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E. W. RUGELEY ET AL

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SYNTHETIC FIBER

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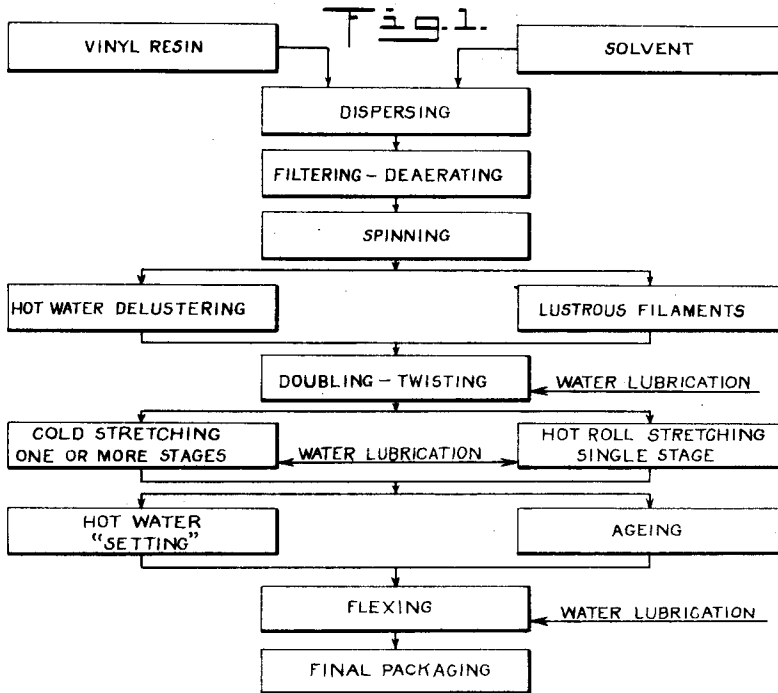
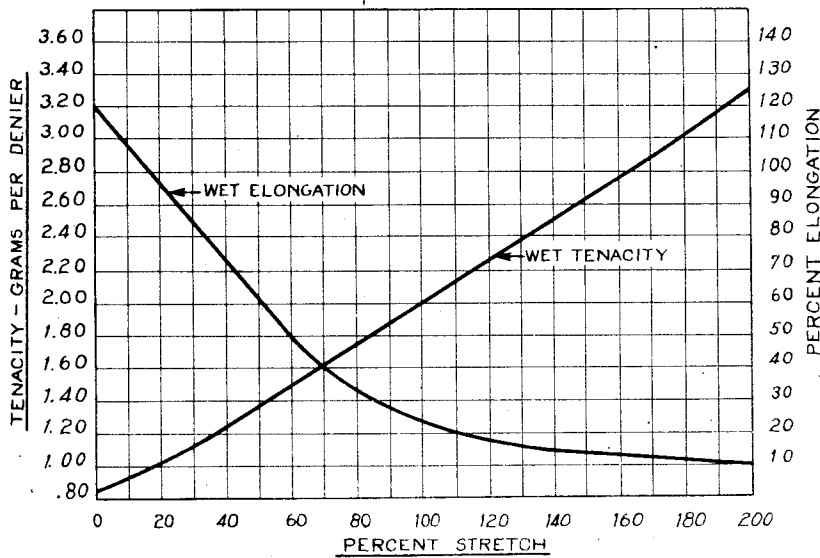


Fig. 2.



INVENTORS  
EDWARD W. RUGELEY  
THEOPHILUS A. FEILD, JR.  
JOHN F. CONLON

BY  
*Charles C. Scheffler*  
ATTORNEY

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## SYNTHETIC FIBER

Edward W. Rugeley, Theophilus A. Feild, Jr., and  
John F. Conlon, Charleston, W. Va., assignors  
to Carbide and Carbon Chemicals Corporation,  
a corporation of New York

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The quest for a truly synthetic textile fiber has had few rivals in its intensity, and, through the past, in its conspicuous lack of success. It has been proposed to make textile fibers and filaments from many synthetically produced materials, but until now none of these has ever yielded a commercially usable product. The only commercially useful textile fibers at present, as in the beginning, are products of nature, supplemented more recently by those made from chemically modified natural products, such as the esters and ethers of cellulose, and cellulose itself regenerated from its derivatives.

This invention makes possible a synthetic fiber of many unique and distinctive properties, including high true elasticity, flexibility, high strength and remarkable resistance, and it provides an easily producible product not originating in nature which equals and surpasses in many respects natural fibers and fibers made from modified products of nature. The synthetic fibers of this invention are formed of certain types of vinyl resins, and the invention includes methods of forming, treating and using the new fibers, all as more fully hereinafter described.

