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ARTIFICIAL FILAMENTS AND YARN

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This invention relates to improvements in artificial filaments and yarn, and it is particularly concerned with the manufacture of regenerated cellulose yarn having high extensibility.

Filaments and yarn composed of synthetic linear polyamides, described in Carothers U. S. Patents Nos. 2,071,253 and 2,130,948, are capable of being cold drawn, i. e. permanently elongated at ordinary temperatures and in the dry state to many times their original length. These polyamide yarns possess, in addition, the unique property, when being cold drawn, of "necking down" during cold drawing. This "necking down" characteristic is described in detail in Babcock U. S. Patent No. 2,289,232 and consists, as shown in detail in Figure 1 and in the specification of said Babcock patent, in the localizing of the draw-point of the filaments to a very narrow region which, in general, is a portion of the length of the filament having a magnitude in the neighborhood of the diameter of the filament. Although the "necking down" of polyamide structures is most easily understood by reference to the individual filaments, yarns composed of several filaments possess the same phenomenon.

Regenerated cellulose filaments and yarns produced by previously known processes, are incapable of being elongated more than a limited degree, for example, about 5% to 25% of their original length when stretched in the dry state. Furthermore, regenerated cellulose filaments produced by known processes, when stretched or permanently elongated, do not draw at a single confined point or region, or even at several confined points or regions, but the elongation occurs throughout the length of the filament undergoing stretching tension. It will be understood that in the following discussion the phenomenon of "necking down" will include not only the drawing at one point or region but will also include the drawing at two or more points in the zone in which stress is imposed with the proviso, however, that the drawing, as indicated in said Babcock patent, is effected in very narrow regions.

It is an object of this invention to produce artificial yarns having the property of being perma-

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nently stretched to a dimension greatly in excess of their original length. A further object of the invention is concerned with the formation of regenerated cellulose filaments which can be permanently elongated to several times their original length and which possess the characteristic of necking down during drawing. A still further object of the invention is concerned with the cold drawing of regenerated cellulose filaments and yarns to several times their original length. Another object relates to a novel procedure for making artificial yarns and filaments possessing the property of necking down during drawing and being permanently elongated to a very large degree. An additional object pertains to the treatment of extensible regenerated cellulose filaments whereby to greatly increase their extensibility. Other objects will appear hereinafter.

The objects of the invention are, in general, accomplished by extruding an aqueous cellulosic solution such as viscose through a nozzle containing one or more holes into a bath which exhibits a rapid coagulating action on the cellulose xanthate dispersion in the viscose while at the same time possessing very little or no tendency under the conditions prevailing during coagulation to convert the cellulose xanthate to regenerated cellulose, the tension imposed on the filaments prior to passing out of the coagulating bath being of a very low order of magnitude, preferably not in excess of 0.01 gram per denier. The yarn is then regenerated in the relaxed state, that is, substantially free from tension. The resulting regenerated cellulose yarn is then subjected to any desired liquid treatments; such as purifying treatments and treatments with a suitable finish, and is dried, these steps subsequent to regeneration also being effected while the filaments are substantially free from tension. The yarn or filaments are then treated in the relaxed state with liquid ammonia until thoroughly wet out and, after the removal of the ammonia, the yarn is then dried in the absence of tension.

The following example, which is intended to illustrate and not to restrict the invention, represents the preferred form of applying the inven-

tion; the parts, proportions and percentages being by weight:

EXAMPLE I

Viscose containing 9% cellulose and 9% caustic, ripened to a salt (sodium chloride) index of 3.5 and possessing a viscosity of 224 poises, is extruded through a nozzle or spinneret having 120 holes into a bath having a rapid coagulating action but, under the conditions obtaining, exhibiting no substantial tendency to convert the cellulose xanthate to regenerated cellulose. The coagulating bath is prepared from an aqueous solution consisting of:

