

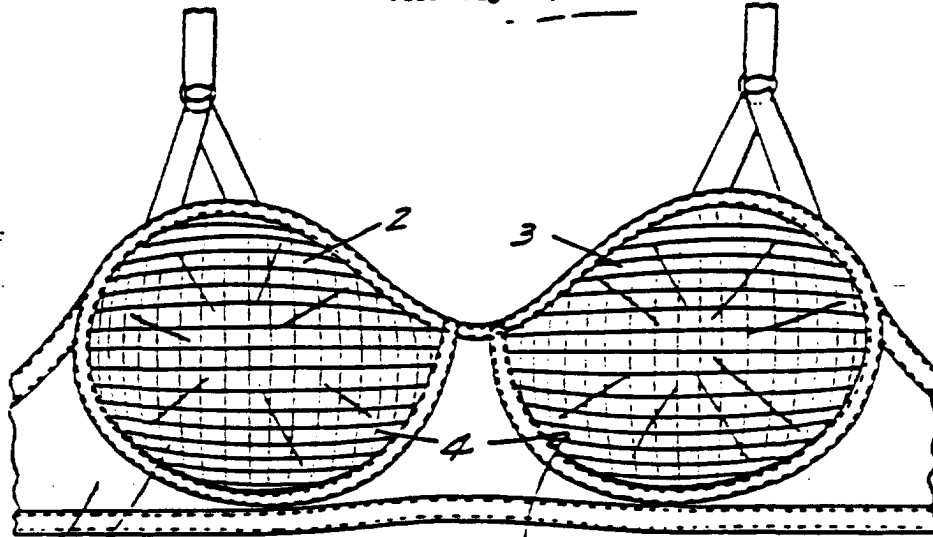
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W M. WESTBERG ET AL
MOLDED NONWOVEN FABRIC ARTICLES

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Reinforcing net integrally
combined in cup structure.

Nonwoven porous seamless brassiere cup. Molded from a carded sheet of interlaced staple fibers, including undrawn polyester fibers that are interbonded and rendered crystalline by heating during molding; all fibers being coated and interbonded by a fiber-sizing latex.

INVENTORS
WALTER M. WESTBERG
PATRICK H. CAREY JR.
BY
Carpenter, Albert, Kuntz & Kinney
ATTORNEYS

PLAINTIFF'S
EXHIBIT

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MOLDED NONWOVEN FABRIC ARTICLES
Walter M. Westberg, St. Paul, and Patrick H. Carey, Jr.,
Bloomington, Minn., assignors to Minnesota Mining
and Manufacturing Company, St. Paul, Minn., a cor-
poration of Delaware
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This invention relates to new and useful molded non-
woven fabric articles, and to the process of making. It
has particularly noteworthy value in the manufacture of
shaped articles of wearing apparel, such as brassiere cups.

The product is formed by molding to a precise predeter-
mined shape a body carded web sheet of initially un-
crossed interlaced staple fibers which includes un-
crossed (amorphous) polyester fibers as thermoplastic
linear fibers, the molded sheet being compacted and uni-
fied into its stable final shape by heating and soft-pressing
which also effects mutual autogenous interbonding of the
interlaced thermoplastic polyester fibers at their crossing
points so as to provide a fiber-unifying and shape-retain-
ing network. These amorphous polyester fibers are ren-
dered crystalline and nontacky during the heating oper-
ation.

This molding operation is preferably performed by
shaping the fully fibrous sheet over a heated male mold
and then uniformly pressing and compacting the sheet
against the mold by use of a non-adhering stretchy rub-
bery blanket thereby simultaneously heating the web to
the required extent after which the molded sheet (which
is rendered non-adherent during the molding operation)
is removed, lifted from the heated mold without need
for drying. A conformable open-mesh net or gauze can
if desired be integrally incorporated, by application over
the fibrous sheet on the mold prior to the pressing step,
thereby providing reinforcement or a desired appearance
effect.

All fibers throughout the structure are then coated by
impregnating with a waterproof resilient polymer latex
which interbonds all the fibers at their crossing points
and imparts the desired body and other physical prop-
erties to the complete article, but without materially reduc-
ing its porosity. The product is normally subjected to
finishing treatments such as washing, bleaching and trim-
ming to produce the final article for use or sale.

The fibers and proportions used in manufacturing
the shaped brassiere cup product are selected so that it
is highly porous, strong and tough, shape-retaining but
flexible and conforming to the skin, and capable of repeated
washing and use as fully explained hereinafter.

