Jan. 2, 1951 J. W. COLEMAN ET AL 2,536,093

METHOD FOR SPINNING ARTIFICIAL FILAMENTS

Filed May 28, 1947 3 Sheets-Sheet 1

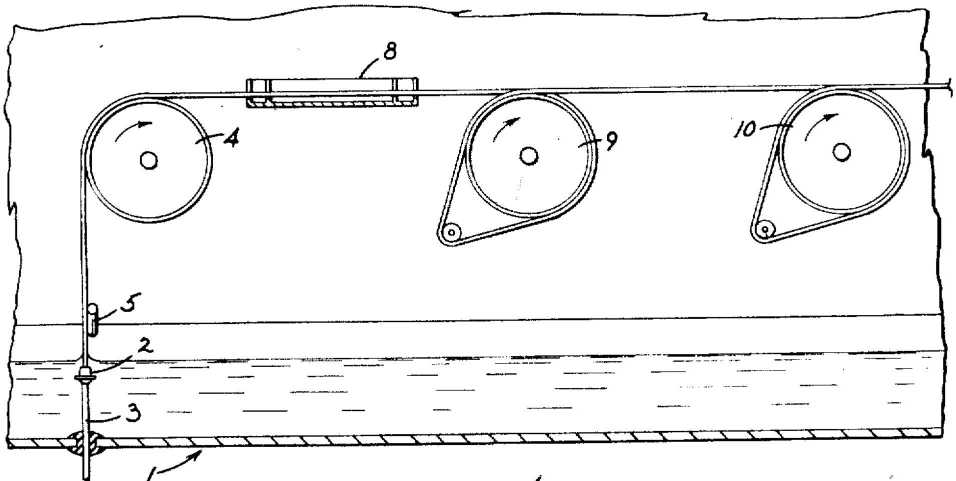

Fig. 1

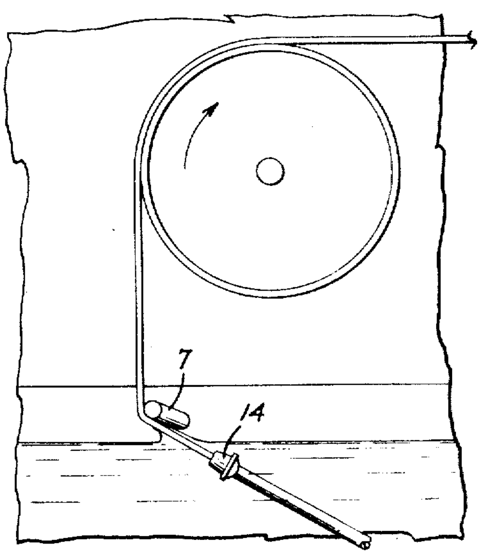

Fig. 2

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METHOD FOR SPINNING ARTIFICIAL FILAMENTS

Filed May 28, 1947 3 Sheets-Sheet 2

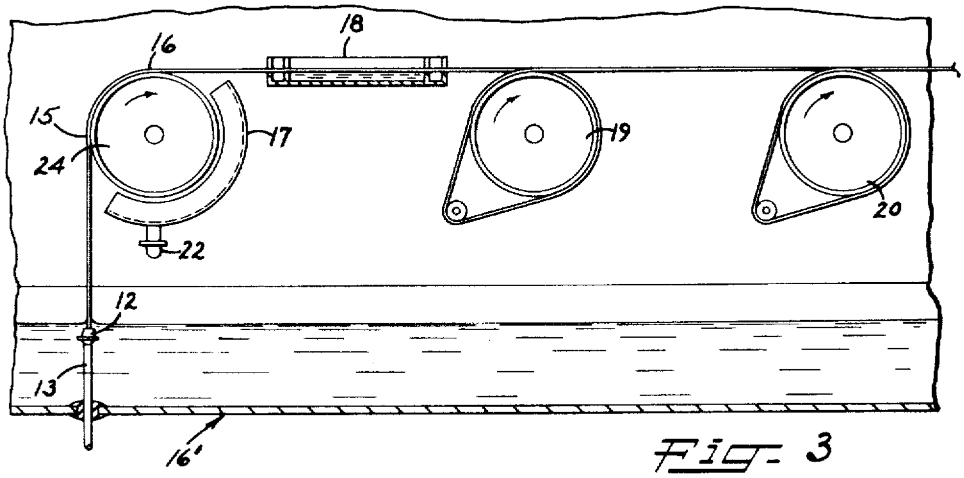

Fig. 3

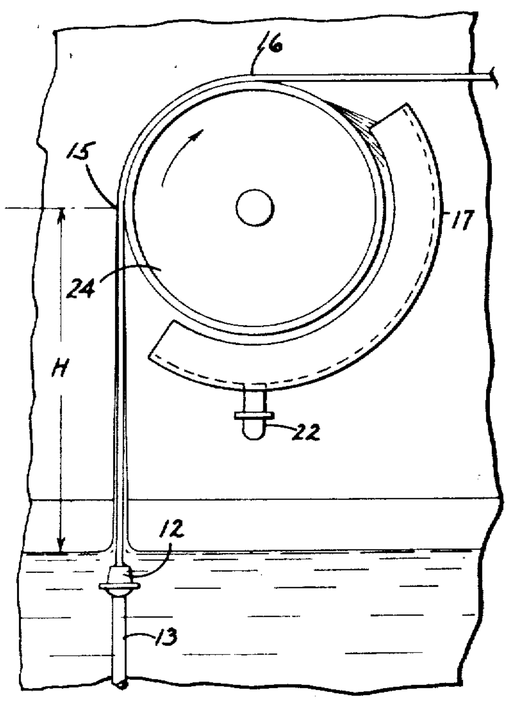

Fig. 4