	Per cent
Monosodium phosphate.....	19
Disodium phosphate.....	5
Sodium sulfate.....	10
Water	66

sufficient phosphoric acid being added to said solution to impart to the solution a pH of 5.0. The coagulating bath is maintained at a temperature of 75° C. The filaments pass from the spinneret through a tubular member open at both ends and submerged in the coagulating bath for a distance of 15 inches, the tubular member having an inner diameter of 18 mm. and being supported horizontally in the bath so that the only flow of bath through the tube is induced by the passage of the filaments, the bath flow therefore being in the direction of passage of the filaments. On leaving the tubular member, the yarn is immediately removed from the bath. It is passed about a feed wheel having a peripheral speed of 816 inches per minute, with a total tension on the filaments during the travel in the bath of about 0.004 gram per denier. The yarn at the feed wheel is about 1,000 denier.

The yarn passes one or more times around the feed wheel to eliminate the danger of slippage and is allowed to drop of its own weight onto any suitable receiving surface, for example, a rectangular tray to which is imparted a predetermined oscillatory traverse which effects the building up, without tension, of a suitable package of yarn. The yarn package is wrapped with a cloth cover and is immersed in a regenerating bath for a period of time sufficient to completely convert the cellulose xanthate to regenerated cellulose, the regenerating bath used having the same composition as the coagulating bath into which the viscose is extruded but being maintained at a boiling temperature. After having been immersed in this bath for a period of 30 minutes during which regeneration is completed, the package is then removed from the bath, is treated with a washing solution, is showered with an aqueous solution or dispersion of a suitable finish, and is dried. During all of these operations, the yarn is substantially free from tension in view of its having been collected in a completely relaxed state.

The dried yarn is then twisted and reeled to skeins, which are immersed without tension in liquid ammonia for a period of approximately 3 minutes. The yarn is then centrifuged to remove excess ammonia, and the remaining ammonia is removed by evaporation, as by drying at room temperature conditions (75° F.).

The yarn produced in accordance with the above example, prior to treatment with ammonia, exhibits an X-ray diffraction pattern showing crystallinity but substantially no orientation, has a dry tenacity of about 1.0 gram per denier, a wet tenacity of 0.5 gram per denier, a dry elongation

of about 100%, a wet elongation of about 120%, and can be cold drawn with a permanent elongation of about 100% of its original length while exhibiting no necking down phenomenon. The cold drawn yarn shows a relatively high degree of orientation as evidenced by the X-ray diffraction pattern, which shows distinct, oppositely opposed arcs as compared with the X-ray diffraction pattern of the yarn before cold drawing, showing clearly defined concentric rings without arcs. The yarn, after being treated with ammonia and dried, can readily be cold drawn (stretched without heat in the dry state at 60% relative humidity and 75° F.) without breaking to 3.5 times its original length (250% stretch) or, after thoroughly wetting with water, can be stretched to more than 4 times its original length. The ammonia treated and dried yarn prior to drawing shows no orientation as evidenced by its X-ray diffraction pattern but, after cold or wet drawing to a high degree, it exhibits very marked orientation as shown in its X-ray diffraction patterns. The ammonia treated and dried yarn, particularly when it contains absorbed moisture, for example when in equilibrium with 60% relative humidity and at 75° F., exhibits a very marked necking down during cold drawing. It also exhibits a very marked necking down during wet drawing. It also possesses a certain degree of thermoplasticity, that is, when the dry, undrawn yarn is placed in contact with a heated metal surface, the tension required to draw or permanently elongate the yarn is greatly reduced.