The accompanying diagrammatic drawing illustrates the
invention as applied to the manufacture of a brassiere 1
having a pair of breast cups 2 and 3 sewn into the harness;
these cups having been molded from nonwoven carded
sheets of interlaced staple fibers in the manner briefly
outlined above and each having a net 4 integrally com-
bined in the surface structure as a reinforcement and to
enhance appearance.

Seamless shaped articles of this invention can be fabri-
cated so as to embody a combination of features which
enhance their efficiency and utility for wearing apparel usage.
They are highly porous and breathable so as to permit of
the free passage of air and moisture; and they are mois-
ture absorbent, resulting in comfort even when worn next
to the skin and in hot or humid weather. They do not
irritate or chafe the skin even upon prolonged contact
and do not cause dermatitis or allergic reactions. There
is no seam to add bulk and detract from appearance or
cause discomfort. They feel soft and comfortable against
the skin. They have excellent high strength and resis-

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ence to hold their shape and to provide comfortable con-
tact and support as in the case of brassiere breast
cups. They can be easily trimmed and readily and durably
sewed to associative woven fabric elements as in manu-
facturing complete brassieres. They are durable and the
initial shape is permanent; the articles not becoming
stretched out, limp, distorted, wrinkled, ragged or sleazy
in continued use or on account of repeated laundering
or dry cleaning. They are initially of attractive appear-
ance and are easily kept clean and fresh looking by
home laundering, and they dry rapidly without wrinkling
or creasing and need no ironing.

The importance of this invention does not reside merely
in the technical and utility merits of the products, crucial
as these may be to user acceptance and satisfaction.
Equally important is the fact that these articles can be
manufactured at a low cost. No weaving or knitting is
required at any stage. There is no cutting and sewing as
is required in making conventional brassiere cups. A
high degree of predetermined shape precision and uni-
formity are obtainable and on a mass production basis.
Such uniformity is desirable in the manufacture of bras-
siere cups, so that anyone who buys brassieres of a given
style, size and make can depend upon them to have the
same fit and feel. Such uniformity is not obtainable
when cups are made by cutting and sewing cloth, particu-
larly so in respect to inexpensive mass-produced cups.
The complete process of manufacture from fibers to prod-
uct is inherently simple and lends itself to high speed pro-
duction. Although the resultant savings in labor costs and
equipment charges make inexpensive manufacture possi-
ble, the products are not shoddy substitutes but are fit for
use in producing quality merchandise. Thus brassiere
cups of the present invention can be employed by brassiere
manufacturers to producing a new and superior type of
product at a lower cost.

Recognition of the desirability of producing seamless
three-dimensional wearing apparel articles, especially bras-
siere cups, by some process of shaping or molding a flat
fibrous fabric or web, goes back many years and a sub-
stantial number of patents have described a wide variety
of proposals. These mostly involved use of special types
of woven or knitted fabrics although non-woven staple-
fiber fabrics have also been suggested for products in this
general category, including brassiere cups. Thus see, for
instance, U.S. Patent Nos. 2,047,230 (1936), 2,190,545
(1940), 2,190,807 (1940), 2,285,967 (1942), 2,460,674
(1949), 2,560,546 (1952), 2,609,539 (1952), 2,616,084
(1952), 2,760,198 (1956).

However, to the best of our knowledge and belief, none
of these prior proposals led to any substantial commer-
cial manufacture or use of seamless shaped brassiere cups.
Brassiere manufacturers have continued to mainly utilize
cups formed by cutting and sewing woven fabrics, despite
the disadvantages of seams and the relatively high labor
costs involved.

Brassiere cups produced according to the present inven-
tion have been embodied in complete brassieres which
have been sufficiently tested and evaluated to indicate
commercial value as a satisfactory and economical re-
placement for conventional brassieres, and to verify the
value of advantageous features attributable to the novel
cups. The evaluations included usage by a large number
of women who subjected their test brassieres to daily
washing and wearing for continuous periods of 30 days or
more, demonstrating a satisfactory wash-and-wear life.

The range of types of materials utilized in fabricating
the seamless wearing apparel products of this invention
are of wide significance in respect to successful low-cost
manufacturing operations as well as in respect to the com-
bination of characteristics produced in the end product.

