July 7, 1959 H. G. LAUTERBACH 2,893,105

FORMATION OF FELT-LIKE PRODUCTS FROM SYNTHETIC FILAMENTS

Filed June 11, 1954

Fig. 1

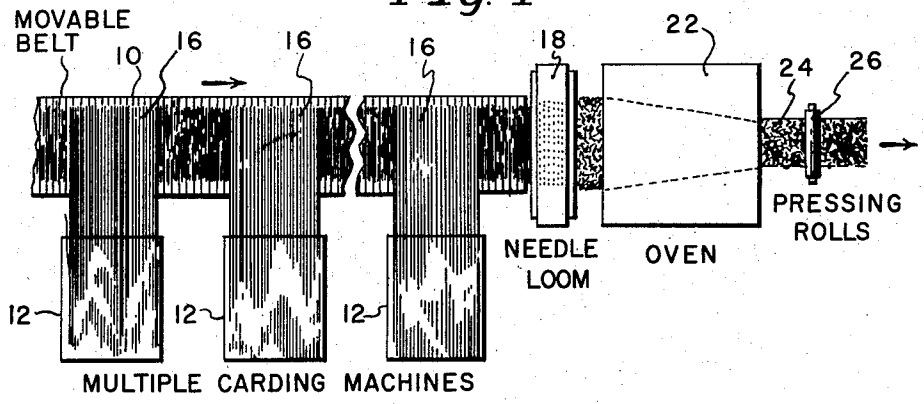


Fig. 2

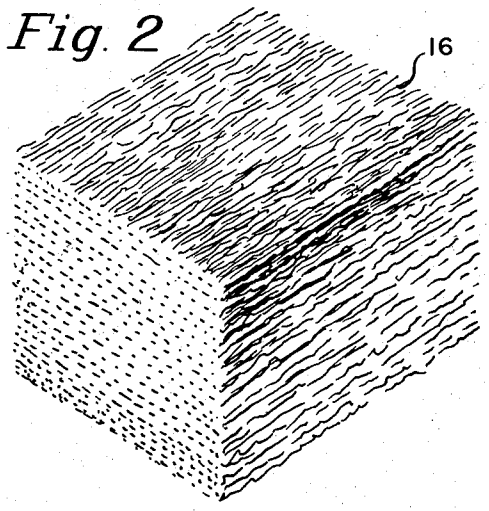


Fig. 3

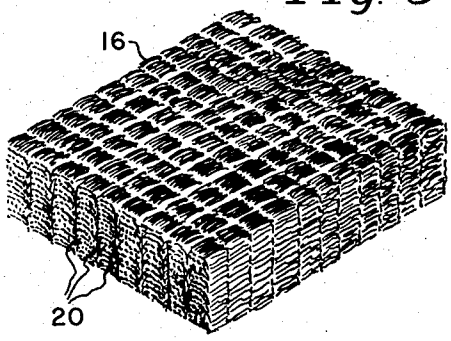


Fig. 4

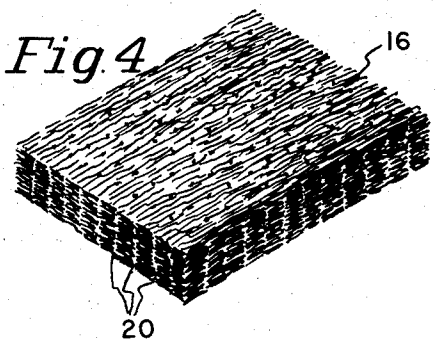
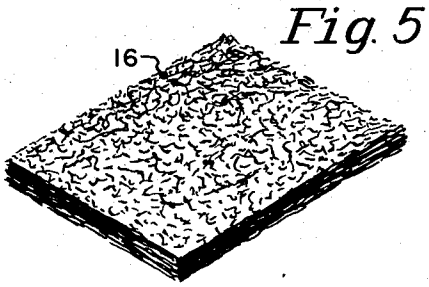


Fig. 5



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United States Patent Office 2,893,105
Patented July 7, 1959

2,893,105

FORMATION OF FELT-LIKE PRODUCTS FROM SYNTHETIC FILAMENTS

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Application June 11, 1954, Serial No. 436,014

3 Claims. (Cl. 28—72.2)

This invention relates to the formation of synthetic fibers into non-woven felt-like products. More particularly, it relates to the production of coherent felt-like products from polytetrafluoroethylene filaments which are heat-retractable, i.e., filaments having the property of shrinking when treated with heat.