The viscose solution employed in the manufacture of the yarn preferably contains 9% cellulose and 9% sodium hydroxide and is ripened to a sodium chloride index of about 3.5. However, this is not essential to the invention. Good results can also be obtained by the use of a viscose solution containing 7% cellulose and 6% sodium hydroxide, or other proportions of these constituents can be used. Generally speaking, however, the higher the content of cellulose, the more pronounced the necking down characteristics after the liquid ammonia treatment. The solution is preferably prepared from slightly aged alkali cellulose, although this is not critical to the invention. The solution, prior to its extrusion into the coagulating bath, is preferably ripened to a sodium chloride index of from 3.5 to 4.5, but, here again, these values are not to be considered as limiting. The solution is preferably prepared from cotton linters cellulose of high alpha-cellulose content and, if desired, this material can, prior to its conversion to cellulose xanthate, be etherified or esterified to a low degree, producing, for example, glycol cellulose, cellulose glycolic acid, cellulose glycolic acid derivatives, methyl cellulose, benzyl cellulose, etc. Methyl cellulose containing, for example, 0.3 methyl group per glucose unit is illustrative of such lowly etherified or esterified materials which can be used in preparing the spinning solution.

The coagulating bath used is preferably an aqueous solution containing at least 10% dissolved phosphate, calculated for convenience as trisodium phosphate. Obviously, the phosphate is not necessarily present or even added in the form of trisodium phosphate but, in referring to said percentage, the assumption that the phosphate is trisodium phosphate facilitates the calculation of the preferred amount of phosphate ion. Alkali metal phosphates, such as the phosphates of sodium and potassium, are preferred, although other water-soluble phosphates, such as ammoni-

um phosphate, amine phosphates, etc., can be used and the phosphates may be present in forms other than the triphosphate, for example, monosodium phosphate, disodium phosphate and phosphoric acid may be used in making up the bath. Some improvement is noted where other ingredients, such as sodium sulfate, are present in the bath together with the phosphate. The phosphate bath may contain metallic sulfates other than sodium sulfate and may also contain sulfuric acid in moderate amounts. In order to have a rapid coagulating action and slow or negative regenerating action, the pH of the coagulating bath should be maintained between 3.0 and 7.0 and preferably between 4.5 and 5.5. The broad scope of the invention contemplates the use of other types of baths, for example, slow regenerating baths and any such baths known to the art may be used, for example, ammonium sulfate-sodium sulfate baths and the like. Generally speaking, aqueous baths containing as an essential ingredient alkali metal salts of weak acids, such as phosphoric acid, sulfurous acid, lactic acid and the like, and adjusted to the proper pH by the addition of the corresponding acid or of a base, serve as excellent coagulating baths.

The coagulating bath must be used under such conditions that substantially no regeneration takes place during the passage of the yarn through the bath. Thus, the temperature of the bath may conveniently be in the neighborhood of 55° C. to 75° C., although it is only necessary to use a temperature at which the bath does not exhibit any substantial regenerating effect.

The water-soluble cellulose xanthate yarn can be regenerated in any suitable type of bath. Thus, baths such as that used in the above example exert a pronounced regenerating effect at elevated temperatures, such as boiling temperature, and regeneration may be effected in the same type of bath, provided the yarn is subjected to the bath for a sufficient period of time and, where necessary, at a sufficiently elevated temperature. Although it is preferred that the yarn be regenerated in a bath of the same composition as the coagulating bath, any suitable regenerating bath, such as dilute sulfuric acid-sodium sulfate bath (Mueller baths), may be used, or heated inert liquids such as aqueous salt solutions or glycerin may be used.

The following Table I presents examples of fast coagulating, slow regenerating spinning baths which may be used and of the physical properties possessed by yarns produced by the use of these spinning baths:

Table I

Spinning bath	A		B		C	
	As Spun	NH ₃	As Spun	NH ₃	As Spun	NH ₃
No. of NH ₃ treatments required to cause necking down		1		1		1
Denier	1,100	1,450	1,300	1,941	1,350	1,952
Filaments	120	120	120	120	120	120
Tenacity:						
Dry, gr./den.	1.0	0.55	0.75	0.38	0.81	0.46
Wet, gr./den.	0.55	0.35	0.42	0.16	0.35	0.20
Loop gr./den.	0.95	0.55	0.67	0.37	0.78	0.44
Elongation:						
Dry, percent	114	250	131	190	115	188
Wet, percent	128	275	154	256	110	225
Loop, percent	100	225	96	167	100	164
Spin tension, gr./den.	0.004		0.002		0.003	
Bath travel, inches	15		15		15	