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An end product might be similar from the standpoint of the user but would itself be manufactured at a comparable cost. Both considerations were involved in the empirical discovery after much experimentation, of the particular combination of materials that is used. These types of materials were naturally old and commercially available (along with a great variety of other fibers and fiberizing agents which are non-equivalent for present usage), but so far as we are aware there was no prior suggestion of their conjoint selection and use for any purpose.

These types of fabrication materials as preferably employed in combination in manufacturing brassiere cups and other articles of wearing apparel, are exemplified by:

(A) Unplasticized polyester staple fibers of the conventional drawn and oriented type employed in the textile industry, and having a length in the range of approximately 1 to 2 inches. These are manufactured by melting and extruding through spinnerets a high molecular weight polyester of a dihydric alcohol and a dicarboxylic acid. The extruded filaments are elongated by drawing (stretching) which brings about an oriented crystalline molecular structure, decreased diameter and denier value, increased tensile strength and elasticity, decreased stretchability, and elimination of a broad softening temperature range in favor of an elevated melting point (actually a narrow temperature range within which the drawn fibers soften and melt). The endless filaments are chopped to produce the staple fibers. Drawn polyester fibers are sold by the Du Pont Company under the trademark "Dacron," and are understood to be made from a polyester of ethylene glycol and terephthalic acid.

(B) Unplasticized thermoplastic polyester staple fibers of the undrawn and amorphous type, having a length in the range of approximately 1 to 2 inches. These are manufactured in the same way as the above-mentioned drawn fibers except that the drawing operation is omitted, thereby avoiding the mentioned changes. These fibers have an inherent wide softening temperature range below the temperature at which they fluidify or melt, within which the thermoplastic fibers can be autogenously interbonded at crossing points by application of light pressure without cutting or mashing the fibers, the fiber identities thus being retained. No plasticizer is needed to obtain this thermobonding property. When heated in this range these fibers acquire a crystalline structure, become stiffer, become nonadherent to a heated metal mold, and the softening temperature is elevated. This initial softening temperature range is below the narrow melting point range of the corresponding crystalline drawn fibers. For instance, fibers chopped from the undrawn polyester filaments produced intermediately in the manufacture of "Dacron" fibers, have a thermobonding softening temperature range of approximately 200 to 450° F. (90 to 230° C.), whereas the regular "Dacron" drawn type of fibers of the same chemical composition have a melting point of approximately 480° F. (240° C.) and are not soft and capable of autogenous interbonding with each other in the 200 to 450° F. range.

(C) Cellulose staple fibers having a length of approximately 1 to 2 inches. These are preferably viscose-rayon fibers but one can also be made of long-staple cotton or ramie fibers.

These three types of fibers are intermixed and all serve as structural fibers. The polyester fibers of undrawn type (B) also function as thermoplastic binder fibers, and are employed in a proportion of about 30 to 50% by weight. The cellulose fibers are employed in a proportion roughly equal thereto, such that the total proportion of both is about 70 to 90%. The drawn polyester fibers are employed in a minor proportion (about 10 to 30%).

A carded mixture of the above-described three types of fibers provides the dry fluffy fibrous web or bat which is molded and subsequently unified (by heating and softening) in accordance with the present invention, prior to the operation of the aqueous latex dispersion. The

fibers of the heterogeneous mixture extend every which way and are interlaced, crossing over and under each other in a random manner, such that each fiber of given type crosses numerous fibers of the other two types as well as numerous fibers of the same type. These relatively long fibers contact each other only at their crossing points. A high ratio of the fiber surface areas is available for subsequent coaling and maximum porosity is achieved. The unbonded web is stretchable and can be shaped on a heated male mold without disruption or wrinkling so as to effect a deep drawing to a precise shape, owing to the length and the initially unbonded interrelationship of the fibers which permit of fiber displacements to obtain conformation but which minimize and localize the fiber motions and disturbances. Heating and soft pressing of the molded fiber web results in compaction and unification: the undrawn (amorphous) polyester binder fibers becoming autogenously interbonded at their mutual crossing points (fusing together at a temperature at which they are soft and mutually cohesive) and then hardening and stiffening without shrinking, to provide a fiber-unifying and shape-retaining network that unifies and stabilizes the shaped structure and does not stick to the heated mold. The other two types of fibers are not mutually interbonded, and are only lightly bonded if at all at the points at which they cross the undrawn polyester fibers, being held in place mainly by mechanical restraint. The thus unified molded article holds its shape so that it can be removed from the nonadhering mold while still warm, and can be saturated with an aqueous latex dispersion and dried, without becoming distorted.