Felts represent the oldest form of textile fabric. Animal fibers such as wool, and to a degree, fur are recognized as the only true feltable fibers. Forming them into felts requires preliminary compaction followed by mechanical working with addition of heat and usually moisture. Felting of other fibers has not been possible previously. While felt blends of synthetic fibers with conventional felt-forming fibers are known, the synthetic fibers have merely functioned as diluents in the felt formation, although perhaps endowing the product with desirable qualities, such as improved abrasion resistance or dimensional stability.

An object of this invention is the production of non-woven felt-like products composed wholly of polytetrafluoroethylene filamentary materials. Other objects will become apparent from the following description and claims.

In accordance with this invention it has been found that coherent, non-woven, felt-like products are formed by preparing a loose batt of a fluffy fibrous mass containing a substantial proportion of retractable polytetrafluoroethylene filaments, forcibly orienting small separated groups of the retractable filaments at intervals into positions substantially perpendicular to the ultimate faces of the product, and then retracting the retractable filaments at least 15% by appropriate treatment with heat. The term "filaments" includes staple fibers wherever the context does not indicate that long, substantially continuous filaments are meant. The retraction of the forcibly oriented filaments, accompanied by retraction of the other filaments which lie principally in planes parallel to the faces of the product, shrinks the batt to a compact felt-like product which is suitable for the general uses for which ordinary felts are employed and, in addition, has many special uses for which ordinary felts are not suitable.

The unusual stability of polytetrafluoroethylene filaments to attack by chemicals and to elevated temperatures, including a high stick temperature, and the extremely low coefficient of friction, open up a host of industrial and household uses for the felts of this invention for which other types of felts are not satisfactory. Felts of polytetrafluoroethylene, which can only be manufactured in accordance with the present invention as far as is known, are suitable for use as ironing press pads, liners, gaskets, vibration mountings, shock mountings, and filters where chemical inertness or thermal stability are important, as in filtering chemical solutions or hot fluids.

The process of this invention is not to be confused with ordinary felt-making operations. The usual steps of matting fibers together by mechanical working, rubbing, or fulling, are eliminated altogether. Furthermore, the synthetic filaments with which this invention is concerned cannot be felted by such mechanical working to make felt-like materials in the conventional manner.

The felt-like products of this invention resemble wool felts except for the different fiber composition, but the structure may be distinguished on close inspection by the presence of the filaments which have been oriented in the thickness direction, i.e., perpendicular to the faces of the product. These oriented fibers occur in small groups at intervals corresponding to the penetration of the needles. These oriented fibers do not interfere with uses of the felt-like products and the fibers are free to move over each other as in the cast of wool felts. The products of this invention are easily distinguished from non-wool felted products containing thermoplastic fibers which have been heated, usually while under external pressure, until many fibers have bonded together. Since the adhered fibers are not free to move, such heat-coalesced products are stiff and undesirable for many uses of felts.

The invention will be understood more readily by reference to the drawings. In the drawings, which illustrate preferred embodiments of the invention,

Figure 1 is a schematic representation of an apparatus for practicing the process of this invention,

Figure 2 is a fragmentary perspective view showing the fiber arrangement when first assembled into a loose batt,

Figure 3 is a similar view showing the appearance of the batt, after filaments have been forcibly oriented by needle-punching,

Figure 4 is a corresponding view after the filaments have been retracted, and

Figure 5 is a corresponding view after the felt-like product of Figure 4 has been rolled or pressed.

In the apparatus shown in Figure 1 an intermittently movable belt **10** supports the filamentary material being formed into a felt-like product. Multiple cards or garnetts **12** are arranged along the sides of the belt to deposit successive carded layers of filamentary material on top of one another on the belt. Alternate cards may be arranged to deposit layers at different azimuthal angles to decrease the difference between longitudinal and transverse orientation of the fibers on the belt. All or some of the cards may be provided with crosser-lappers to shift the orientation of successive layers. Ordinarily successive crosser-lappers would be arranged to shift the layers by plus and minus an equal number of degrees.