Spinning bath	Composition	Temperature, °C.
A-----	20% NaH ₂ PO ₄ —10% Na ₂ SO ₄ ; pH 5.0	75
B-----	24% NaHSO ₄ —3% Na ₂ SO ₄ —10% Na ₂ SO ₄ ; pH 5.0	55
C-----	20% (NH ₄) ₂ SO ₄ —7% Na ₂ SO ₄ —1.1% H ₂ SO ₄ ; pH 1.7	55

It is also preferred that the same magnitude low tension of the spinning operation not be exceeded during the subsequent regeneration, purification, drying and after-treatment of the yarn. For example, the yarn leaving the coagulating bath may be formed without tension into a cake package, as in the preferred embodiment of the invention, or the yarn may be collected free of tension in the form of overlapping loops and ringlets, as in British Patent No. 379,880 to Topham wherein the yarn is allowed to drop freely onto a slowly moving conveyor belt which advances the yarn under showers of regenerating and purifying liquids and through a suitable drying means.

The dried yarn is preferably twisted and wound in skein form before treatment with liquid ammonia. However, this is not necessary, provided only that the yarn is treated in a substantially tensionless state.

The above description has been generally concerned with the production of highly extensible yarn having the characteristic of necking down by the use of the specific procedure set forth, followed by two and preferably a single treatment with liquid ammonia. It has been found that when a single treatment with liquid ammonia does not produce the necking down property, the latter can be developed by subjecting the yarn to additional treatments with liquid ammonia. When a plurality of treatments with liquid ammonia are used, the yarn is immersed in liquid ammonia until the yarn becomes thoroughly wet out by the liquid ammonia, the ammonia removed and the yarn dried, all these steps being performed while the yarn is in a relaxed state, and this cycle of steps repeated until the necking down property is developed.

Though in the specific procedure set forth the yarn, prior to treatment with liquid ammonia, is produced by the use of fast coagulating, slow regenerating baths, particularly the phosphate bath, it has been found that the property of necking down can be developed by treatment with liquid ammonia of yarn produced without the use of fast coagulating baths having little or no regenerating action if the yarn is spun under low tension, preferably not in excess of 0.01 gram per denier, and substantially the same magnitude low tension is not exceeded during the subsequent purification, drying and after-treatment of the yarn. Thus, for example, regenerated cellulose yarn spun under a tension not in excess of 0.01 gram per denier in the so-called "Mueller" type baths (aqueous solutions of sodium sulfate and sulfuric acid, with or without zinc sulfate and other additions) and purified and dried under the same magnitude low tension can, if subjected in the relaxed state to continued and consecutive treatments with liquid ammonia, develop the property of necking down. When a single treatment with liquid ammonia does not produce the necking down property, the latter can be developed by subjecting the yarn to additional treatments with liquid ammonia, as previously described.

The following Table II includes examples of

spinning baths, the physical properties possessed by yarns produced under low tensions by the use of these spinning baths, and the number of treatments with liquid ammonia required to develop the necking down property:

formed as previously described will develop the necking down property.

The following Table III illustrates the effect of increased tension on the extent to which the

Table II

Spinning bath	A		B		C		D		E	
	As Spun	NH ₃	As Spun	NH ₃	As Spun	NH ₃	As Spun	NH ₃	As Spun	NH ₃
No. of NH ₃ treatments required to cause necking down.....	2	2	2	2	2	2	2	2	2	2
Denier.....	950	1,600	950	1,600	925	1,425	950	1,460	958	1,520
Filaments.....	120	120	120	120	120	120	120	120	120	120
Tenacity:										
Dry, gr./den.....	1.19	0.56	1.16	0.56	1.13	0.61	1.19	0.60	0.81	0.43
Wet, gr./den.....	0.55	0.30	0.56	0.29	0.47	0.31	0.63	0.34	0.49	0.29
Loop, gr./den.....	0.99	0.53	1.06	0.54	1.08	0.60	1.16	0.59	0.76	0.41
Elongation:										
Dry, per cent.....	76	165	62	152	60	148	69	183	46	153
Wet, per cent.....	90	216	86	188	68	190	91	247	89	255
Loop, per cent.....	52	145	52	140	52	142	61	177	42	143
Spin tension, gr./den.....	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Bath travel, inches.....	15	15	15	15	7	7	7	7	7	7