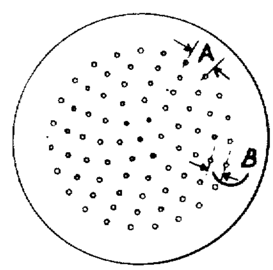

Fig. 5

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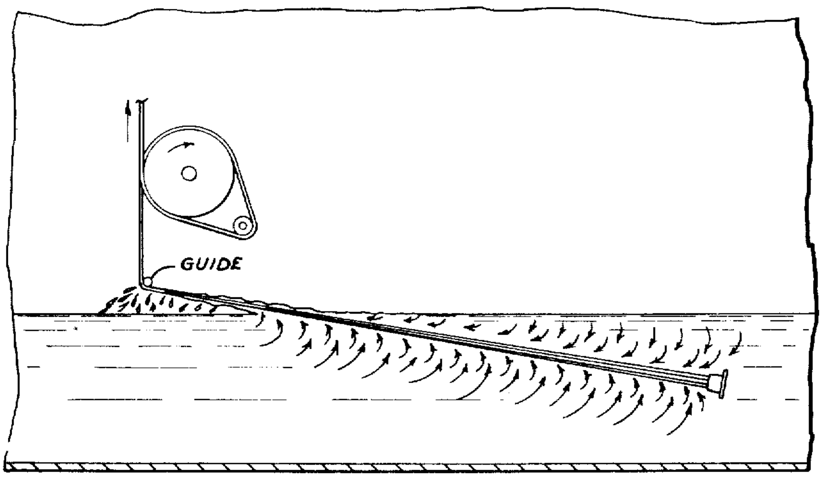

Fig. 6

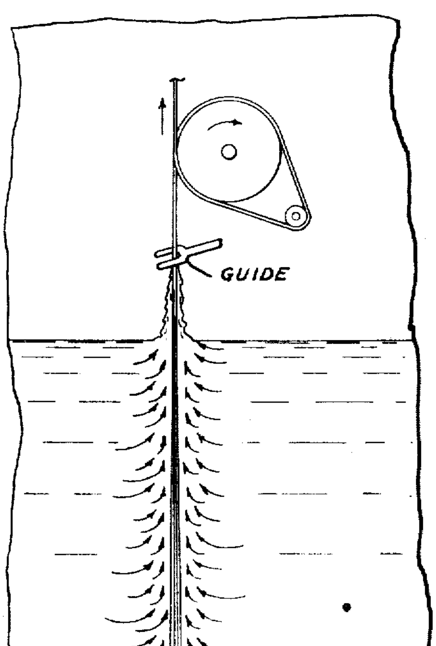

Fig. 7

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UNITED STATES PATENT OFFICE

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METHOD FOR SPINNING ARTIFICIAL FILAMENTS

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Application May 28, 1947, Serial No. 750,946