After sufficient layers have been laid down on the belt to provide a batt **16** of the required thickness, the batt is advanced through a needle loom **18** which punches filaments through the batt and holds it together. The batt, which initially had the appearance shown in Figure 2, now appears as in Figure 3. The forcibly oriented fibers are shown at intervals **20**. The needle-punched batt is now carried by the belt through an oven **22** in which the filaments are heated to a suitable temperature to cause them to retract. If the filaments are to be retracted in a liquid bath instead, the belt is arranged to carry the batt through a tank where the filaments are submerged in or sprayed with the retraction liquid. This may be followed by suitable means for removing the liquid, such as rinsing baths, wringer rolls and a drier, as will be understood in the art.

Retraction of the filaments causes the batt to shrink as indicated at **24** in Figure 1. The appearance of the product is shown in Figure 4. The forcibly oriented filaments can still be seen at intervals **20**, but are scarcely noticeable and do not restrict the use of the product. The product outwardly resembles conventional felts made with wool and, by selection of the proper conditions can be adapted to the same uses. When a smooth surfaced or more highly compacted product is desired, the retracted product may be passed between relatively cool rolls,

shown at 26 in Figure 1. A pressed product similar to that shown in Figure 5 may be prepared in this way.

A substantial proportion of the filamentary material used in the practice of this invention must have the ability to retract at least 15% when heated. The retraction may result from a simple reduction in length, as of a filament already non-linear in shape, or from a distorting of the filament into an irregular shape, or both. The degree of retraction is expressed as the percent decrease in distance between two points on a filament as a result of the treatment and, when both shrinking and crimping occur, is a summation of the effect produced by shrinking in length and crimping to assume a more irregular path between the points of measurement. A working minimum on retraction is about 15% and preferably amounts to at least 25%. A needled batt composed of fibers which are retractable to the extent of about 15% will be reduced in area by about 20% when the fibers are retracted. Retraction of at least 50% is especially desirable for some purposes. Materials which do not retract sufficiently under the conditions of manufacture may be bended or lapped with retractable filaments in order to achieve special effects.

The amount of retraction obtainable with polyetrafluoroethylene filaments depends upon the extent to which they have been drawn. Undrawn filaments may shring as little as 8%, where as highly drawn filaments shrink or retract as much as 75% or more in length when heated. Shrinkage of drawn filaments commences gradually as the temperature is raised and also depends upon the length of heating. Accordingly, the amount of retraction can be controlled by the extent and temperature of drawing, the temperature of heating and the exposure time. Normally the filamentary batts will be retracted by heating so that the filaments are at a temperature below the fusion temperature of the polymer. For maximum shrinkage the filaments will be heated to a temperature between 300° C. and 327° C. If dimensional stability is required, the felt produced should not be used at a higher temperature than was used in its preparation. Conversely, if it is desired to stabilize the felt dimensionally for use at a given temperature, the retraction temperature should exceed the use temperature. By sufficiently intense heating, substantially all of the draw given a filament may be recovered in the form of retraction. Thus, the desired amount of shrinkage, with its attendant effect on density and hardness of the felt, can be imparted to the filaments used.

Instead of using filaments which have been given a predetermined draw-ratio, there may also be used mixtures of filaments having different draw-ratios or mixtures of drawn and undrawn filaments. Thus loose undrawn filaments of polytetrafluoroethylene may be fed to a garnett machine or machine suitable for conversion of undrawn fiber stock. The filaments should be of sufficient length so that the converting machine will convert them to drawn staple by drawing and severing. The mixture of essentially all drawn stock is then ready for feeding to the crosser-lapper.

The polyetrafluoroethylene filaments are quite slippery and formation of the batt is facilitated by using a mixture with another fiber which later may be removed either by solvent or heating. Any fiber which can be dissolved in a solvent can be used because polytetrafluoroethylene will invariably be insoluble. Also any fiber which is removed by decomposition when heated to the shrinking temperature of polyetrafluoroethylene fibers may be used. If the admixed fiber is to be removed, it will ordinarily be chosen because of its low cost, and the low cost or ease of recovery of the solvent. Cellulose acetate is suitable and is readily removed with acetone. The mixture of fibers is formed into a batt, needled, and the needled batt is immersed in acetone to remove the acetate fibers, then rinsed well and dried before heating to retact the polyetrafluoroethylene filaments and form the felt. This procedure assists in easy batt formation and reduces loss of polyetrafluoroethylene fibers due to fibers falling out of the card. Regenerated cellulose is also suitable as a blending fiber to facilitate carding and batt formation. In addition to the above blending methods it may be desirable in some instance to mix with the polytetrafluoroethylene other fibers such as glass and/or asbestos, which will not be removed from the final product.