(D) An aqueous dispersion of a fiber-unifying latex, which is used to impregnate the molded product so as to bind the fibers together and impart strength and shape-retention to the final article. An aqueous carboxylic acrylate polymer latex dispersion containing a small proportion of a curing agent is preferred in manufacturing washable wearing apparel articles, such as brassiere cups. This latex dispersion is used for saturating the molded and autogenously unified fibrous web so as to size coat the fibers and interbond them at their crossing points, and produce a product of the type previously described which is porous, tough, durable and launderable. A functionally equivalent polymer coating dispersion can be used, the purpose being to impart certain physical properties to the product; the particular chemical composition not being critical per se. The carboxylic acrylate polymer is a soft, elastic and slightly tacky copolymer made by copolymerizing a lower-alkyl acrylate ester monomer (preferably in the ethyl, propyl, butyl range) with a small proportion of acrylic or methacrylic acid monomer (or equivalent carboxylic acid monomer) so as to incorporate a small proportion of carboxylic side groups into the acrylate polymer molecule and thereby enhance the adhesive binding action but without rendering the copolymer highly tacky. An emulsion polymerization procedure is used so as to provide an aqueous latex dispersion, which can be diluted with water to provide the desired solids concentration for treatment of the web. A coagulated dried mass of the uncured polymer is soft and slightly tacky and has an elastic snap. A commercially available carboxylic acrylate polymer latex dispersion of this type is the "HA-1" dispersion sold by Rohm & Haas Company.

A water-soluble cyclic urea-formaldehyde type curing agent is preferred when the aforesaid carboxylic acrylate polymer latex is employed. It is inactive in the aqueous dispersion, which is stable, but upon drying and heating of the treated article the carbonyl-containing ring structure of the molecule opens so that it becomes reactive and the compound then functions to cure ("vulcanize") the polymer coating, presumably by providing cross-linking between carbonyl groups, producing a three-dimensional waterproof resilient polymer fiber-coating which is firmer and more resilient, non-tacky, heat-resistant and less thermoplastic, highly insoluble, strongly bonded to the fibers,

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and highly resistant to water absorption and to softening or removal by repeated launderings and dry cleanings. Use of this type of curing agent also has the advantage that it treats the surface structure of the cellulose fibers (apparently by reacting with hydroxyl groups of the cellulose molecules to produce cross-linking and also by self-polymerizing) so as to render these fibers more resistant to water-absorption and to shrinkage. It also produces a stronger and more water-resistant bond between the cellulose fibers and the contacting acrylate polymer coatings, apparently by cross-linking. An illustrative curing agent compound of this type is dimethylol cyclic ethylene-urea, also designated as 1,3 bis (hydroxymethyl)-2-imidazolidinone, which is commercially available under the trademark "Rhonite R-1" from Rohm & Haas Company. A similar curing agent is sold under the trademark "Rhonite R-2" and is believed to comprise the same compound but in a partially polymerized form that is likewise miscible with water in all proportions.

The following steps are employed in fabricating porous shaped fabric articles (such as brassiere cups) from the foregoing materials:

(1) The three types of staple fibers are mixed and the mixture is continuously formed into a carded web by a garnet machine or the like. A "Rando-Webber" machine (sold by Curlator Corp., Rochester, N.Y.) may be used. The staple fibers are thereby randomly directed and interlaced into a loose fluffy web wherein the various types of fibers cross over and under each other so as to be held together in three dimensions in a coherent bat, being held in restraint by mechanical and frictional forces. The resultant fibrous web may be identified as a "carded web" on the basis of characteristic fibrous structure even when not literally made by a carding procedure in the strict sense. The total fiber weight per unit area is selected with reference to the particular article to be produced and the properties desired. In general, a fiber weight in the round figure range of about 100 to 200 pounds per thousand square yards (about 50 to 110 kgs. per thousand square meters) will be employed. A fiber weight of about 150 pounds per thousand square yards (about 80 kgs. per thousand square meters) has proved quite satisfactory in the manufacture of brassiere cups; the fiber mixture consisting (by weight) of 20% drawn polyester fibers (3 denier), 40% undrawn polyester fibers (7 denier), and 40% viscose-rayon fibers (3 denier); these staple fibers all having a length of 1 1/4 inches. Preferably, the web is put through a needling type felting machine, having barbed needles spaced half an inch apart, which pushes tufts of fibers through the fibrous bat from one face to the other, thereby imparting greater coherency and absorbency to the web.