8 Claims. (Cl. 18—54)

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This invention relates to improvements in methods for spinning artificial filaments. More particularly this invention relates to improvements in methods for spinning artificial filaments wherein filament forming material is extruded into a liquid bath.

In the manufacture of artificial filaments wherein the filament forming material is extruded into a liquid bath, the filament forming material is extruded beneath the surface of the liquid bath and the filaments that are formed are drawn from the liquid bath by a positively driven roller or other rotary device the peripheral speed of which is a factor in determining the spinning speed. Thereafter the filaments are usually subjected to stretching and liquid treatments.

With the present invention certain spinning procedures and apparatus are employed whereby artificial filaments of high quality and uniform physical properties are produced.

Although the present invention will be described hereinafter largely with reference to viscose regenerated cellulose filaments and the viscose process this is for purposes of illustration and it is to be understood that the invention is also applicable just as well to the spinning of cuprammonium, cellulose nitrate and other filaments where a spinning solution is extruded in a liquid bath and especially where the liquid of the bath carried by the filaments continues to act on the filaments after they have been withdrawn from the bath.

In the production of artificial filaments by the viscose process for instance, a solution of cellulose xanthate is extruded through a spinneret positioned in a regenerating bath generally comprising dilute sulphuric acid, sodium sulphate and other metal salts such as zinc sulphate and the like. The bath chemically reacts with the viscose solution to form filaments of regenerated cellulose. The chemical reaction takes place while the viscose solution and the filaments being formed are passing through the bath and the bath carried by the filaments after they emerge from the bath continues the reaction. The coagulation of the viscose and regeneration of the cellulose comprising a filament first take place in the outer layer of the filament and proceed inwardly. In order to obtain filaments having

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a certain tensile strength and extensibility the filaments are subjected to a positive stretching step by positively driven rollers or other rotary devices after a sufficient preliminary set up and regeneration of the cellulose has taken place. The filaments after being stretched are further set up, washed, processed and finally dried.

It was found that with conventional practices although great care was taken to keep the spinning conditions constant by maintaining the bath temperature uniform, recirculating the bath and maintaining its composition uniform, and withdrawing the filaments and stretching them by rotary devices positively driven at uniform speeds, the danger of broken filaments due to the resistance offered by the spinning bath to the passage of the tender filaments was always present. Eddy currents and other uncontrollable bath flow induce stresses that influence dyeing and other physical characteristics unfavorably, irrespective of whether the spinning takes place vertically or horizontally. While these harmful conditions are present at ordinary spinning speeds, at higher spinning speeds these conditions are greatly increased and result in lower quality due to more broken filaments and decidedly lower tensile strengths and extensibilities.

This invention has for its principal object to provide improvements in methods for spinning artificial filaments that overcome objections and disadvantages found in the prior art.

This invention has for another object to provide improvements in methods for spinning artificial filaments that produce filaments of high quality and uniform physical properties.

This invention has for a further object to provide improvements in methods for spinning artificial filaments that produce filaments of high quality, uniform physical properties and improved tensile strength and extensibility.

These and other objects and advantages of the invention will be apparent from the following description and the accompanying drawings.

In the drawing:

Figure 1 is an elevational view with parts shown in section of a form of apparatus for carrying out the present invention.

Figure 2 is an enlarged elevational view of a portion of a form of apparatus similar to that shown in Figure 1 and in which a directional guide means is provided positioned laterally of the spinneret.