Fluid jets may be used to form the initial batt. Depositing filaments with fluid jets permits elimination of blending and carding procedures and generally simplifies handling of starting materials. It also facilitates the use of continuous mono- or multifilaments, or mixtures of continuous filaments and staple fibers, in the preparation of the batt. Heretofore, use of continuous filaments in felt structures has been confined to woven backings or cores. Synthetic filaments are initially produced as continuous filaments and use in this form simplifies the manufacturing operation. The use of continuous filaments frequently imparts added compactness and strength to the product. Staple fibers may be deposited randomly by a similar blowing technique.

Regardless of how the batt is formed and the type of filaments used, whether continuous or staple or a combination, the batt will ordinarily have been built up gradually by super-position of a number of layers of material. The resulting batt consists initially of loose, fluffy mass in which the fibers may be oriented in layers in planes parallel to the belt or other surface on which the batt is formed. These fibers will remain oriented in layers more or less parallel to the faces of the final product unless some way is found to cause the fibers to interlock between layers. Hence, retraction of unmodified layers will give a product that is weak in the vertical direction and quite inferior to conventional felts. A surprising feature of the present invention is the discovery that retraction of the filaments will accomplish the desired result if even relatively small numbers of the filaments have been reoriented by needle-punching into position substantially perpendicular to the surface on which the batt was formed.

Needle-punching with a needle loom has been described as a preferred method of achieving the required reorientation of filaments in the batt. This loom has a large number of closely spaced needles supported in position to be reciprocated into and then out of the batt. The batt is moved intermittently through the loom, being advanced only while the needles are drawn clear of the batt. In addition to the conventional felting needles containing protruding barbs which catch bundles of filaments and carry them through the batt, there may also be used unbarbed needles or notched needles. (Preferably obtained by etching away the barbs of ordinary felting needles in concentrated hydrochloric acid), which force individual filaments through the batt. The needles without barbs normally permit more penetrations per square inch of batt surface than do the barbed needles to produce satisfactory orientation and entanglement of fibers before subjecting the batt to a retraction treatment. Since this type of loom is well-known for use in other textile operations, further description is unnecessary. Alternatively the batt may be moved continuously through the needle loom. Obviously, any other suitable means may be used for forcibly orienting filaments into the desired position, and the operation is designated as punching the filaments in the present application.

The forcible orientation of localized fiber groups by the needle-punching may compress the batt considerably, depending upon the frequency with which the punched areas occur on its surface. The punching may extend through the entire thickness of the batt to hold the loose mass of fibers together quite firmly. The fibers are then less likely to become disarranged during handling before

retraction, which may be important if the batt is to be retracted after passage of considerable time, and especially when the batt is to be shipped to another location before retraction. Increased frequency or depth of punching has an even more important effect which becomes apparent after retraction, when it will be seen to have imparted an increased stability to the thickness or vertical dimension of the product. Retraction of the punched fibers or filaments, with consequent entangling and interlocking with their neighbors, may be made sufficient to overcome the tendency of the batt to increase in thickness when retracted, since retraction of fibers not so oriented acts to reduce the lengthwise and widthwise dimensions of the batt. Depending upon the frequency and depth of punching, the mass may gain or lose in thickness; infrequent punching may be insulfficient to overcome the opposing tendency to increase in thickness as the surfaces of the batt corresponding to faces of the product diminish in area.

The rather fuzzy surface of the product can be smoothed by pressing. A heated pressing surface may induce additional retraction of surface fibers, but the temperature should be maintained below the softening temperature of the fiber to prevent fusion. This added compacting treatment is not essential in the majority of uses. Furthermore, satisfactory felts are produced without subjecting the batts at any time to any conventional felting treatment. The initial conditions of batt density and the intensity of the treatment described can be chosen to produce practically any desired density and coherence in the product without any rubbing pretreatment or conventional felting treatment.