Vinyl resins have been proposed for use in forming textile fibers by nearly all who have had experience with them, and this was entirely to be expected, since these resins are products which are truly synthetic, as well as readily formable, inherently colorless, odorless, tasteless, and not readily inflammable. Nevertheless, in the twenty years and more since vinyl resins first were suggested for this purpose, useful or practical fibers have never been produced from any vinyl resin of these types.

The new fibers of this invention are formed from vinyl resins such as may result from the conjoint polymerization of vinyl halides with vinyl esters of aliphatic acids, and which have an average macromolecular weight of at least about 15,000. (Molecular weights referred to herein are those calculated by means of Staudinger's formula from viscosity determinations of solutions of the resins.)

Briefly, the fibers are formed by spinning a solution or dispersion of the vinyl resin into filaments. These filaments are formed into fibers of the desired size by twisting and doubling operations as desired, and thereafter the fibers are stretched to yield products suitable for use in the customary textile operations. The stretching of the fibers is carried out while they are in their normal state, by which is meant that they are not softened by heat or by the action of a solvent.

This stretching operation is a vital feature in the production of useful textile fibers from the vinyl resins, and it serves the dual purpose of greatly increasing the tensile strength, and of conferring on the fibers the unusual and highly desirable property of true elasticity. By means of the stretching operation, the two highly important properties of tenacity and elongation may be varied and controlled almost at will.

The fibers in finished form are soft and flexible, and are characterized by their ability to be woven and knitted and formed into a large number of exceptionally useful materials. The new fibers possess a very high strength by comparison with other textile fibers, and they are unusual in that their strength is virtually the same whether they are wet or dry, and, surprisingly enough, the wet strength of the new fibers is, if anything, slightly greater than the dry strength. The unique resistance to impairment by water, together with the true elasticity, resistance to chemical, bacterial and fungal attack, thermoplasticity, lack of inflammability and great flexibility of the fibers, makes possible many uses for these materials which are radically different from those to which ordinary textile fibers are applicable.

The general sequence of operations in the formation of the new textile fibers according to this invention is shown by the flow sheet appearing as Fig. 1 in the accompanying drawing.

As has been indicated, the vinyl resins from which the new fibers are prepared must have special characteristics. The class of resins useful in this invention are those such as are described in Patent 1,935,577 to E. W. Reid, and these resins may be made by the processes described by that patent or by other means, such as the process described in Patent 2,064,565 to E. W. Reid. Of these conjoint polymers of vinyl halides with vinyl esters of aliphatic acids, the preferred resins are those which contain from 80% to 95% by weight of the halide in the polymer. Within this range, those resins formed from vinyl chloride and vinyl acetate which contain in the polymer about 85% to 90% by weight of the chloride are especially desirable.

The resin must have an average macromolecular weight of at least 15,000, and the upper value is limited only by the solubility of the resins in suitable liquids to yield spinnable solutions or dispersions. Vinyl resins, as prepared, ordinarily consist of a mixture of polymeric aggregates of different molecular sizes. Those to be used in this invention should be freed from polymers

having excessively low molecular weights in order that the average macromolecular weight of the resin will be at least the minimum stated above. This may be accomplished by various extraction procedures, such as those described in Patent 1,990,685 to C. O. Young and S. D. Douglas, or by similar methods of partial dissolution and precipitation. The resin after such treatment must be completely dispersible in warm dry acetone, or in other liquids from which the filaments may be formed in the spinning operation. By "dry" acetone is meant this substance which contains less than about 0.60% by weight of water. It has been found that, when the acetone used contains water in excess of this amount, the quality of the resin dispersion is materially impaired, and solutions made from such solvents can be filtered and spun only with great difficulty. The concentration of the vinyl resin in the spinning solution is dependent upon and varies inversely with the macromolecular weight of the resin, but the resin content ordinarily employed using acetone as the solvent is 25% or less by weight. In forming the solution, the resin is best employed in the form of a dry powder, and the dispersion, or the spinning "dope", may be made by combining the resin with the requisite quantity of dry acetone in a mixing device, such as one of the dough-type mixers or kneaders, provided with means of temperature control, and equipped to effect reflux of the solvent. The temperature of mixing and subsequent handling is conveniently maintained at about 50° C. The time required for mixing to obtain useful dispersions must be adjusted according to the ease of dispersion of the resin in the solvent, and this ordinarily consumes about 12 hours. The resulting "dope" is a clear, heavily gelatinous, non-flowing, plastic mass at room temperature, while at a temperature of 50° C. it assumes a very viscous, slowly flowable state. This viscosity has been determined by experiment to be desirable in the subsequent manipulation of the solution and its formation into filaments.

The dispersion, or "dope", may be filtered in high-pressure type plate-and-frame filters, the material being moved by means of high-pressure gear-type pumps. Throughout the handling of these dispersions, it is highly desirable to provide all storage tanks and conduits with temperature control means, such as jackets supplied with heated water or steam, so that an elevated temperature may be maintained to reduce the pressure necessary to handle the viscous mass. Filtration may be carried out in one or more stages, and the filtering medium may be any suitable material capable of removing the last traces of undispersed or insoluble material from the "dope". Filtering pressures of from about 200 to 500 pounds per square inch, in general, are suitable for this operation. The filtered "dope" should be thoroughly de-aerated, and this may be effected by permitting the dispersion to stand for about 24 hours at the operating temperature of 50° C., and this may be assisted, if desired, by creating a partial vacuum over the dispersion.

The spinning, or filament extrusion, operation may be carried out in equipment customarily employed for so-called "dry-spinning" of other types of filaments. A bobbin-type thread take-up may be employed, or the filaments may be given a twist at the point of spinning by employing a "cap-type" mechanism. In the spinning device, or drying cell, the filaments are dried by

heated air or other gas, and the length of the drying cell is determined by the rate of drying so effected. In general, the length of drying cell required for the formation of these vinyl resin filaments is somewhat greater than is true of other plastic materials, such as the cellulose esters, because of the tendencies of the material to retain the solvent. It is desirable to direct a stream of water heated to a temperature above 50° C. on the thread at the take-up bobbin. This serves to remove or dilute any solvent retained by the filaments and thereby to prevent subsequent fusion of the fibers or loss of their identity as individual filaments. At the same time, this treatment produces delustering of the fibers which persists in large part throughout their formation into finished yarn. This method of delustering the fibers has no effect on their tensile properties, elasticity or other qualities, and because of its simplicity and economy it has obvious advantages over delustering methods which involve the addition of foreign substances to the filaments themselves.

The filaments or thread delivered from the take-up bobbin may be twisted, or doubled and twisted, to form a yarn. It is necessary in most cases to permit the filaments to age for at least 12 hours before the twisting or doubling operations are performed. Ageing of the filaments can be advantageously replaced by a brief treatment with heated water. For example, if the filaments on the bobbins are immersed in water at 65° C. for a period of 2 to 5 hours, no ageing is required. Throughout all handling and transferring of the threads or filaments in such operations as doubling and twisting, the fibers must be lubricated, and for this purpose water is quite satisfactory, since it serves the dual purpose of lubrication and reduction of static electrical charges which otherwise would develop on the yarn. The remarkable resistance of these new fibers to impairment in any way by water makes it possible to carry out the twisting, and similar operations, from bobbins of the yarn immersed in water.

The fibers, after twisting or twisting and doubling, are to be stretched, and it is therefore necessary initially to impart greater twist than is intended for the finished yarn, inasmuch as the stretching operation obviously will reduce the twist per unit length of the yarn. Allowance for reduction in twist as a result of stretching the yarn is a direct linear function of the degree of stretch to be given the fibers, and can be readily computed.

The next step in the yarn processing is that of stretching, and this step is one of paramount importance in the production of the new fibers. The amount of stretch imparted to the yarn may vary considerably up to about 200%, and in normal procedure a stretch of from about 75% to about 180% is applied. The extent of stretch used is determined by the polymer size (average macromolecular weight) of the resin, and by the characteristics desired in the finished yarn. It is important to conduct this operation while the yarn is adequately surface-wetted, and this may be done by immersing, or partly immersing, the spools from which the yarn is to be stretched in water which may contain a wetting agent or surface tension depressant, such as a sodium salt of a higher alkyl sulfate, or another of the materials commonly used for this purpose in textile operations. The actual stretching of the yarn can be accomplished by any means which will