Figure 3 is an elevational view with parts shown in section of another form of apparatus for carrying out the present invention.

Figure 4 is an enlarged view of a portion of the apparatus shown in Figure 3 and comprising the spinneret, draw off wheel and means for collecting the used spinning bath.

Figure 5 is a plan view of the face of a spinneret that may be used in practicing this invention.

Figure 6 is an elevational view showing diagrammatically the bath currents and flow present in conventional spinning of artificial filaments with so-called horizontal immersion.

Figure 7 is an elevational view showing diagrammatically the bath currents and flow present in conventional spinning of artificial filaments with so-called vertical immersion.

In accordance with the present invention it was found that artificial filaments of high quality and uniform physical properties could be obtained by practically eliminating all tensile stresses to which the filaments were formerly subjected during the initial stages of filament formation referred to as set up and/or regeneration until the regeneration had proceeded sufficiently to permit stretching and then positively stretching the filaments a controlled amount by passing them between a pair or pairs of godets or other rotary devices positively driven at successively higher peripheral speeds while maintaining the composition of the spinning bath adjacent the spinneret uniform.

A careful analysis of the spinning procedures usually employed showed that the individual filaments were subjected to variable bath resistance and stresses before the filaments were toughened by sufficient set up to withstand such severe and drastic treatment. These variable stresses were difficult, if not impossible, to uniformly control and the physical properties of the filaments produced under those conditions were adversely affected.

It is always desirable in the manufacture of artificial filaments that broken filaments be avoided and that the filaments have uniform dyeing properties. The tensile strength generally measured in grams per denier and the extensibility are also important physical characteristics. For certain purposes, such as in crepe yarn, it is desired that the filaments have a high extensibility while for other purposes, such as tire cord, it is desired that the filaments have a low extensibility and a high tensile strength. For any purpose it is desired that the number obtained by multiplying the tensile strength by the extensibility be high. This number is hereinafter referred to as the quality index.

It was observed that with the usual travel of the filaments through the spinning bath or immersion, appreciable stresses on the filaments being spun were caused by the drag of the spinning bath on the filaments and the weight of the liquid carried along with the filaments after they emerged from the bath. These stresses were not only large but also variable and uncontrollable. There was usually a turbulent condition where the filaments emerged from the bath and a large amount of the spinning bath carried by the filaments ran or dripped off the filaments after they had emerged from the bath. In the ordinary spinning procedure the volume of the spinning bath carried by the filaments is determined by such factors as the number of filaments, the spacing of the filaments, the size of the filaments, the length of travel of the filaments in the bath (immersion) and the speed at which they are drawn through the bath. In the usual practice immersions are adjusted merely to provide sufficient set up for subsequent stretching and handling of the filaments.

Figure 6 of the drawing shows diagrammatically the manner in which the bath is moved and swept along by the filaments with a horizontal immersion of the usual length. Figure 7 illustrates this movement of the bath by the filaments where the filaments are spun vertically with the usual immersion length. Both illustrations indicate the large volume of bath being moved by the filaments and the turbulence of the bath where the filaments emerge from the bath and the back flow of the bath along the filaments to demonstrate the work the tender filaments are called upon to perform while still in a semi-viscose condition. This movement of the bath commences immediately at the point where the individual viscose streams emerge from the face of the spinneret. As the rate of drawing the filaments through the spinning bath is increased with the usual immersion length it is found that the stresses imposed on the filaments are increased and at higher speeds the quality and physical characteristics of the filaments are not satisfactory.

The data in the examples in the following Table I show the effect of increases in the speed of the rotary means for drawing the filaments from the bath on the physical characteristics of the viscose artificial filaments that are produced in ordinary viscose process spinning procedures. With increases in speed of the draw off means the tensile strength and extensibility of the filaments either wet or dry and the quality indices are decreased. Irrespective of whether yarn is washed and dried immediately on a continuous basis or collected in an acid or washed condition in a spinning box and subsequently treated and dried the same loss in physical properties is experienced when spinning speeds are increased.