Practically all synthetic polymeric filamentary materials can be manufactured so as to have the necessary retraction, and can be used in admixture with polytetrafluoroethylene filaments in the process of this invention to produce useful products. These other filaments useful for blending include those made from polyamides, polyesters and polyesteramides, polyvinylidene and polyvinyl compounds and their copolymers or interpolymers, polymerized hydrocarbons, proteinaceous polymers, and cellulose esters and ethers, as well as regenerated cellulose. If the other filaments are to appear with the polytetrafluoroethylene filaments in the final product, the retraction temperature should be chosen to prevent fusion of the other filament. Glass and asbestos filaments may also be blended with the polytetrafluoroethylene filaments.

According to this invention, the resultant product surface area and density may be controlled by choice or variation not only of the kinds or the relative amounts of starting materials, but also by adjusting the intensity or the duration of the treatment employed, including lapping, needle-punching, and retraction. The retraction treatment may consist of heating by various means, in an inert medium such as fused salt baths, molten metal, oil, steam, air or other fluid, or by infra-red radiation. The time of treatment may vary from a few seconds to hours depending on the temperature employed, although for simplicity, times of the order of one to sixty minutes are preferred.

The following examples illustrate the invention but are not to be construed as limitative or as indicating that the products obtained are in any sense equivalents. In all the examples the temperatures given were the ambient furnace temperatures as measured by thermocouples. In no instance did the actual filaments reach a temperature of 327° C.; in other words care was taken to prevent fusion or heat coalescence of the polytetrafluoroethylene filaments. These filaments may be prepared by the process of U.S. Patent No. 2,559,750 to Berry, or by the process described in application Serial No. 171,534, filed June 30, 1950, by Llewellyn and Lontz, now U.S. Patent 2,685,707, and assigned to the assignee of the present application.

Example 1

Polytetrafluoroethylene filaments of 3 to 5 denier, drawn to three times the original length, at room temperature, were skeined and cut into 3-inch staple. The retractable staple was run through a garnett to open it up. The staple was passed through the garnett a second time and collected as a loose batt about one and one-half inches thick. The batt was passed through a needle loom provided with etched needles of Example 1 of U.S. application Serial No. 427,465, now U.S. Patent No. 2,857,650 filed May 4, 1954, in the name of Herbert G. Lauterbach. This needling treatment punched a number of the fibers into and through the batt in the direction of its thickness, i.e., roughly perpendicular to the top and bottom surfaces. The needling action occurred about 100 times per square inch of batt surface. After needle-punching from the top of the batt it was turned over and run through the needle loom again to punch it from the other side. The same effect can be obtained by hand punching or other suitable treatment (e.g., sewing or tufting machine) with any instrument effective to disorient one or more fibers from the surface toward the interior of the batt. The needled batt was suspended in a Lindberg furnace at 300° C. for 1 hour. The treatment decreased the thickness of the batt and shrank the batt about 40% in area to a loose soft felt useful as a gasketing material.

Example 2

A needled batt was prepared as in Example 1 using the same needles and heated in the furnace at 325° C. for 1 hour. It decreased in thickness and contracted about 50% in area to form a much stronger though still fairly soft felt. This felt is useful as a wick for corrosive liquids.

Example 3

A felt prepared as in Example 1 using the same needles was passed through the needle loom again once on each side (making a total of four passes through the loom), and then heated for an additional 4½ hours in the furnace at 325° C. There was a further decrease in thickness below that of the felt product of Example 1. An overall area shrinkage of 75% was obtained, resulting in a very hard felt which is useful as a felt for dust filtration, especially involving corrosive fluids and/or high temperatures.

Example 4

Sixty grams of 3 to 5 denier polytetrafluoroethylene filaments, which had been drawn to seven times the as-spun length, was cut into approximately 3-inch staple lengths and mixed with 10% by weight of 2 denier, 2-inch, cellulose acetate staple. The mixture was carded and collected on a drum. The resultant batt was folded 4 times to give a thickness of about 1½ inches and needle punched once on each side by passing it through a needle loom provided with unetched needles of Example 1 of application Serial No. 427,465. The needle punched batt was immersed in acetone to remove the acetate fibers, rinsed well and dried. The dried batt was inserted in a Lindberg furnace at 450° C. for a few seconds. Shrinkage took place immediately. The resultant felt was removed from the furnace quickly, so that it did not reach a temperature as high as 327° C. There was a small decrease in thickness of the felt from the thickness of the original batt. A strong, moderately soft felt was obtained, useful as a filter cloth for corrosive liquids.

