FIG. 1.

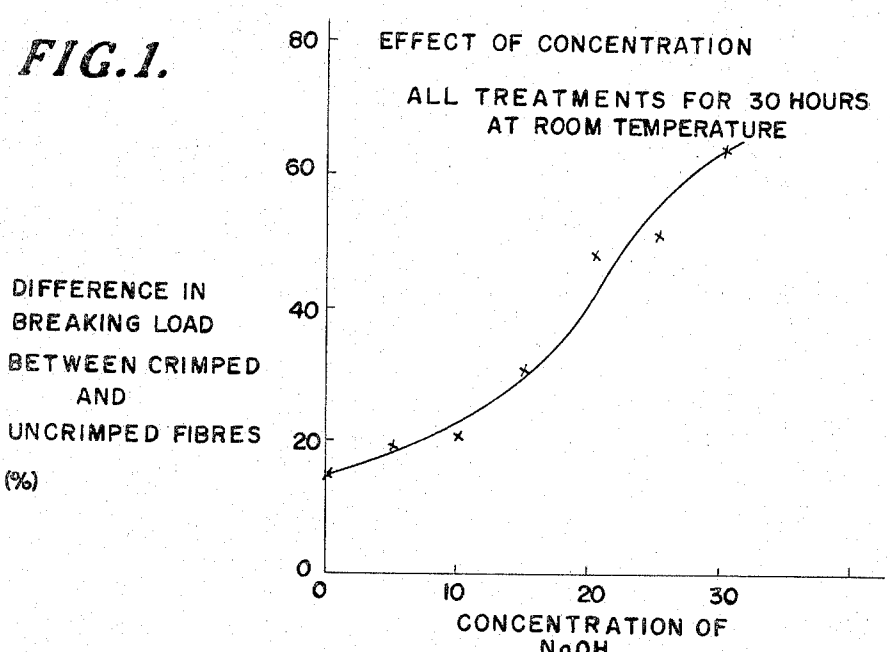
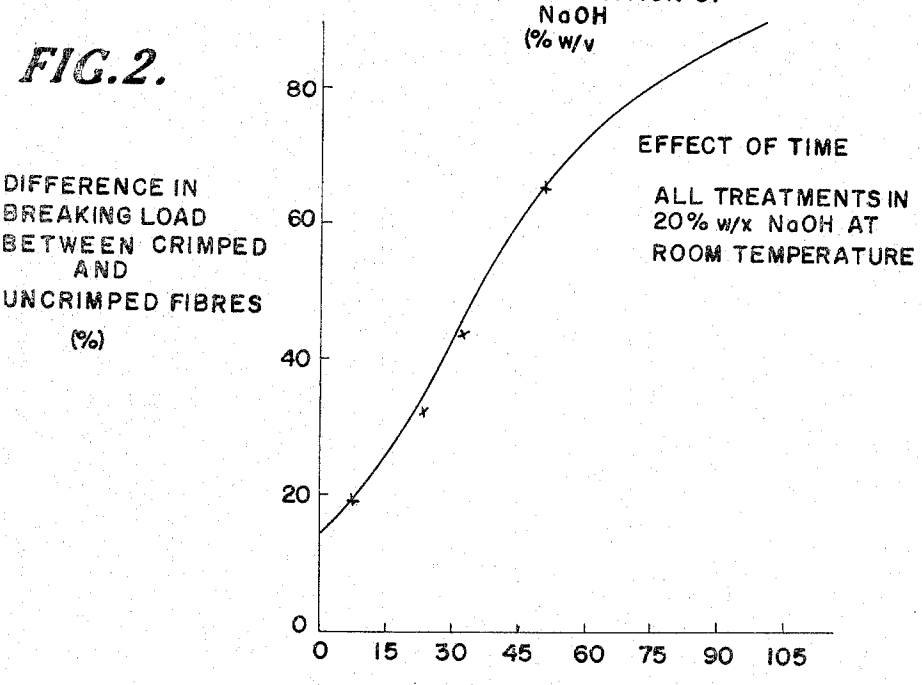


FIG. 2.



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FIG. 3.