TABLE I

Example 1

Conditions:
- 150 denier, 60 filament
- 12" vertical immersion
- 25% stretch
- Continuously washed and dried

Speed of Draw Off Wheel, m./min.	Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet Ext., percent	Qual. Dry	Index Wet	Combined Qual. Index
47.5	2.05	21	1.11	29.5	43.0	32.8	75.8
67.5	1.94	17.5	1.00	25.0	33.9	25.0	58.9
90.0	1.95	16.0	.98	23.0	31.1	22.5	53.6
112.5	2.00	16.0	.95	19.5	32.0	18.5	50.5

Example 2

Conditions:

150 denier, 60 filament
12" immersion
25% stretch
Collected in spinning box, washed and treated in skein form

Speed of Draw Off Wheel, m./min.	Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet Ext., percent	Qual. Dry	Index Wet	Combined Qual. Index
56.3	2.15	22	1.20	34.0	47.3	40.8	88.1
75.0	2.15	18.5	1.20	28.0	39.8	33.6	73.4
93.8	2.15	19.0	1.10	25.0	40.8	27.5	68.3
112.5	1.80	16.0	.90	21.0	28.8	19.0	47.8

It was found in accordance with this invention that, if substantially all tensile stresses on the artificial filaments being spun were eliminated until the filaments were toughened sufficiently in the initial set up and the filaments were in condition to be positively stretched, filaments of high quality and having suitable physical characteristics could be spun at normal speeds of the draw off means, around forty to sixty meters per minute, as well as speeds greatly in excess thereof, such as speeds of the order of one hundred twenty to one hundred sixty and more meters per minute. This is effected by using an immersion length, that is, path of the filaments from the face of the spinneret to the surface of the spinning bath of not more than 2" and more particularly of from 1¼" to ⅛". The filaments pass from the spinneret to a positively driven draw off means such as a godet, roller, thread store device or the like, the peripheral speed of which is a factor that determines the spinning speed. Using an immersion length of from 1¼" to ⅛", the filaments smoothly emerge from the spinning bath without turbulence and substantially all of the spinning bath that is withdrawn by the filaments from the bath is carried in a uniform and smooth column along with the filaments without any apparent back flow of the bath along the filaments or dripping off the filaments. The path of the filaments from the spinneret to the draw off wheel may be direct or with only a directional guide means lightly contacting the filaments and the filaments during this travel are subjected to approximately only the tensile stress caused by their own weight and that of the spinning bath that is carried up with them. The filaments may be in contact with the draw off means for less than 360° of its periphery or may be wrapped in successive turns to provide storage and thus time for additional regeneration of the partially set up filaments. The filaments then pass to the means for positively stretching the filaments. The stretching means may comprise a godet, roller or thread store device positively driven at a speed higher than the draw off means or spaced godets, rollers, or thread store devices driven at successively increased speeds. The filaments may be subjected to additional spinning bath or other setting up treatment by passing them through a supplementary bath after they pass over the draw off means, or spinning bath or other active setting up materials may be applied on a plurality of turns of the filaments on the draw off means before they reach the positive stretching means. The filaments in their travel from the spinneret to the positive stretching means are maintained substantially free of tension and during this time are permitted to shrink by providing for complete relaxation during their travel through the supplementary set up. Further advantage can be taken of the filaments' desire to shrink by utilizing as the draw off means a thread storage device which has a taper corresponding to a relaxation or shrinkage of the filaments of the order of 3 to 5%.

With this procedure the spinning bath liquid that is carried out of the spinning bath with the filaments does not perceptibly drip off or flow back along the filaments, but substantially all of the liquid withdrawn by the filaments from the bath remains with the filaments in the form of a uniform column until the filaments contact the directional guide means where one is used or the draw off means. The spinning bath is found to stay on the draw off means to approximately the position where the filaments leave the draw off means in passing to the positive stretching means.