Additional useful felts may be prepared in a similar manner from batts comprising layers of dissimilar materials, and one or more layers may be of woven material. For example, a sandwich of one material between two layers of polytetrafluoroethylene filaments may be so constructed and treated that only the outer layers retract, providing an inner cushion or layer of woven or non-woven filamentary material securely held by contor-

tion of the needled portions of the outside layers onto it and each other. The outer layers may be made very dense without an equal increase in density of the center layer. The unretracted center inner layer may be made of undrawn polytetrafluoroethylene filaments or any other fibers insensitive to the particular retracting treatment effective upon the outer layers. For example, natural mineral fibers or non-retractable ceramic or glass fibers may be used. Also a sandwich may be formed of retractable polytetrafluoroethylene as the outer layers combined with another retractable material as the inner layer. Optionally, either the outer or inner layers of a sandwich may be retracted or both may be retracted. In each case the polytetrafluoroethylene may form either the outer or the inner layer.

Felt-like products of substantially any desired characteristics may be formed from polytetrafluoroethylene filaments (either staple or continuous, or a mixture of the two) according to the process of this invention. The products may be made in suitable form for use in a number of industrial and household applications; such as papermaker's felts, filter media for almost all known chemicals, wicks for liquids especially for corrosive chemicals, carpets and their underliners, gaskets, electrical and heat insulation, sound absorbents, chemically-resistant clothing, hats and gloves, and many other industrial and apparel uses.

It has been found that in order to effectively seal a glass-to-glass joint under low pressures with a needle-punched and retracted felt of polytetrafluoroethylene, it is necessary before sealing to impregnate the felt with an aqueous colloidal dispersion of polytetrafluoroethylene, followed by drying at about 40° C. to remove the water. Where this impregnated felt is used as the gasket to seal a relatively low pressure glass-to-glass joint, there is no leakage of liquid through the joint. When an unimpregnated felt is used in the same manner, the joint leaks.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

What is claimed is:

1. Process for making a felt-like laminar non-woven product comprising forming a batt of filaments including both heat-retractable polytetrafluoroethylene filaments and filaments characterized by decomposition into volatile substances upon heating to a temperature below 327° C., forceably orienting some of the polytetrafluoroethylene filaments into parallelism with one another substantially perpendicular to the faces of the batt, removing essentially all except the polytetrafluoroethylene filaments from the product by heating to a temperature below 327° C., the fusion temperature of the polytetrafluoroethylene filaments, and above the decomposition temperature of the other filaments, and diminishing the batt by retraction of the filaments into a coherent mass.

2. Process for making a felt-like laminar non-woven product comprising forming a batt of filaments including both heat-retractable polytetrafluoroethylene filaments and filaments characterized by solubility in an ordinary organic solvent, forceably orienting some of the polytetrafluoroethylene filaments into parallelism with one another substantially perpendicular to the faces of the batt, removing essentially all except polytetrafluoroethylene filaments from the batt by solvent extraction and diminishing the batt by heat-retraction of the filaments into a coherent mass.

3. Process for making a felt-like laminar non-woven product comprising forming a batt of filaments including both heat-retractable polytetrafluoroethylene filaments and filaments of another material, forceably orienting some of the polytetrafluoroethylene filaments into parallelism with one another substantially perpendicular to the faces of the batt, removing substantially all except polytetrafluoroethylene filaments from the batt, and diminishing the batt by heat-retraction of the filaments into a coherent mass.

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CERTIFICATE OF CORRECTION

Patent No. 2,893,105 July 7, 1959

Herbert G. Lauterbach

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 21, for "bended" read -- blended --; line 26, for "shring" read -- shrink --; same column 3, lines 24 and 25, 60, 67, 75, and column 4, line 2, for "polyetrafluoroethylene" read -- polytetrafluoroethylene --; column 5, line 28, for "treatment" read -- treatments --.

Signed and sealed this 10th day of November 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents