claim 1, wherein the outer surface of the fabric article further comprises one or more second regions of relatively lesser surface durability due to relatively lesser durability of a second binder material applied by engineered pattern printing technology to a fabric web.

**27**. The fabric article of claim 26, wherein said one or more second regions comprises at least body regions.

**28**. The fabric article of claim 26, wherein one or more of the second other regions of relatively lesser surface durability have no or only negligible density of binder material per unit area.

**29**. The fabric article of claim 28, wherein one or more of the second other regions of the outer surface comprises regions of pile or raised fibers or fleece and one or more of the first regions of the outer surface remains non-raised or smooth face.

**30**. The fabric article of claim 29, wherein said one or more second other regions comprises at least body regions of the fabric article.

**31**. The fabric article of claim 24, wherein the outer surface of the fabric article further comprises one or more second regions of relatively lesser surface durability due to relatively lesser durability of a second binder material applied by engineered pattern printing technology to a fabric web.

**32**. The fabric article of claim 31, wherein said one or more second regions comprises at least body regions.

**33**. The fabric article of claim 31, wherein one or more of the second other regions of relatively lesser surface durability have no or only negligible density of binder material per unit area.

**34**. The fabric article of claim 33, wherein one or more of the second other regions of the outer surface comprises regions of pile or raised fibers or fleece and one or more of the first regions of the outer surface remains non-raised or smooth face.

**35**. The fabric article of claim 34, wherein said one or more second other regions comprises at least body regions of the fabric article.

**36**. A method of forming a fabric article, said method comprising the steps of:

interlacing yarns comprising multi-filament fibers to form a fabric body of knit or woven construction,

forming one or more raised or fleece regions upon an inner surface of the fabric body; and, thereafter,

applying binder material to one or more regions of an outer surface of the fabric article to form a discontinuous coating of binder material upon yarn fibers on at least the outer surface of the fabric article, to resist pilling and fraying of yarn fibers at the outer surface.

**37**. The method of claim 36, wherein applying binder material to one or more regions of an outer surface of the fabric article forms a discontinuous coating of binder material upon yarn fibers at least at interlacing intersections.

**38**. The method of claim 36, wherein applying binder material comprises applying binder material by standard printing technology.

**39**. The method of claim 38, wherein the standard printing technology is selected from the group consisting of: printing by rotary screen roll, printing by gravure roll, and printing by ink jet printing.

**40**. The method of claim 36, wherein applying binder material comprises applying the binder material with a kiss roll.

**41**. The method of claim 36, further comprising removing binder material in liquid state from interstitial spaces of the fabric body in a manner to control reduction of air permeability.

**42**. The method of claim 41, wherein removing binder material comprises blowing air through the interstitial spaces.

**43**. The method of claim 41, wherein removing binder material comprises drawing air by suction through the interstitial spaces.

**44**. The method of claim 36, wherein applying binder material comprises applying one or more binder materials in one or more forms selected from the group consisting of: resin, latex, polymer emulsion, polymer dispersion, and plastisol system.

**45**. The method of claim 36, wherein the binder material is selected from the group consisting of: melamine, acrylate, polyurethane, silicon, poly vinyl chloride, epoxy and blends thereof.

**46**. The method of claim 36, wherein applying binder material to one or more regions of an outer surface comprises the steps of:

applying first binder material to one or more regions by screen printing techniques in a first pattern, and

applying second binder material the same or different from the first binder material to one or more regions by screen-printing techniques in a second pattern not overprinting the first pattern.

**47**. The method of claim 36, wherein applying binder material comprises applying binder material in a liquid carrier and allowing the liquid carrier to evaporate leaving the binder material.

**48**. The method of claim 36, wherein applying binder material comprises applying binder material in a foam liquid carrier and allowing the foam carrier to collapse leaving the binder material.

**49**. The method of claim 36, wherein the fabric article is formed of a knit construction with a technical face defining the outer surface and a technical back defining the inner surface, and the method comprises raising the technical back and thereafter applying the binder material to the technical face.

**50**. The method of claim 36, wherein applying binder material comprises applying binder material by engineered pattern-printing technology to a fabric web.

**51**. The method of claim 50, wherein applying binder material by engineered pattern printing technology to a fabric web comprises the steps of:

forming one or more first regions of enhanced surface durability by applying a first pattern of a binder material with relatively greater density of binder or binder dots per unit area, and

forming one or more second other regions of relatively lesser surface durability by applying a second pattern of a binder material with relatively lesser density of binder or binder dots per unit area.

**52**. The method of claim 46, claim 50 or claim 51, wherein applying binder material by engineered pattern printing technology to a fabric web comprises:

forming one or more first regions of enhanced surface durability by applying first binder material, and

forming one or more second other regions of relatively lesser surface durability by applying second binder material.

**53**. The method of claim 52, wherein forming one or more first regions of enhanced surface durability comprises applying the first pattern with relatively greater density of binder or binder dots per unit area at least upon one or more regions selected from the group consisting of: shoulder regions and elbow regions.

**54**. The method of claim 52, wherein forming one or more second other regions of relatively lesser surface durability comprises applying the second pattern with relatively lesser density of binder or binder dots per unit area at least upon body regions.

**55**. The method of claim 50, wherein applying binder material by engineered printing technology to a fabric web comprises the steps of:

forming one or more first regions of enhanced surface durability by applying a first pattern with relatively greater density of binder or binder dots per unit area, and

forming one or more second other regions of relatively lesser surface durability by applying no or only negligible density of binder or binder dots per unit area.

**56**. The method of claim 55, wherein forming one or more first regions of enhanced surface durability comprises applying the first pattern with relatively greater density of binder or binder dots per unit area at least upon one or more regions selected from the group consisting of shoulder regions and elbow regions.

**57**. The method of claim 55 or claim 56 wherein forming one or more second other regions of relatively lesser surface durability comprises forming second other regions at least upon body regions.

**58**. The method of claim 55, comprising a further step performed after applying binder to the one or more first regions of enhanced surface durability, the further step comprising raising or napping the one or more second

regions bearing little or only negligible density of binder or binder dots per unit area to form fleece or velour.

**59**. The method of claim 36, comprising, prior to forming a raised or fleece region upon an inner surface of the fabric body,

applying binder material to one or more predetermined regions of the inner surface by engineered printing technology, and

generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing.

**60**. The method of claim 59, comprising a further step of forming the fabric body by plaited knit construction.

**61**. The method of claim 60, wherein the fabric body is circular knit with terry sinker loop.

**62**. The method of claim 36, wherein applying binder material to one or more regions of an inner surface of the fabric body is synchronized with wet printing in other regions.

**63**. A method of forming a fabric article, said method comprising the steps of:

interlacing yarns comprising multi-filament fibers to form a fabric body of knit or woven construction,

forming one or more raised or fleece regions upon an outer surface of the fabric body,

applying binder material to one or more regions of an inner surface of the fabric body to form a discontinuous coating of binder material upon yarns fibers on at least the inner surface of the fabric body, and

generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing.

**64**. The method of claim 63, wherein applying binder material to one or more regions of an inner surface of the fabric body forms a discontinuous coating of binder material upon yarns fibers at least at interlacing intersections.

**65**. The method of claim 63, further comprising the steps of:

applying binder material to the inner surface of the fabric body in a manner to cause the binder material to penetrate to the outer surface of the fabric body, and

generating, upon the outer surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the outer surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing.

**66**. The method of claim 65, further comprising the step of:

generating, upon the inner surface of the fabric body, an engineered three-dimensional pattern of raised or fleece regions and non-raised or non-fleece regions designed to meet predetermined thermal insulation and/or breatheability at predetermined regions by forming one or more raised or fleece regions upon the inner surface of the fabric body while the one or more regions to which binder material is applied resist raising or fleecing, one or more raised or fleece regions of the inner surface of the fabric body being in registration with one or more raised or fleece regions of the outer surface of the fabric body.

**67**. The method of claim 63 or claim 65, comprising the further step of forming the fabric body by reverse plaited knit construction.

**68**. The method of claim 67, wherein the fabric body is circular knit with terry sinker loop.

**69**. The method of claim 63, wherein applying binder material to one or more regions of an inner surface of the fabric body is synchronized with wet printing in other regions.

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