In the viscose process the spinning bath that is withdrawn from the bath with the filaments acquires reaction products such as water, sodium sulphate, sulfur, thionic acids and gaseous products that ordinarily dilute or contaminate the spinning bath and inhibit the initial setting up reaction. In the present method of spinning these reaction products may be largely removed immediately after they are formed so that the spinning bath may remain substantially uncontaminated and uniform in composition. Furthermore, it it found that much of the sulfur normally carried by the filaments is removed by this method of eliminating the reaction products as they are formed.

It is found that as the spinneret is moved vertically under the bath from deep to shallower immersions, the amount of bath activated and moved by the filaments becomes less and less. At the customary immersions of several inches a large volume of bath is carried by the filaments and considerable back flow along the filaments or stripping of the bath from the filaments takes place after they emerge from the bath. Also there is substantial agitation of the bath where the filaments emerge from the bath. This condition is so serious at the higher speeds that it is impossible to obtain filaments of satisfactory quality and physical characteristics. However, as the immersion is shortened a critical point is reached where at that immersion length and with shorter immersions the volume of bath carried by the filaments is so small that the filaments are able to support the entire volume and substantially all of the liquid withdrawn from the bath with the filaments adheres to the filaments in the form of a smooth column without appreciable back flow. Also no turbulence or apparent agitation of the bath occurs where the filaments break through the surface of the bath when the immersions are at or less than said critical point. This critical point depends upon spinning speed, denier per filament, filament count and spacing of holes in the spinneret face. In general, filaments of uniform dyeing and good physical characteristics can be obtained if immersions are kept at an amount less than the point where the back flow or drip off of the bath from the filaments starts. This amount of immersion may be called the critical immersion. It has been found that dyeing properties of the filaments are uniform and the other physical properties are not materially affected at any spinning speed if the load on each filament carrying bath in the form of a smooth column from the surface of the spinning bath to the draw off wheel does not exceed 0.002 to 0.0025 gram per inch of length but is preferably in the range from 0.00025 to 0.0015 gram per inch of length.

This invention is not limited to spinning any particular number of filaments, or a yarn having any particular number of filaments. The larger the number of filaments that are spun from the same spinneret, the greater the quantity of spinning bath that is drawn up with the filaments. However, the load on each filament remains virtually constant and the usual loss in physical properties is not found in this method of spinning. Using an immersion less than the critical amount, not more than 2'' and preferably 1¼'' to ⅛'', satisfactory spinning conditions and filaments are obtained. This is shown by the data set forth in the following Table II. This data applies to viscose regenerated cellulose yarn of 150 denier and to a speed of the draw off wheel of 112.5 meters per minute with a ¼'' immersion but similar beneficial results are obtained at other deniers and higher or lower spinning speeds.

TABLE II

No. Filaments	Vol. Bath Carried By Yarn, cc./min.	Dia. of Bath Column in mm.	Weight of Bath/In. Yarn in Grams	Load on Ea. Filament/In. Length in Grams	Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet Ext., percent	Qual. Index		Combined Qual. Index
									Dry	Wet	
60	212	1.6	0.062	.0010	2.20	20	1.15	30	44	34.5	78.5
90	253	1.75	0.074	.00082	2.25	19	1.24	27	42.8	33.6	76.4
120	304	1.9	0.089	.00074	2.20	18	1.20	26	39.6	32.2	71.8

Improved results may be obtained in the practice of this invention by using spinnerets in which the holes are grouped together at the central portion of the face and are spaced close together in the same circle and from circle to circle a distance of the order of 0.005 to 0.015 inch. This is shown by the data in Examples 1 and 2 of the following Table III of a viscose spinning procedure.

TABLE III

Example 1

Conditions:
- 150 denier, 60 filament
- ¼'' immersion
- 30% stretch
- Speed of draw off wheel—105 m./min.

Jet Hole Spacing		Vol. of Bath/ Minute	Dia. of Bath Column	Weight of Bath/ Inch Yarn	Load on Each Filament/ Inch Length
Circle/ Circle	Hole/ Hole				
Inch	*Inch*	*Cc.*	*Mm.*	*Grams*	*Grams*
0.01	0.01	165	1.4	0.052	0.0009
0.03	0.03	245	1.7	0.077	0.0013
0.045	0.045	290	1.90	0.091	0.0016

Dry Str., g./den.	Dry Ext., Percent	Wet Str., g./den.	Wet Ext., Percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.10	20.0	1.13	30	42.0	34.0	76.0
2.06	19.0	1.00	26.0	39.2	26.0	65.2
1.96	19.0	0.97	26.0	37.2	25.2	62.4

Example 2

Conditions:
- 150 denier, 60 filament
- ½'' immersion
- 45% stretch
- Speed of draw off wheel—82.5 m./min.

Jet Hole Spacing		Vol. of Bath/ Minute	Dia. of Bath Column	Weight of Bath/ Inch Yarn	Load on Each Filament/ Inch Length
Circle/ Circle	Hole/ Hole				
Inch	*Inch*	*Cc.*	*Mm.*	*Grams*	*Grams*
0.005	0.005	62	0.53	0.025	0.0004
0.010	0.010	240	1.65	0.096	0.0016
0.030	0.030	374	3.17	0.148	0.0024

Dry Str., g./den.	Dry Ext., Percent	Wet Str., g./den.	Wet Ext., Percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.28	23	1.21	31	52.5	37.5	90.0
2.07	22	1.03	27	45.5	27.8	73.3
2.24	18.5	1.08	23	41.5	24.8	66.3

The data in the following Table IV show the results of spinning 150 denier, 60 filament count with selected immersion lengths at a draw off speed of 97.5 meters per minute, using a spinneret with 0.005'' hole to hole and circle to circle spacing. It is shown that a critical point is reached where the immersion length is approximately 2 inches. Immersion lengths greater than this are shown to have a marked effect on the extensibility and tensile strength of the filaments.

TABLE IV

Conditions:
- 150 denier, 60 filament viscose regenerated cellulose yarn
- 35% stretch
- Spinneret—60 hole with 0.005'' hole to hole and circle to circle spacing
- Speed of draw off wheel—97.5 m./min.

Immersion	Vol. Bath Carried By Yarn, cc./min.	Dia. of Bath Column, in mm.	Weight of Bath/ In. Yarn, in Grams	Load on Ea. Filament/In. Length, in Grams
Inches				
⅛	55	0.70	0.019	0.00031
¼	60	0.75	0.020	0.00034
½	68	0.83	0.023	0.00038
¾	97	1.05	0.033	0.00055
1	107	1.10	0.036	0.00058
1¼	118	1.18	0.040	0.00063
1½	200	1.55	0.058	0.0011
2	340	2.05	0.115	0.00192
3	424	2.25	0.142	0.00240
4	406	------	------	------
5	366	------	------	------

Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet, Ext., percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.13	23.5	1.14	32	50	36.5	86.5
2.10	24.0	1.10	33	50	36.5	86.5
2.06	24.0	1.15	34	50	39.5	89.5
2.14	23.5	1.13	34	50	39.5	89.5
2.10	23.0	1.13	32	48	36.5	84.5
2.07	20.5	1.12	30	43	34.0	77.0
2.13	21.0	1.13	32	45	36.5	81.5
2.10	22.5	1.10	32	47	35.0	82.0
2.08	17	1.06	22	36	23.5	59.5
2.10	17	1.12	23	36	26.5	62.5
2.08	16	1.11	22	34	25.0	59.0

Another example of the effect of immersion lengths is shown in the following Table V in spinning 150 denier, 60 filament count viscose regenerated cellulose yarn at a draw off speed of 105 meters per minute. Here the spinneret hole spacing is 0.01″ hole to hole and circle to circle. A critical point is reached at approximately ¾″ immersion. At immersions longer than this a decided drop in extensibility and strength is noted. At immersions longer than 2″ the results are erratic due to uncontrolled back flow of bath carried by the filaments and bath drag.

TABLE V

Conditions:

150 denier, 60 filament
30% stretch
Speed of draw off wheel—105 m./min.