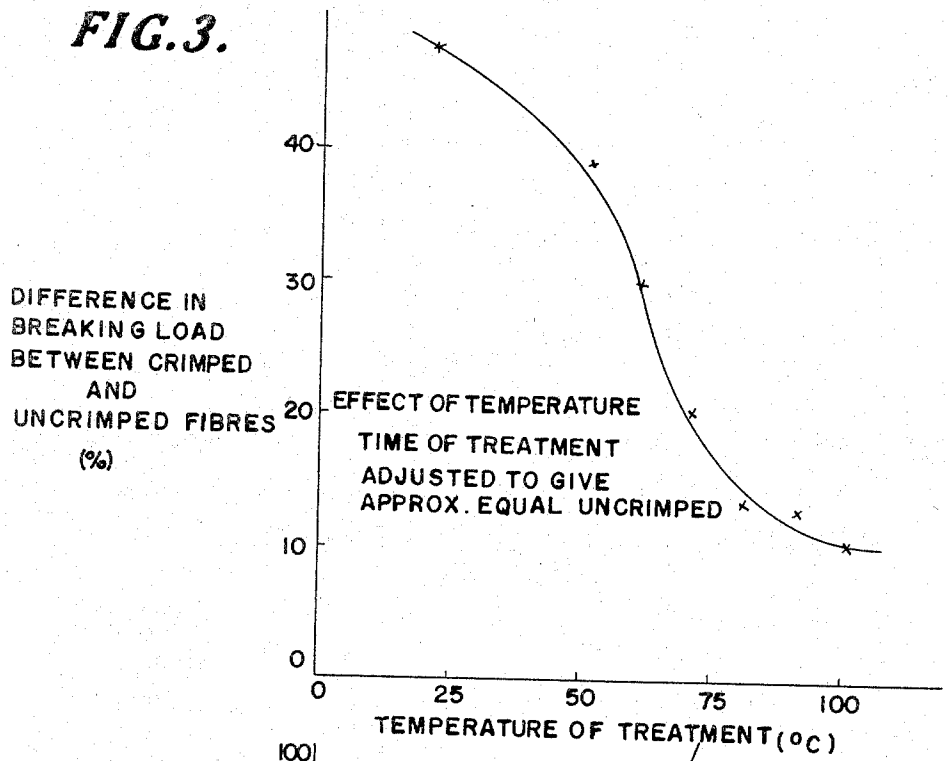
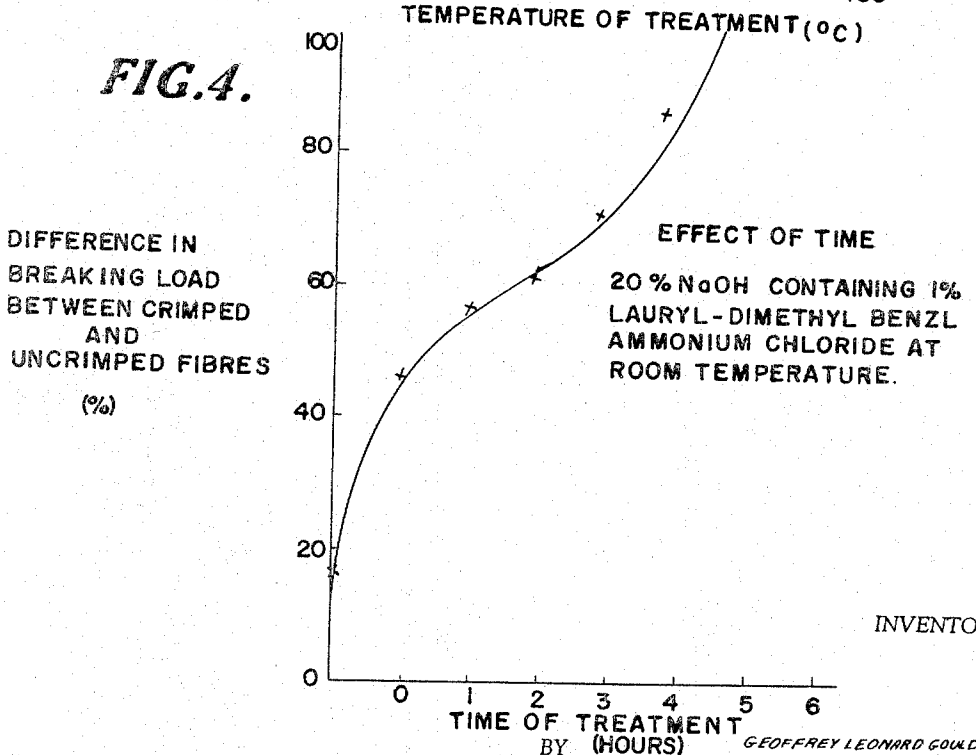


FIG. 4.



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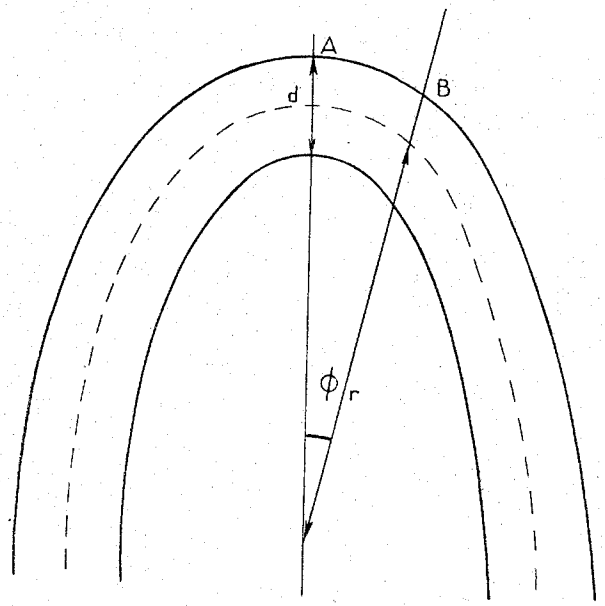


FIG. 5.

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FABRICS

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Original application Sept. 29, 1961, Ser. No. 141,791, now Patent No. 3,287,787, dated Nov. 29, 1966. Divided and this application Mar. 29, 1963, Ser. No. 274,370

Claims priority, application Great Britain, Sept. 30, 1960, 33,612/60

9 Claims. (Cl. 161—75)

This invention relates to the manufacture of improved fibres and fabrics made therefrom.

This application is a division of our copending application, Ser. No. 141,791, filed Sept. 29, 1961.

Some fabrics containing staple fibres of natural or synthetic origin particularly when made from polyesters such as polyethylene terephthalate show a tendency to form small balls of fibres or pills on their surface, due to wear. The propensity of forming such balls of fibres during wear is known as pilling and is believed to be associated with the migration of the fibres which are not firmly held in position in the yarn or fabric. Pilling is therefore encountered in low twist yarn and in loosely woven or knitted fabrics containing such yarns, when made from polyester fibres.

It is an object of our invention to provide improved fibres which can be made up into fabrics in which pilling is reduced or at least becomes less noticeable, even when low twist yarns and loosely woven or knitted fabrics containing such yarns are used. We have made the observation that polyester fibres can be weakened at intervals by chemical means if they have been deformed by crimping so that they subsequently break under mechanical stress e.g. as encountered during wear of the fabric. As a result any loosely held fibres which migrate to the surface of the fabric are broken ot the weakened intervals and the formation of pills is eliminated or reduced and any pills which are formed can be easily removed from the fabric surface by appling mechanical stress e.g. by brushing.

It is another object of our invention to produce tows of polyester filaments which can be converted into tops by a stretch breaking process, known as tow to top-conversion, in which the forces necessary for breaking the filaments are less and breaking is facilitated. Overlengths during cutting are eliminated.

The invention is illustrated in part by the drawings which are graphs showing the effects of variables in the chemical treatment included therein.

FIGURE 1 shows the effect of concentration;

FIGURE 2 shows the effect of time;

FIGURE 3 shows the effect of temperature; and

FIGURE 4 shows the effect to time when a quaternary ammonium salt is included in the bath;

FIGURE 5 is a diagrammatic plan view of a part of a polyethylene terephthalate filament beig strained by bending, the view being useful in imparting an understanding of the point of selective pronounced attack of the chemical agent according to the present invention.

According to our invention, we provide improved crimped filaments and fibres characterised in that they have been weakened at intervals corresponding substantially to the apexes of their crimp when the crimp is caused by a permanent deformation involving compression beyond 1 to 2% of the elastic limit on the inner curvature of the bent filament or fibre. Preferably the fibres have 5 to 18 crimps per inch. It is also preferred that the fibres should be reduced in strength by at least one-third at the apexes of their crimp, compared with the stronger fibre portions between said weaker portions.

We also provide a process for making such filaments and fibres wherein crimped synthetic polyester filaments or fibres are treated with a chemical agent under conditions such that the filaments or fibres are weakened at intervals corresponding to the apexes of their crimp. The process is preferably applied to filaments in the form of a crimped, drawn two before the filaments have been subjected to a heat setting process for setting the imparted crimp and before cutting or breaking into staple fibre.

Many chemical agents may be used, the most convenient are alkaline solutions such as sodium hydroxide solution, ammonia, solutions of certain quaternary ammonium salts or methyl alcohol, which may be added to the sodium hydroxide solution, or certain diamines such as a solution of hexamethylene diamine, anhydrous glycols including high molecular weight glycols their esters and ethers, which are still liquid at room temperature. Inert diluents may be added to these solutions if desired.

Our invention also provides improved fabrics characterised in that they contain at least a proportion of crimped polyester fibres which are weaker at intervals corresponding substantially to the apexes of their crimps. Such fabrics have a reduced propensity of pilling even when they are made from yarns or using fabric constructions, which when made from or applied to yarns of unweakened fibres, show a marked propensity to pilling.