Spinning bath	Composition	Temperature, °C.
A.....	40% (NH ₄) ₂ SO ₄ ; pH 6.0.....	55
B.....	40% (NH ₄) ₂ SO ₄ ; slightly ammoniacal.....	55
C.....	40% (NH ₄) ₂ SO ₄ -4.8% H ₂ SO ₄	55
D.....	10% H ₂ SO ₄ -22% Na ₂ SO ₄	55
E.....	10% H ₂ SO ₄ -22% Na ₂ SO ₄ -0.8% ZnSO ₄	55

Where substantial tensions were used during the coagulation in the case of fast coagulating,

yarn must be treated with liquid ammonia to develop the necking down property, and it also compares the number of treatments with liquid ammonia necessary for regenerated cellulose yarn produced according to standard methods utilizing a bath which possesses both rapid coagulating and rapid regenerating action, such as the Mueller type bath.

Table III

Sample	A		B		C		D		E		F	
No. of NH ₃ treatments required to cause necking down.....	1	5	6	9	6	10	10	269	275	1,058	10	83
Spin tension, gr./den.....	0.01	0.06	0.10	0.17	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Denier.....	960	1,277	908	2,080	972	1,728	864	2,100	100	269	275	1,058
Filaments.....	120	120	120	120	120	120	120	120	40	40	120	120
Tenacity:												
Dry, gr./den.....	1.05	0.67	1.77	0.58	1.84	0.82	2.62	0.66	1.90	0.38	3.3	0.36
Wet, gr./den.....	0.55	0.34	0.93	0.42	1.06	0.54	1.66	0.60	0.90	0.30	1.9	0.37
Loop, gr./den.....	0.98	0.64	1.47	0.50	1.47	0.50	1.92	0.46	1.77	0.41	2.5	0.31
Elongation:												
Dry, percent.....	99	155	33	275	26	85	15	202	23	170	12	217
Wet, percent.....	119	181	49	227	35	166	20	151	26	258	18	197
Loop, percent.....	78	146	23	161	17	87	9	46	19	165	8.1	188
Bath travel, inches.....	24	80	95	115	75	75	75	75	18	180	47	47
Bath temperature, °C.....	75	75	75	75	75	75	75	75	47	47	47	47
Reference.....	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)

Samples A, B, C and D represent yarns spun into a coagulating bath prepared from an aqueous solution of 18% NaH₂PO₄, 10% Na₂SO₄ and 72% water, adjusted to a pH of 5.2 by the addition of phosphoric acid or trisodium phosphate;

Sample E represents regenerated cellulose yarn manufactured according to a standard manufacturing method by the use of a Mueller type bath; and

Sample F represents a high tenacity yarn likewise produced by spinning into a sodium sulfate-sulfuric acid-zinc sulfate bath and suitable for use in the manufacture of tire cord.

(1) signifies the yarn before the liquid ammonia treatment;

(2) signifies the yarn after the number of ammonia treatments indicated in the table.

slow regenerating baths, such as phosphate baths, either during the spinning or during the subsequent treatments up to and including drying, it has been found that although the necking down phenomenon may not be present in the yarn after a single treatment with liquid ammonia, nevertheless additional treatments with liquid ammonia will develop this property, the additional treatments with liquid ammonia being performed as previously described. Similarly, in treating rayon produced by standard processes as distinct from the use of fast coagulating, slow regenerating baths and where substantial tensions are used during spinning or during the subsequent treatments up to and including drying, a plurality of treatments with liquid ammonia per-

The above Table III also makes reference to the bath travel in inches, since the length of bath travel obviously has an effect on the degree of regeneration which may take place before the yarn passes out of the spinning bath.

It has also been observed that a yarn, made by the cellulose acetate process and made under low tension conditions, which has been subjected to substantially complete saponification to produce a regenerated cellulose yarn, when subjected to a single liquid ammonia treatment for 3 minutes in the relaxed state and dried, exhibits the property of necking down and of becoming elongated on stretching several times its original length. This type of yarn, before the ammonia treatment, is completely unoriented when tested by its X-ray diffraction pattern but

is definitely crystalline, as shown by the shape of the concentric rings peculiar to its X-ray diffraction pattern.

The ammonia treated yarns of this invention, as stated above, possess the distinctive necking down property never before obtained in cellulose yarns. Instead of cold drawing the filaments at a relative humidity of 60% and a temperature of 75° F., they may be stretched during or after immersion for a short time in an aqueous solution of a soluble phosphate, such as mono-, di- or trisodium phosphate. Drawing of the yarn in either a cold or heated stretching bath develops a high orientation along the fiber axis, but drawing of the yarn in a hot stretching bath permits a high degree of stretching than can be obtained when the yarn is drawn in a cold stretching bath.

The following Table IV shows the physical properties of yarns prior to stretching and after stretching in a cold or hot aqueous sodium phosphate solution:

Table IV

	Yarn before NH ₃ treatment	NH ₃ treated yarn	NH ₃ treated yarn stretched cold to 217% of its original length	NH ₃ treated yarn stretched hot to 224% of its original length	NH ₃ treated yarn stretched hot to 291% of its original length
Reference.....	(1)	(2)	(3)	(4)	(5)
Tenacity:					
Dry, gr./den.....	0.9 to 1.1	0.5 to 0.6	2.1	2.25	2.84
Wet, gr./den.....	0.4 to 0.55	0.3 to 0.4	1.05	1.22	1.37
Loop, gr./den.....	0.85 to 1.1	0.5 to 0.6	1.80	1.72	2.26
Elongation:					
Dry, per cent.....	90 to 145	175 to 285	4.3	4.9	5.4
Wet, per cent.....	100 to 170	190 to 300	11.9	11.0	10.4
Loop, per cent.....	80 to 130	170 to 280	3.3	2.7	3.8
Ratio loop to dry tenacity.....			0.86	0.76	0.80
Orientation.....	none	none	high	high	high

Reference:

- (1) Yarn spun at low tension in a phosphate bath.
- (2) Yarn of the type referred to in (1) treated once with liquid ammonia.
- (3) Yarn stretched at 35° C. in bath composed of 19.1% NaH₂PO₄+10% Na₂SO₄ with pH adjusted to 5.1.
- (4) Yarn stretched in bath same as (3) but at temperature of 85° C.
- (5) Yarn stretched at 100° C. in bath composed of 17.8% NaH₂PO₄+10% Na₂SO₄ adjusted to pH of 4.2.

Each of the stretched yarns referred to in Table IV was obtained by passing the designated undrawn yarn through 55 inches' travel in the respective bath at the temperature set forth in the table and, while immersed in the bath, stretching to the extent set forth in the table, removing the yarn from the bath and collecting it under the stretching tension on a bobbin and, while on the bobbin, washing it free from the bath, finishing with an emulsion of a sulfonated vegetable oil, and drying.

Though a hot aqueous solution of a soluble phosphate is the preferred stretching bath, satisfactory results are also obtained when a hot aqueous solution of potassium formate or glycerin stretching bath is used.

The yarn obtained by drawing the ammonia treated yarn in a hot stretching bath and drying under tension possesses a high elastic recovery but loses a substantial part of this elastic recovery if boiled off, or wet out and dried under low tension. However, if the tension-dried product is cross-linked (chemically combined) with formaldehyde under tension, a major portion of the elastic recovery is retained. The hot drawn ammonia treated yarn, either prior or subsequent to cross-linking with formaldehyde, is substantially non-brittle. This is indeed unusual for a cellulosic yarn, since up to now all evidence points to substantial embrittlement of cellulosic yarns on cross-linking with formaldehyde. The cross-linked product possesses a higher crease an-

gle than the uncross-linked product and is crush-resistant. So far as is known, this is the first time that a cellulosic fiber has been produced which is both crush-resistant and non-brittle and which can be used in textile operations.

Though the invention has been specifically described in connection with the preferred embodiment which utilizes liquid ammonia to develop the necking down property, the invention is not restricted thereto. In general, substances which, when dissolved in water, form free hydroxylions may be used to develop the necking down property. Hereafter are set forth several examples of illustrative substances of the general class:

EXAMPLE II

In Example I, after the dried yarn is twisted and reeled to skeins, its is immersed in liquid ethylamine for a period of approximately 3 minutes, centrifuged to remove excess ethylamine, and the remaining ethylamine then removed and the

yarn dried, all of the steps being performed without any tension on the yarn. This cycle of steps is repeated 3 times.

EXAMPLE III

In Example I, after the dried yarn is twisted and reeled to skeins, it is immersed in a 30% sodium hydroxide solution for 10 minutes at 30° C., then quenched in a saturated ammonium sulfate solution, washed and dried, all of the steps being performed without any tension on the yarn. This treatment is repeated 3 times.

By the use of this invention, it has become possible to produce cellulosic yarns having many of the properties of polyamide yarns, particularly the ability to be stretched many times their original length and the localizing of the draw-point, i.e. necking down. The imparting of these new properties to cellulosic yarns widens the field of application of yarns of this general type, especially where it is required that the yarn possess a high work factor, i.e. the ability to elongate greatly under conditions of stress.

Although the advantages of the invention are more apparent in the preparation of yarns comprising a number of filaments, it is obvious that the same advantages follow when the invention is applied to the preparation and treatment of monofil.

Since it is obvious that many changes and modifications can be made in the above-described details without departing from the nature and spirit

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of the invention, it is to be understood that the invention is not to be limited thereto except as set forth in the appended claims.

I claim:

1. A regenerated cellulose filament capable of being stretched at least 100% without heat in the dry state and exhibiting the property of necking down during drawing, at 60% relative humidity and 75° F., beyond the elastic limit but before the point of rupture.

2. A regenerated cellulose filament capable of being stretched at least 100% without heat in the dry state, exhibiting the property of necking down during drawing, without heat in the dry state at 60% relative humidity and 75° F., beyond the elastic limit but before the point of rupture, and showing no orientation as evidenced by its X-ray pattern.

3. A regenerated cellulose filament capable of being stretched at least 100% without heat in the dry state, exhibiting the property of necking down during drawing, without heat in the dry state at 60% relative humidity and 75° F., beyond the elastic limit but before the point of rupture, and possessing a degree of thermoplasticity whereby the tension required to elongate the filament in the dry heated state is substantially less than that required to elongate the filament in the dry unheated state.

4. A regenerated cellulose filament capable of being stretched at least 100% without heat in the dry state, showing no orientation as evidenced by its X-ray pattern, and exhibiting the property of necking down during drawing, at 60% relative humidity and 75° F., beyond the elastic limit but before the point of rupture, said filament possessing a degree of thermoplasticity whereby

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the tension required to elongate the filament in the dry heated state is substantially less than that required to elongate the filament in the dry unheated state.

RUDOLPH WOODELL

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Patent No. 2,462,927.

Certificate of Correction

March 1, 1949.

RUDOLPH WOODSELL

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 9, line 16, for the word "high" read *higher*; column 10, line 11, for "hydroxylions" read *hydroxyl ions*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of October, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.