effect the necessary extension, and it can be conveniently carried out by transferring the yarn from the spool on which it is contained to a second spool positively driven at a higher speed than that at which the first spool is allowed to rotate. In another typical arrangement, the yarn, as twisted, can be stretched by immersing the bobbin in cold water and bringing the yarn from this bobbin once around a roll positively driven at constant speed and thence to another roll, or bobbin, driven at a speed sufficiently higher to impart the degree of stretch desired. The same effect can also be obtained by making the first driven roll of small circumference with respect to the second. In these stretching operations from spools or bobbins of the yarn immersed in cold water, it is usually desirable to apply the desired stretch in two or more stages. Thus, the yarn may be initially stretched, say, 90%, and in two subsequent operations given additional stretching to the extent of 10% or 20% in each stage. If water heated to about 80° to 90° C. is applied to the yarn at the first driven roll, and a stretch in excess of 125% is applied, the yarn is delustered simultaneously with the stretching operation. In the case of stretching in the cold in two or more stages, the yarn is also delustered, but to a lesser extent than is true when the high degree of stretch is applied in a single stage. The application of heated water to the yarn just prior to stretching apparently does not cause the yarn to be stretched while appreciably softened by heat, since it is likely that most of the heat is dissipated prior to the actual stretching of the yarn. This has been demonstrated, in some cases, by the fact that heated water applied to the yarn at points intermediate to the two driven rolls had the apparent effect of restoring some luster to the yarn, and resulting in the production of yarn of lower quality than was otherwise produced by the preferred stretching operation described above.

Throughout all such operations, suitable traverse movements should be employed to provide correct cake-build of the yarn on the several spools and bobbins.

For a period after the yarn has been stretched, it shows a marked tendency to contract. This characteristic may be readily controlled and modified by a "setting" treatment. The setting of the stretch in the yarn may be accomplished in several ways; for example, by prolonged ageing of the extended yarn under tension on the stretcher spool, or by subjecting the tensioned stretched yarn to elevated temperatures, which greatly accelerate the rate of setting. The latter treatment may be conveniently carried out by immersing the yarn contained on the stretcher spools in water heated to the desired temperature, or by applying water so heated to the revolving stretcher spool. This latter procedure enables stretching and setting of the yarn to be conducted simultaneously. The temperature of the setting operation depends upon the properties ultimately desired in the yarn, and these effects are more fully described below. In general, the stretched yarn may be set at any temperature below about 75° C. If the yarn is stretched in several stages, the stretch may be set in the yarn between each stage of stretching. Immersion of the stretched yarn in water at about 65° C. for 2 to 3 hours will accomplish this.

It has been observed that the yarn processed as described above did not always possess a uniform softness or "hand". This was particularly noticeable from portions of the yarn wound

next to the bobbin or spool as compared with that near the outside of the yarn cake, that on the outside being softer than that first wound on the bobbin. This irregularity can be eliminated, and yarn of uniformly desirable hand and softness can be produced by subjecting the stretched yarn to abrupt flexing at high speeds while immersed in water. Such flexing can be easily carried out by simply transferring the yarn from one bobbin to another by way of an intermediate roller or set of rollers operating under water and arranged to cause the yarn passing over it to change direction through a short radius once or several times. For example, three rollers of small diameter, say 0.125 inch, may be staggered to cause the yarn to change direction abruptly as it passes over each roller. If an idler roll of large diameter is used with such an arrangement, the yarn may be sharply flexed in this manner three times, or some multiple of three times, in each pass through the arrangement, depending on the number of turns of yarn over the idler roll.

As has been stated, the characteristics of the finished yarn are largely controlled by the stretching operation. In any textile fiber the properties of filament size, softness, luster, strength, suppleness or flexibility, and extensibility or elongation are of extreme importance. It is desirable to have the proper balance between these properties, particularly those of strength, or tenacity, and elongation. The yarn produced in accordance with this invention before stretching may have, for example, a tenacity of 0.83 gram per denier, and an elongation of 120% or more. When this same yarn had been stretched as described herein to the extent of 90%, the resultant product possessed a tenacity of 2.00 grams per denier and an elongation of 35%. If, for example, the same, or a similar, yarn were stretched to the extent of 180% (based on the original yarn), the product resulting may show a tenacity of 3.40 grams per denier and an elongation of 11%. The foregoing examples will clearly show that, by controlling the degree of stretch imparted to the yarn, the tensile properties of the product can be varied almost at will. As the amount of stretch is increased, the elongation is correspondingly reduced until an impractically low value for the latter is reached. This correlation of the tenacity and elongation with the degree of stretch is illustrated by the accompanying drawing, in which Fig. 2 graphically represents this relation of properties as it exists in one particular sample of yarn.