A treatment of uncrimped filaments or crimped but heat set filaments under the same conditions does not lead to the same weakening at spaced intervals along the lengths of the filaments or fibres, because the chemical agents attack more uniformly. It should be appreciated that the weakening or breaking of the filaments or fibres by our treatment is a direct consequence of the selective intensity of the attack caused by the agents at intervals along the filaments or fibres at the apexes of the crimps, whereas the portions between the apexes are affected to a lessor degree or may remain substantially unaffected by the uniform application of the chemical agent. As a result the portions of the filaments or fibres treated with a suitable agent break under mechanical stress preferentially at intervals whereas the portions between may remain substantially unaffected in strength.

It is believed that the selected weakening at the apexes of the crimps is brought about by internal stresses causing local disorder in the filaments or fibres imparted by the acute deforming operation during crimping. For this reason stuffer box crimping and gear crimping are preferred.

The conditions of treatment have to be determined by experiment and should be selected so that no intolerable weakening of the filaments or fibres should occur in the uncrimped portion, whereas the apexes of the crimps are weakened by at least one third or preferably by about one half or more, compared with their original strength. This can be done by measuring the tenacity of a small sample of the filaments or fibres before and after the treatment and by examining the broken ends of the

fibres which should occur only at the apexes of their crimp.

The strains introduced during crimping should preferably be such as to cause bending of the filaments at defined intervals and which results in a permanent deformation involving compression beyond 1%–2% of the elastic limit on the inner curvature of the bent filament and a tension on the outer curvature of the bent filament to cause a deformation not beyond 5% of the elastic limit, only at intervals along the filament axis. In the case of polyester filaments having a substantially circular cross-section the deformation should preferably involve bending the filaments at intervals to a curvature which is less than 50 times the filament diameter, e.g. a 4 denier filament should be bent to a radius of curvature of less than 2 times 10^{-1} cm. Conditions of crimping should preferably be arranged so that the intervals between crimps result in 5–18 crimps per inch. If the crimp frequency is below 5, the crimped fibres which migrate to the surface of the fabric may cause the fibres to be broken off at intervals which are too large to prevent the formation of pills. In other words the projecting broken fibre ends will be too long to prevent the formation of pills. If on the other hand the crimp frequency is allowed to rise above 18 crimps per inch, the useful lengths of fibre between the apexes of the crimps may be too short and fabrics made from such fibres are likely to have a reduced resistance to abrasion and wear and therefore will deter from their commercial value.

For a better understanding of the above requirements we refer to FIG. 5 showing a diagrammatic plan view of a part of polyethylene terephthalate filament being strained by bending. In FIG. 5 a filament of diameter d is being strained by bending to a radius r such that a small part of the filament A–B, which part is of the order of the filament diameter d, subtends an angle ϕ at the centre of curvature. At the inner curvature of the filament, compression beyond 1%–2% will cause a permanent deformation and disorientation of the fibre forming polymer. This is believed to permit the selective pronounced attack of the chemical agent compared with the remaining portions of the fibre, because of a reduction in the order of the filament structure in the bent portion.

On the outer curvature an elongation occurs which causes further orientation. Because of this, the disorientation at the inner curvature of the bent filament, the latter becomes prone to greater attack by the treating agents. On the outer curvature bending will cause orientation which may be accompanied by crystallisation and for these reasons the elongated deformation should preferably not be allowed to rise beyond 5% and heating before the chemical treatment should likewise be avoided. This therefore defines the amount of strain caused by the bending of the filaments. As stated, bending of the filament should preferably be caused to be less than 50 filament diameters to fulfill the above requirements according to the formula:

$$\frac{r\phi-\left(r-\frac{d}{2}\right)\phi}{r\phi}=\frac{d}{2r}>1\text{-}2\%$$

The desired crimp may be obtained using a stuffer box crimper having relatively large diameter feed rolls and by adjusting the pressure in the stuffer box from which the exit of the crimped filaments is restrained by means of a dead weight or by hydraulic pressure. We have found feed rolls of 4–6″ diameter about 1″ wide suitable for the crimping of tows of 100,000–300,000 denier, in a stuffer box crimper.

It should be appreciated that a uniform application of the chemical agent is necessary in order to obtain the selective weakening of the filaments according to our invention. Strong aqueous caustic alkali solution of 20–30% by weight, may be used at low temperatures, for example at 20–40° C., for a treatment lasting 30–50 hours. The addition of small amounts of catalytic accelerators to the caustic alkali solution selected from methyl alcohol and certain quaternary ammonium salts, speed up the reaction. Suitable quaternary ammonium salts comprise e.g. cetyl trimethyl ammonium bromide and lauryl dimethyl benzyl ammonium chloride. The effect of other quarternaries such as cetyl trimethyl pyridinium bromide, dimethyl phenyl benzyl ammonium chloride and tetramethylammonium bromide is less marked, and because of the additional cost to the treatment they are therefore not recommended. With the addition of the accelerators the concentration of the caustic alkali solution may be considerably decreased e.g. to 5% by weight or as low as 1%. Using temperatures near the upper limit as specified hereafter, the time of the treatment may be drastically reduced. Quite small amounts of the accelerator are suitable e.g. 0.005% to 1% by weight of the solution, as described in our copending U.S. Patent No. 3,135,577. It must be emphasised, however, that the treatment should be carried out at a temperature below heat setting temperature to obtain effective treatment. It will be appreciated that the time of treamtent can be shortened as higher temperatures are used, but since the selective degradation of the crimped filaments decreases with increasing temperature, temperatures below 110° C., preferably room temperature up to about 70° C. are preferred.

In the case of crimped filaments having an overall tenacity above 4 gms. per denier the tenacity should be reduced preferably below 3 and above 1.5 g.p.d. In the case of medium tenacity fibres below 4 gms. per denier it is desirable to reduce the overall fibre tenacity to 2.5 gms./denier or below but above 1.0 gm. per denier. It will be appreciated that a certain amount of reduction in the tenacity even in the stronger fibre portions, between the crimps, is tolerable but this should preferably not exceed ⅓ of the initial tenacity. In the case of the treatment with caustic alkali a loss in weight of up to 10% with a corresponding reduction in the diameter of the filaments may be brought about and this is associated with an improved handle of the fabric.

Our invention will more particularly be described relating to polyester filaments and fibres made from polyethylene terephthalate for which it is particularly suitable, the filaments having a substantially circular cross section. It will be appreciated, however, that our invention is not intended to be so limited and that it applies also to filaments and fibres having a non-circular cross section, particularly a cruciform, Y-shaped, tri-lobal, dog-bone, or any other known cross section for thermoplastic filaments. Similarly it will be applicable to other polyester or co-polyester filaments as stated herein and which show a propensity to pilling.

Preferably polyethylene terephthalate filaments are produced by a process of melt spinning followed by drawing at a temperature below 110° C. preferably between 80 and 98° C. The drawn filaments in the form of tows are then subjected to a stuffer box crimping operation ensuring a deformation in the filaments to cause bonding at intervals to a curvature which is less than 50 times their filament diameter in order to impart the desired crimp, at a frequency of between 5 to 18 crimps per inch, depending upon the filament diameter which may be between 1 to 5 denier per filament.

The crimped tows are then subject to the treatment with the defined chemical agents which are removed by e.g. neutralising with dilute strong acid solution, rinsing with water, followed by drying and heat setting at a temperature above 110° C., preferably using steam at superatmospheric pressure and temperatures between 130–150° C., and temperatures up to 220° C. using dry heat. Setting is necessary to bring residual shrinkage in boiling water for 1 minute, to less than 1%.

Suitable finishing lubricants may be applied before or

after heat setting in order to facilitate processing and to prevent the accumulation of static electricity. The crimped, treated and heat set tows are then out into staple fibres of the desired length, e.g. between 1½" and 7".

From these staple fibres improved fabrics can be produced by known methods comprising weaving and knitting; such fabrics have a reduced propensity to pilling.

We also provide a new type of synthetic polyester fibre having 5–18 crimps per inch and an overall tenacity of 2.5 gms. per denier or below, but above 1.5 g.p.d., the tenacity of the stronger portions of the fibre, between the apexes of the crimp, being only up to ⅓ less than the initial tenacity of the drawn fibres. By comparsion the drawn crimped fibres have a tenacity of 4 gm. per denier and up to 6 gm. per denier, before the treatment with the chemical agent.

The polyester filaments and fibres referred to in this specification are made by a process of melt spinning and denote fibre forming polyesters including polyethylene terephthalate, copolyesters derived from up to 15% of another component which may be selected from the group of dicarboxycylic acids having the formula:

HOOC—R—COOH

where R may be methylene, polymethylene or arylene, other than paraphenylene, represented by a sebacic, adipic and isophthalic acid, and the remainder polyethylene terephthalate; or modified fibre forming polyesters such as poly (hexa hydro-paraxylylene) terephthalate.

The filaments may be subjected to a deformation step which is effective, followed by the treatment with a suitable agent and if desired followed by further steps such as heat setting before or after further deformation steps to bring about a greater crimp frequency. The filaments need not be cut and may be made up into fabrics from our treated filaments in the form of filament yarn.

If the filaments or fibres in their specified crimped condition are to be treated in fabric form, no heat setting of the imparted crimp must take place after crimping and prior to the treatment.

The polyester filaments may be subjected to immersion or spraying with hot substantially anhydrous polyethylene glycols and nonyl phenyl polyethylene glycol ethers, of a molecular weight of 200–2000, using temperatures above 80° C. but at least 30° C. below the melting temperature of the polyester, preferred temperatures are 110°–130° C. The polyglycols may be applied before or after drawing of the polyester filaments and this brings about a considerable improvement in dye uptake. One such application of polyglycols is described in our co-pending U.S. application Ser. No. 114,021.

The following examples in which all parts and percentages are by weight illustrate but do not limit our invention.

EXAMPLE I

A 275,000 denier tow containing 70,000 filaments of polyethylene terephthalate is crimped in a stuffer box crimper so that the tow has 10–14 crimps per inch. The crimped but unset tow is treated by immersion in a 22.5% sodium hydroxide solution in water at 30° C. for 40 hours. Excess solution is removed between squeeze rolls and the tow is washed with water, dried and heat set with steam at 130° C., and cut into staple fibres of any desired length. When a number of filaments from the treated tow are tested in a tensile testing apparatus, it is found that breakage occurs always at the apex of the crimp, and the single fibre tenacity compared with an untreated control is reduced by 94%. Fabrics containing the treated staple fibres show no pilling, whereas fabrics containing untreated fibres show numerous pills.

The single fibre tenacity of crimped tow which is heat set using steam at 140° C. for half an hour, before the treatment with the sodium hydroxide solution in Example I, is reduced by only 32%.

EXAMPLE II

A tow of polyethylene terephthalate filaments is crimped and the crimped tow treated with sodium hydroxide solution and washed as in Example I. The treated tow is converted into top or yarn by a stretch breaking process designed to give the desired staple length between 2½ and 6 inches.

Conversion of the tow into top or yarn is facilitated as lower stretching forces are required, because the alkaline treatment has produced positions of low tensile strength at the apexes of the crimps and the tow will break to give the required fibre length more easily. Undesirable overlengths and underlengths in the staple fibres will therefore be absent.

In the following Examples III to VI, experiments are described to illustrate the effect of setting on a simulated crimp in polyethylene terephthalate yarn under various treating conditions with caustic soda solutions, with and without an accelerator, and the testing method used for determining the breaking load and extension of the yarn.

Yarn.—Polyethylene terephthalate 75 denier 36 filament yarn having a tenacity of 4.5–5.5 g.p.d. and an extension at break of 27–17%.

Crimping.—The yarn was wrapped round a 2 centimeter wide strip of copper foil 0.25 mm. thick, placed between polished steel plates and subjected to a pressure of 15 tons per square inch for five minutes in a hydraulic press, to obtain a simulated crimped yarn, in which each filament is deformed by compression beyond the elastic limit on the inner curvature of the bent filaments, when the elastic limit is between 1–2%.

Setting.—The yarn was subjected to dry heat setting by a treatment in an electric oven at 140° C. for ten minutes. Other samples of the same yarn were subjected to steam setting in a Sanderson oven at a steam pressure of 40 lbs. per square inch, equivalent to a temperature of 140° C., for fifteen minutes.

Treatment.—The crimped yarn, set or not set as required, was placed with an uncrimped control in a 100 ml. flask and treated as described. After the treatment the samples were washed thoroughly in water and dried.

Testing.—Lengths of yarn containing one crimp only were mounted on cards, the crimp position marked and the fibre breaking load and extension at break were determined on an "Instron" tensile tester. Figures quoted in the following tables are the mean of ten tests.

The uncrimped controls were tested similarly.

EXAMPLE III

Effect of setting the crimps.—The results are shown in Table 1 in which the treatment time used was 30 hours using a 20% w./v. sodium hydroxide solution at room temperature. Unset, dried heat set, and steam set yarns both crimped and uncrimped were tested for breaking load and extension at break both before and after the treatment with caustic soda. It will be seen from the table that the effect obtained produces considerable differences in tensile strength between the crimped and uncrimped portion of the filaments and that this effect is achieved with the unset fibre where, after treatment, the crimped fibre was 48% weaker than the uncrimped fibre. The set fibres do not show this significant strength difference.

Dry heat set fibre differs by approximately 6% between crimped and uncrimped samples, both before and after treatment. Crimped steam set fibre was twice as weak compared with an uncrimped sample, after treatment as before the difference was still only 21%.

In every case the unset treated samples *broke at the crimp* when tested, whereas the controls and also the set crimped samples did not always break at the crimp. A sufficient number of tests have been made to conclude that weakening occurs preferentially at the apex of the crimp in the case of unset filaments.

TABLE 1.—EFFECT OF SETTING

[Treated for 30 hours in 20% w./v. NaOH at room temperature]

Yarn	Uncrimped		Crimped		Percent Difference	
	Breaking Load	Extension	Breaking Load	Extension	Breaking Load	Extension
Unset:						
Control	355	41.0	276	24.4	22	40.5
Treated	283	28.2	147	14.0	48	51
Dry Heat Set:						
Control	342	38.6	319	36.5	6.7	4.9
Treated	241	26.5	227	23.7	5.8	10.5
Steam Set:						
Control	345	38.8	298	35.9	14	7.5
Treated	289	34.3	229	17.0	21	50.5

EXAMPLE IV

Effect of concentration

Unset crimped yarn and uncrimped controls as described, were used to investigate the effect of varying the concentration of the alkali and the time of treatment. The results are summarised in Tables 2 and 3 (and in FIGURES 1 and 2). The difference in strength between the crimped and uncrimped fibres increased both with concentration and with time of treatment.

EXAMPLE V

Investigation of the effect of the temperature is shown in Table 4 and FIGURE 3. The time of treatment was varied in order to give a constant value for the strength of the uncrimped fibres and the results showed that at treatment temperatures of over 50° C. the difference in strength between crimped and uncrimped yarn decreased rapidly with increasing temperature. This could be due to the setting effect of the hot liquid.

TABLE 4.—EFFECT OF TEMPERATURE

(See also Figure 3)

Treatment		Uncrimped		Crimped		Percent Difference	
Temperature, ° C.	Time, min.	Breaking Load	Extension	Breaking Load	Extension	Breaking Load	Extension
100	3.5	287	30.2	257	22.3	10.5	26.1
90	7.5	287	31.5	249	22.1	13.2	29.8
80	18	277	29.7	239	22.0	13.7	25.9
70	36	302	33.6	240	21.6	20.5	35.7
60	88	285	30.6	199	17.2	30.2	43.8
50	168	283	32.2	172	15.4	39.2	52.2
20	1,800	283	28.2	147	14.0	48.0	50.5

TABLE 2.—EFFECT OF CONCENTRATION

[Unset yarn treated for 30 hours at room temperature]

Concentration of NaOH, Percent	Uncrimped		Crimped		Percent Difference	
	Breaking Load	Extension	Breaking Load	Extension	Breaking Load	Extension
5	330	32.5	268	22.9	18.8	30.4
10	320	32.6	252	24.0	21.2	26.4
15	336	32.0	232	16.5	31.0	48.5
20	283	28.2	147	14.0	48.1	50.4
25	243	24.0	117	12.3	51.6	48.7
30	254	28.3	90	9.9	64.6	65.0

TABLE 3.—EFFECT OF TIME

(See also Figure 2)

[Unset yarn treated at room temperature in 20% w./v. NaOH]

Time of treatment	Uncrimped		Crimped		Percent Difference	
	Breaking Load	Extension	Breaking Load	Extension	Breaking Load	Extension
Control	329	40.9	276	24.4	16.1	40.3
7½ hours	303	32.6	244	21.6	19.5	33.8
23½ hours	272	30.5	180	17.0	33.8	44.2
31½ hours	256	26.3	140	14.0	45.3	46.8
50 hours	228	25.4	75	8.3	67.2	67.3
95½ hours	194	21.0	19	2.4	90.3	77.5

EXAMPLE VI

Polyethylene terephthalate yarn was treated at room temperature with 20% sodium hydroxide solution to which 1% lauryl-dimethyl benzyl ammonium chloride, available under the trade name "Vantoc C.L.," had been added. The results of the treatment during one to seven hours on uncrimped and crimped filaments is shown and the difference in tensile properties and the percentage difference between uncrimped and crimped samples are tabulated in Table 5 (and FIGURE 4). It can be seen that after only six hours the crimped yarn was too weak for the tensile strength to be measured. If the time for the difference in strength between crimped and uncrimped yarn to reach 50% is compared, the use of 1% accelerator ("Vantoc C.L.") is seen to speed up the reaction twenty-six times, that is to say, 1.3 hours compared with 34 hours in Example III.

TABLE 5.—EFFECT OF ACCELERATOR

(See also FIG. 4.)

[Unset yarn treated at room temperature with 20% w/v NaOH containing 1% lauryldimethylbenzylammonium chloride]

Time of Treatment (hours)	Uncrimped		Crimped		Percent Difference	
	Breaking Load	Extension	Breaking Load	Extension	Breaking Load	Extension
1	299	38	161	16	46.1	58
2	294	34	127	13	56.8	62
3	267	30	104	9	61.2	70
4	277	26	80	5	71.2	81
5	224	26	30	2	86.5	92
6	197	24	----	----	100	100
7	191	21	----	----	100	100

EXAMPLE VII

This example illustrates the effect of the treatment on pilling. A stuffer box crimped unset drawn polyethylene terephthalate tow was treated for thirty hours in 20% aqueous sodium hydroxide solution at room temperature, washed with water, dried, set in air at 140° C. for 10 minutes, cut into 2 inch lengths and resulting staple fibres were converted on standard cotton equipment to give spun cotton type polyester yarn and this was woven into a twill fabric which was tested for pilling.

Table 6 shows the properties of the fibre at various stages of fabric production, compared with untreated polyester cotton-type 2" long staple fibres. It will be seen that improved pilling performance is achieved at the expense of decreased flex abrasion resistance and tensile strength. The lower extension at break of the treated fibre is of particular advantage if the fibres are blended with cotton.

It will be seen from the examples that:

(1) Unset crimped fibre is preferentially attacked at the crimp apexes by strong aqueous caustic soda solution.

(2) Both steam and dry heat-set crimped fibres do not undergo this preferential attack to the same extent.

(3) Addition of quaternary ammonium salts to caustic soda solution accelerates the rate of attack.

(4) Fabric made from treated fibre shows an improvement in pilling performance compared with untreated fibres.

Although in the preceding examples polyethylene terephthalate filaments and fibres have been used, it is believed that similar effects are obtained with other commercially available crimped oriented high tenacity synthetic polymer filaments or fibres such as nylon, "Perlon" and polypropylene, provided that the treatment is carried out with a suitable agent which will attack at the apexes of the crimp and when the crimp has been obtained by bending under compression beyond the elastic limit and not set, so that the filaments and fibres are weakened at intervals corresponding to the apexes of their crimp.

The Brush and Sponge test referred to in Example VII is described in A.S.T.M. 1958 D. 1375–55T, page 515. This test is intended to determine the resistance of woven fabrics to pilling and fuzzing. The method provides a laboratory procedure for mechanically simulating wear conditions by first brushing a fabric to form free fiber ends and then subjecting the fabric to a circular rubbing action with a sponge which rolls the fiber ends into pills.

The terms "fibre" and "filament" are used substantially interchangeably herein in instances where no intended distinction is evident from the context.

What we claim is:

1. An oriented synthetic polymer fibre oriented along substantially the whole length thereof having 5–18 intervals per inch throughout the length thereof of reduced

TABLE 6.—FABRIC PRODUCTION

Production Details	Fibre Form	Property	Units	Untreated Fibre	Treated Fibre
	Cut fibre	Fibre length	Inches	2	2
		Denier		3	3
		Tenacity	G.p.d	5.37	2.38
		Extension	Percent	30	18
Spinning fibre spun into 2/18.7's cc. yarn with 10Z singles and 5S doubling twist.	Singles yarn (1/18.7's); Doubled yarn (2/18.7's).	Tenacity	G.p.d	2.42	1.42
		Extension	Percent	30.3	17.7
		Tenacity	G.p.d	2.77	1.45
		Extension	Percent	32.2	17.9
Weaving yarn woven into a 2/2 twill fabric 32" wide 52 x 52 ends x picks/inch finished sett.	Finish, fabric	Pilling (sponge test 200 mins.).	Pills/sq. in. 28		8
		Flex abrasion	No. of flexes to break	6,000	1,800
		Flat abrasion	----	Similar	

diameter compared to the remainder of the fibre between said intervals, each interval being on the order of two times the fibre greatest diameter in extent, lengthwise of the fibre; the tenacity of said fibre in said intervals being within the range of greater than 1.5 and less than 4 grams per denier, the tenacity of said fiber between said intervals being within the range of greater than 2⅔ and no greater than 6 grams per denier and being substantially greater than the tenacity of said fibre in said intervals.

2. The oriented synthetic fibre of claim **1** wherein said fibre has 5–18 crimps per inch throughout the length thereof, each of said intervals being coincident with the apex of a respective crimp of said crimps.

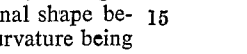
3. The oriented synthetic fibre of claim **2**, having a substantially circular transverse cross-sectional shape between said intervals, each crimp radius of curvature being less than 50 times the greatest filament diameter in the remainder of said fibre.

4. Yarn comprising the fibre of claim **2.**

5. Textile fabric comprising the fibre of claim **2.**

6. The oriented synthetic fibre of claim **2** in which the fibre comprises a polyester.

7. The oriented synthetic fibre of claim **6**, wherein the polyester essentially comprises polyethylene terephthalate and up to 15 percent of another polyester chosen from the group consisting of polyesters derived from bicarboxylic acids having the formula:



where R is a member of the group consisting of methylene, polymethylene, and poly (hexa hydro-para-xylene) terephthalate.

8. The oriented synthetic fibre of claim **1** having an overall tenacity of between less than 3 grams per denier and more than 1.5 grams per denier.

9. The oriented synthetic fibre of claim **8** having a fineness of within the range of 0.9–5 denier.

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