(2) A dry fluffy sheet of suitable size, cut from the foregoing carded web, is fitted over a heated male mold having the desired contour. A mold of cast aluminum, internally heated by an electric heating element, is preferred; the surface temperature being in the range of about 250 to 400° F. The fluffy web is rapidly conformed (as by hand smoothing) to an unwrinkled approximate fit, the fibers being able to shift about to make this possible without wrinkling or impairing the uniformity of the web or stretching the fibers. A sheet of conformable open-mesh net or gauze can be fitted over the fibrous web, if desired, and will be co-shaped and integrated with the surface in the subsequent operation. An example is a polyester fiber (e.g., "Dacron") net which has been knit on a Rochelle machine. During the few seconds required for this step, the undrawn polyester fibers of the fluffy web do not have time to become heated up to a soft and sticky condition, nor is there time for the web to shrink and distort, as would occur if prolonged exposure to the heated mold were permitted prior to the next step.

(3) A stretchy nonadhering silicone rubber blanket (mounted in a frame) is promptly brought against the web over the mold so that a relatively uniform soft pres-

ing action is exerted on the intervening web. The mold is located on a platform provided with holes communicating to the mold and connected to a vacuum line. When the blanket frame contacts the platform, the suction is turned on to produce a vacuum between the blanket and the mold, so that the stretchy blanket is quickly and uniformly pressed against the web by the external atmospheric pressure, and air pockets are prevented. This results in a final and precise molding of the web to the shape of the mold, the fibers still being able to move in the initial phase of this step; and the web is simultaneously compacted by the soft pressing action. The undrawn amorphous thermoplastic polyester binder fibers now become heated sufficiently by the hot mold to fuse together at their mutual crossing points, thus becoming automatically interbonded, and fiber stresses are relieved. The heating and pressing are insufficient to cause mashing or cutting of fibers, and fiber identity is retained. Continued heating converts the soft and sticky undrawn polyester fibers from an amorphous to a crystalline state which elevates the softening temperature to above the temperature of the mold. This change of state hardens and stiffens these fibers, renders them nonadherent to the mold, and stabilizes the unified molded web so that it will retain its shape even though still warm. Absent such change of state, the web would stick to the hot mold (unless the latter had a special antistick type of surface) and would not be set in a stable shape, and hence could not be removed from the hot mold without being distorted.

(4) The vacuum is released and the blanket is removed. The exposed molded article is grasped about its periphery and lifted from the hot mold, no intervening cooling being required. The article does not stick to the hot mold and can be easily and bodily lifted away without being distorted. This forming process can be performed successively at the rate of 2 or 3 articles per minute per mold. A single operator can handle formations on a substantial number of molds. A plurality of adjacent molds can be combined in a single production unit utilizing a single blanket, in which case a single large sheet of the carded web can be fitted over all of such molds to permit of simultaneous molding. Thus a single operator can produce two to three thousand molded brassiere cups per hour.

(5) The molded article is then saturated or impregnated by the aforesaid preferred aqueous latex dispersion (D), the concentration of the latex solids being selected so that the fibers will be sized or coated therewith but without filling the interstices; the end product on a dry basis consisting of about 50 to 75% fibers and 25 to 50% polymer coating solids, by weight. This can be conveniently and efficiently effected by positioning the article, convex side up, under a dispensing head containing small orifices or holes through which the dispersion is allowed to stream upon the article until it is thoroughly wetted and saturated. This saturation is facilitated by the wicking action of the compacted fibrous structure. The dripping on of the dispersion in this way does not collapse or distort the article, which has sufficient stiffness to resist the moderate forces involved. The previously unified network of interlaced cross-bonded fibers immobilizes the fibers of the structure so as to inhibit movement during this step. The dispensing head is connected to a supply vessel at a higher level so that gravity feed controls the rate and force of flow in the desired manner. This and the following steps can be performed on an automatic production line basis, a series of articles being continuously moved along by a conveyor system.

(6) The wet saturated article is then subjected to heating with hot air to successively dry the article and cure the polymer size coatings, the fibers not being raised to a temperature that causes softening or melting. In continuous production the series of articles is conveyed through an oven having circulating hot air which provides heat for drying and curing, and which also carries away