The finished yarn may be packaged according to any of the conventional forms in which yarn is supplied by employing any standard equipment for transferring the yarn from the spools or bobbins containing the stretched and flexed yarn to the final packages. For example, spooling, capping, skeining, and coning may be readily carried out, and in such operations as coning, where lubricants are required, these may be conveniently applied to the yarn by means of a conditioning roll.

All of the foregoing is directed primarily to the production of textile fibers in which continuous filaments are employed. It is also possible to apply these procedures to the formation of staple fibers, or artificial wool-like masses. The filaments of this invention may be used in this manner either in the unstretched or stretched condition, and the shorter filaments, or staple fibers, are particularly desirable for use in con-

junction with other types of natural or artificial textile fibers.

The staple fiber produced from unstretched filaments of the type shown herein is particularly useful as a binding agent or stiffener for use in admixture with wool and cotton fibers. It is thermoplastic, and fusion or partial fusion of the vinyl resin fibers in such a mixture permits novel and desirable stiffening or binding action to be achieved. Staple fiber produced from stretched filaments or yarn made in accordance with this invention lends high strength to the yarn or thread produced from mixtures of textile fibers containing it.

The following examples are illustrative of specific methods of carrying out this invention:

#### Example 1

A vinyl resin resulting from the conjoint polymerization of vinyl chloride with vinyl acetate in such proportions as to produce a resin containing 87% of the chloride in the polymer was treated by fractional extraction according to the method of Patent 1,990,685 to free the polymeric aggregate from the lower average macromolecular weight polymers, and to yield a resin having an average macromolecular weight of about 17,000. This resin conformed to the following specifications, which are, in general, applicable for determining the suitability of vinyl resins for use in the practice of the invention:

1. Complete dispersibility in warm dry acetone.
2. Average macromolecular weight in excess of 15,000.
3. Impact strength (Izod notched bar method, A. S. T. M.\*) not less than 0.32 foot pounds/piece.
4. Tensile strength (Olsen method, A. S. T. M.) not less than 9500 pounds/square inch.
5. Plasticity in oil at 140° C. (Scott Plastometer) not greater than 10%.
6. Heat distortion point not less than 66° C.
7. Water absorption not greater than 0.30%, at 60° C.
8. Viscosity (7% solution in methyl isobutyl ketone at 26° C., Ford cup, #4 orifice) not less than 14 seconds.
9. Vinyl chloride content 84.5% to 92%.

This resin in the form of fine powder was dispersed in acetone having a water content of 0.4% to form a dope containing 23% by weight of resin. The dispersion of resin in the solvent was effected at 50° C. by means of a heated dough-type mixer provided with means for slow solvent reflux. At 25° C., the viscosity of the resin dispersion was not measurable by ordinary means. At 50° C., its viscosity was determined as 200,000 centipoises. This dispersion was filtered in a plate-and-frame filter press, using a filter pad consisting of several layers of cheesecloth and 4 oz. cotton batting, followed by several thicknesses of special filtering cloth. An operating pressure of between 250 and 350 pounds per square inch was sufficient to force the dope through this filter. The material was moved and handled by means of high-pressure gear-type pumps. All of the storage tanks and conduits were jacketed to permit them to be maintained at a temperature of about 50° C. by means of hot water. The filtered dope was de-aerated by allowing it to stand for 48 hours at about 50° C.

The filament extrusion operation was carried

out in a device very similar to those commonly used for the "dry-spinning" of other materials. The resin dispersion was fed to the spinning machine by means of metering pumps which discharged to a candle-filter located near the top and within the drying cell proper. Immediately adjacent to the candle-filter was the spinnerette, which was 1.5 inches in diameter, provided with 40 orifices, each having a diameter of 0.06 mm. The drying cell itself was a water-jacketed vertical cylinder 8 inches in inside diameter, provided with a bobbin take-up at its lower end. The effective filament drying space in this cell was about 16 feet in length. The temperature of the water in the drying cell jacket was maintained at 80° C., and heated air, also at 80° C., was admitted to the drying cell at the rate of 5 cubic feet per minute. The air was admitted near the top of the cell at the spinnerette face and directed by means of a cone baffle transverse to the travel of the extruded filaments. The drying air, laden with solvent vapor, was withdrawn from the lower part of the cell by means of a suction pump. The filaments at the bottom of the cell were gathered together through a guide and then wound parallel on a bobbin, the thread crossings and cake build being controlled by the usual equipment. The rate of filament passage through the drying cell was 250 meters per minute, and the filament denier was between 2.5 and 3.0.

After the filaments had been allowed to stand for at least 12 hours on the take-up bobbin, the yarn was twisted by means of a standard duplex ring twister. The amount of twist imparted was six turns per inch in the yarn. The thread in this operation was delivered to the twisting device from the spinning bobbins immersed in a water bath. As pointed out before, the water picked up by the thread from this bath served both to lubricate the thread and to eliminate static electrical charges.

The twisted yarn was next stretched by immersing the spool on which it was contained in water containing a small amount of the sodium salt of the sulfate ester of a 17 carbon atom branched chain secondary alcohol, which served as a wetting agent. The thread was then guided to a positively driven roll around which it was wrapped a few times to preclude slippage. From this roll the thread was passed upward to a take-up spool, also positively driven, at a sufficiently higher speed to impart a stretch of 100% to the thread. After this operation, the stretch was set in the yarn by immersing it for about 2 hours, while on the take-up spool, in a bath of water heated to about 65° C. Following this treatment, the yarn was given a second stage stretching in the same manner as before, and the extent of stretch was 20% of its length. The total stretch imparted by these two stretching operations thus amounted to about 140% based on the original yarn. The stretching operations were carried out with a thread travel of 150 meters per minute. In the stretching operation, the amount of twist in the yarn and its denier were reduced.

For a period immediately following the final stretching operation the extended yarn shows a marked tendency toward contraction. This characteristic was controlled as indicated by immersing the spools containing the stretched yarn in water heated to 65° C. for a period of 2 to 3 hours. The final yarn was then coned ready for use. It possessed a wet tenacity of 2.75 grams per denier, with an elongation of 15%.

Its true elasticity was about the same as that of real silk. These properties may be compared with those of other artificially produced textile fibers, such as cellulose acetate yarn, which may, in one of its commercial forms, have a dry tenacity of 1.45 grams per denier with an elongation of about 25%, and a wet tenacity of about 0.85 gram per denier with an elongation of 35%; or a commercial form of regenerated cellulose yarn which may have a dry tenacity of 1.80 grams per denier with an elongation of about 20% to 25%, and a wet tenacity of about 0.85 gram per denier with an elongation of 25%. Yarns of both of these types have practically no true elasticity. The tensile properties of the fibers of this invention as given above are practically the same whether the yarn is wet or dry, or, if any difference exists, the strength is slightly greater when the yarn is wet.

#### Example 2

A portion of the vinyl resin dispersion described in Example 1 was spun under the conditions set forth in that example. Small tubes were affixed to the traverse arms which controlled the cake build on the take-up bobbins, and through these tubes streams of water heated to 65° C. were directed onto the filaments at the point of thread feed to the individual bobbins. The filaments were instantly dulled, and the water served the additional purpose of removing or diluting any residual acetone retained by the filaments so that fusing or sticking of the filaments was precluded. The yarn on the take-up bobbins was then prepared for further treatment by immersing it in water at 65° C. for a period of three hours. The dulled and aged filaments were then subjected to the usual twisting and doubling operation, as shown in the preceding example. In this operation the yarn was given a twist of nine turns per inch from bobbins immersed in cold water to provide the necessary lubrication.

The spools containing the twisted yarn were then immersed in cold water from which the yarn was fed to the stretching device. The yarn from each spool passed first to a driven roll which operated in a water bath heated to 90° C. The stretch was imparted to the yarn between this roll and a second roll driven at a higher speed so that the yarn was stretched 185%. The rate of travel of the yarn in the stretching operation was 300 meters per minute. The stretch was then set in the yarn by immersing the spools containing it in water heated to 65° C. for a period of about 3 hours. The resulting yarn had a wet tenacity of 3.50 grams per denier and an elongation of 11%. Its filament denier was about 1.0, and its true elasticity was as great as that of natural silk.

In order to make uniform the softness and hand of the stretched yarn, it was subjected to a flexing operation in which the yarn from the stretcher take-up spools was passed at high speed around a series of small rollers operating under water and arranged to cause the yarn to change direction through a sharp angle nine times, after which it passed to take-up bobbins. Following this operation, the yarn was coned and packaged for use.

The yarn produced in the foregoing examples possessed the typical properties of the new textile fibers of this invention, one of the most outstanding of which is the high true elasticity of the yarn. The practical value of the new fibers

is apparent from the fact that their tensile strength is nearly as high as that of natural silk while they possess true elasticity practically as great as that of natural silk. Under prolonged exposure to a highly concentrated source of ultraviolet light, this yarn demonstrated a greater resistance to deterioration, as indicated by strength reduction, than was to be true with certain other artificial and natural textile fibers. The yarn is definitely water-resistant and waterproof, but surface wetting may be readily accomplished through the use of wetting agents. The yarn is thermoplastic, and its fusion temperature is somewhat lower than that of fibers formed of cellulose acetate filaments, but the yarn will not support combustion. It is resilient, and has natural crease resistance to a high degree. It is outstandingly characterized by marked resistance to chemical attack. It is wholly unaffected by alkalies and mineral acids of both high and low concentration. It can be dissolved by the lower aliphatic ketones and certain halogenated hydrocarbons, and it tends to swell when in contact with diethyl ether and the lower aromatic hydrocarbons, but is unaffected by alcohols, gasoline and other aliphatic hydrocarbons, as well as most other types of solvent materials. It will not support bacterial or fungus growth, and is wholly unaffected and immune to attack by bacteria and fungi. It is definitely non-conducting to electrical charges and is an excellent insulator.

The yarn may be dyed by incorporating dye-stuffs in the resin dispersion prior to filament extrusion, or it may be dyed, after its formation, from baths containing mixtures of solvents and non-solvents for the resin which temporarily swell the yarn. It can also be dyed by means of many types of dye-stuffs according to standard dyeing procedures which are modified slightly as to temperature and the use of dispersing agents for the dye. Some oil-soluble dyes can be applied to the yarn from hydrocarbon baths.

As is the usual practice with textile fibers, it is frequently desirable to deluster or dull the yarn. This can be accomplished by incorporating pigments such as titanium dioxide of small particle size in the resin dispersion, and the degree of delusterization can be controlled by variation of the particle size of the pigment and the amount used. It is preferable to achieve the desired dulling of the fibers by means which do not involve the incorporation of other substances in the filaments. As shown above, this may be effectively done by treatment of the filaments with heated water at their point of formation, coupled with the additional delustering effected by the stretching operations. These treatments are simple and very effective and do not detract from the softness, elasticity and tensile strength of the yarn. The application of water heated above 50° C. to the filaments as they leave the spinning cell causes the fibers, when viewed under the microscope, to have a slightly roughened or scaly exterior. This surface modification of the fibers is highly desirable, and is a further instance of the manner in which the properties of the new fibers of this invention resemble those of natural fibers.

This yarn lends itself readily to all ordinary textile processing, and it can be knitted, woven, braided and plaited readily. It is especially well adapted to knitting operations, and tests have shown that it is possible to obtain a much tighter stitch without thread rupture than is the case

with previously known yarns. In weaving it may be used either as filling, warp or pile. It is desirable to carry out weaving operations with this yarn under conditions of high relative humidity in order to reduce the development of static electrical charges. Due to the unusual resistance of the yarn to water, it can be woven while wet without sacrificing strength or risking thread breakage or undue stretching. In weaving, hygroscopic warp sizing should be used which will form a pliable film on the thread.

If the yarn after being stretched is not subjected to a stretch-setting treatment, it shows a tendency toward shrinkage which is variable in degree according to the temperature to which it is subjected. In general, this tendency towards shrinkage in the unset yarn varies according to the table below:

Temperature, °C.	Shrinkage, percent
30	0.70
40	1.25
50	4.50
60	8.50
70	21.00

Where this contraction amounts to as much as 10%, a reduction in luster accompanies it. Shrinkage of the yarn also results in reduction in tenacity and an increase in elongation proportional to the extent of the stretch which is lost. After the yarn has shrunk as a result of being subjected to elevated temperatures, it no longer shows any tendency toward contraction when reheated to the same or a lower temperature. This shrinkage of the unset stretched yarn can be utilized in many applications of the yarn to tighten the stitch in knitted or woven materials and thereby to prevent "laddering" or thread slippage.

The yarn can be produced in many filament sizes, and it has been determined that the filament denier which most conveniently lends itself to the processes of textile manufacture is around 1.0 to 1.5.

The unusual properties of the new yarn make possible many applications which take advantage of its remarkable true elasticity, water-resistance and high wet strength, together with its resistance to attack by chemical influences or micro-organisms. For example, it is of value in industrial filtering fabrics; in fishing lines, nets and seines; in forming acid- and alkali-resistant clothing; protective pipe coverings; electrical insulation; shower curtains; bathing suits; water-proof clothing; fire-proof awnings and curtains; hosiery; fusible shape-retaining fabrics; and, in admixture with other textile materials, mixed fabrics for obtaining cross-dyeing effects and the like. The new yarn is useful in pile fabrics such as velvet, and it can be advantageously employed as either the backing or the pile or both. The staple fibers of this invention, in admixture with natural materials such as cotton and wool, make possible the production of fabrics which will retain a pressed fold, and improve mercerizing and acid carbonizing.

Many special uses and adaptations of the materials of this invention will be apparent to those skilled in the art. The procedures by which the new textile fibers are formed can be varied in many of their details, and such modifications are included within the invention as defined by the appended claims.

We claim:

1. Textile fiber composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000.

2. Textile fiber composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which has an average macromolecular weight of at least 15,000 and which is substantially free from lower molecular weight polymers.

3. Textile fiber composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which has an average macromolecular weight of at least 15,000 and which is substantially free from lower molecular weight polymers, said resin being completely dispersible in warm dry acetone and having a heat distortion point above 65° C.

4. Textile fiber composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of vinyl chloride with vinyl acetate, which contains from about 85% to 90% by weight of the chloride in the polymer and which has an average macromolecular weight of at least 15,000, said resin having a heat distortion point above 65° C. and being completely dispersible in acetone containing less than 0.60% by weight of water at about 50° C.

5. A textile fiber formed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 85% to about 90% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said fiber being characterized by resistance to deterioration in strength on exposure to ultra-violet light, and by water-resistance, non-inflammability, immunity to attack by bacteria and fungi, and resistance to alkalies and mineral acids.

6. Staple textile fiber formed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 85% to about 90% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said fiber being characterized by resistance to deterioration in strength on exposure to ultra-violet light, and by water-resistance, thermoplasticity, non-inflammability, immunity to attack by bacteria and fungi, and resistance to alkalies and mineral acids.

7. A textile fiber formed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 85% to about 90% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said fiber being characterized by true elasticity, high strength, resistance to deterioration in strength on exposure to ultra-violet light, and by water-resistance, non-inflammability, immunity to attack by bacteria and fungi, and resistance to alkalies and mineral acids.

8. Synthetic textile yarn formed of filaments composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymer-



ization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having high elasticity and a tenacity of at least 2.0 grams per denier and an elongation of from 10% to 35%.

9. Synthetic textile yarn formed of filaments composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having a tenacity of at least 2.0 grams per denier and an elongation of from 10% to 35% and which has been initially stretched to the extent of between 75% and 200%.

10. Synthetic textile yarn formed of filaments composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having high true elasticity and a tenacity of at least 2.0 grams per denier and elongation of from 10% to 35% in both wet and dry states.

11. A composition suitable for extrusion to form textile filaments composed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, dispersed in acetone containing less than 0.60% by weight of water, said dispersion being filterable, clear, viscous and slowly flowable at a temperature of 50° C.

12. Knitted fabrics or articles comprising yarn formed of filaments of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having been stretched between 75% and 200%.

13. Woven fabrics or articles comprising yarn formed of filaments of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having been stretched between 75% and 200%.

14. Pile fabrics or articles in which the pile is composed of yarn formed of filaments of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having been stretched between 75% and 200%.

15. Braided articles, lines and cords comprising yarn formed of filaments of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, which contains from about 80% to 95% by weight of the halide in the polymer and which has an average macromolecular weight of at least 15,000, said yarn having been stretched between 75% and 200%.

16. Synthetic textile fibers, fabrics and articles comprising yarn composed of filaments formed of a vinyl resin substantially identical with a resin resulting from the conjoint polymerization of a vinyl halide with a vinyl ester of an aliphatic acid, said resin containing from about 80% to about 95% by weight of the vinyl halide in the polymer and having an average macromolecular weight of at least 15,000, said yarn having been stretched to the extent of from 75% to 200% and being characterized by high tensile strength in the wet state, high true elasticity, controllable shrinkage, resistance to water, alkalies and mineral acids, resistance to attack by bacteria and fungi, non-inflammability, crease resistance, thermoplasticity, electrical insulating qualities, controllable luster, and high flexibility.

EDWARD W. RUGELEY.  
THEOPHILUS A. FEILD, JR.  
JOHN F. CONLON.

## DISCLAIMER

2,161,766.—*Edward W. Rugeley, Theophilus A. Feild, Jr., and John F. Conlon*, Charleston, W. Va. SYNTHETIC FIBER. Patent dated June 6, 1939. Disclaimer filed July 22, 1946, by the assignee, *Carbide and Carbon Chemicals Corporation*.

Hereby enters this disclaimer to claims 1 to 6 inclusive, and claim 11 in the said specification.

[*Official Gazette August 20, 1946.*]