Immersion	Vol. Bath Carried By Yarn, cc./min.	Dia. of Bath Column, in mm.	Weight of Bath/ In. Yarn, in Grams	Load on Ea. Filament/In. Length, in Grams
Inches				
⅜	145	1.3	0.045	0.0007
½	205	1.5	0.065	0.001
⅝	245	1.7	0.077	0.0012
¾	290	1.9	0.092	0.0015
⅞	335	2.0	0.107	0.0017
1	412	2.2	0.130	0.0021
1⅛	430	2.3	0.136	0.0022
1¼	460	2.4	0.145	0.0024
1⅜	500	2.5	.158	0.0026
1½	540	2.55	0.170	0.0028
1⅝	500	--------	--------	--------
1¾	470	--------	--------	--------
1⅞	460	--------	--------	--------
2	445	--------	--------	--------
2½	425	--------	--------	--------
3	400	--------	--------	--------
4	405	--------	--------	--------
5	380	--------	--------	--------
6	380	--------	--------	--------

Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet, Ext., percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.15	19.5	1.16	28	42	32.5	74.7
2.1	21	1.15	29	44	33.4	77.4
2.2	21	1.17	28	46	32.8	78.8
2.2	21	1.15	28	46	32.2	78.2
2.1	20	1.1	27	42	29.8	71.8
2.15	20	1.06	25	43	26.5	69.5
2.1	18.5	1.05	24	39	25.2	64.2
2.15	18	1.07	26	39	27.8	66.8
2.1	18.5	1.05	25	39	26.3	65.3
2.05	17.5	1.0	23.5	36	23.5	59.5
2.0	17	1.03	23	34	23.7	57.7
2.15	18	1.05	23	39	24.2	53.2
2.0	17	1.06	22	34	23.3	57.3
2.0	17	1.0	22	34	22.0	56.0
2.05	19	1.05	23	39	23.1	62.1
2.1[illegible]	19	1.0	23	40	23.0	63.0
2.2	18	1.1	22	40	24.2	54.2
2.1	17	1.04	20	36	20.8	56.8
2.1	17	1.08	20	36	21.6	57.6

The following Table VI shows the effect of immersion lengths when spinning 150 denier, 40 filament count using a spinneret with 0.010″ hole to hole and 0.010″ circle to circle spacing and with the speed of the draw off wheel 97.5 meters per minute. In this case a critical point is reached at approximately ¾″. At greater immersion depths the back flow and increased drag of the bath have a deleterious effect on the extensibility and tensile strength of the filaments.

TABLE VI

Conditions:

150 denier, 40 filament viscose regenerated cellulose yarn
35% stretch
Speed of draw off wheel—97.5 m./min.

Immersion	Vol. Bath Carried By Yarn, cc./min.	Dia. of Bath Column, in mm.	Weight of Bath/ In. Yarn, in Grams	Load on Ea. Filament/In. Length, in Grams
Inches				
¼	130	1.20	0.044	0.0011
½	215	1.60	0.073	0.0017
¾	290	1.90	0.098	0.0024
1	395	2.2	0.133	0.033
1¼	470	2.4	0.159	0.040
1½	430	2.3	0.145	0.036
2	415	2.25	0.140	0.035
5	335	2.1	0.113	0.028

Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet, Ext., percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.17	20.5	1.13	28	44.5	31.7	76.2
2.19	20	1.17	26.5	43.8	31.0	74.8
2.08	17.5	1.12	25.0	36.5	28.0	64.5
2.13	17	1.10	23	36.2	25.3	61.5
2.09	15.5	1.10	22.5	32.4	24.7	57.1
2.13	14.5	1.09	20.5	30.8	22.4	53.2
2.13	15.5	1.07	21.0	33.0	22.5	55.5
2.18	14.5	1.12	19.0	31.6	21.3	52.9

The following Table VII shows the effect of immersion lengths when spinning 100 denier, 40 filament count using a spinneret with a 0.010″ hole to hole and 0.010″ circle to circle spacing and with a draw off speed of 97.5 meters per minute. Here the critical point is reached when the immersion length is approximately ¾″.

TABLE VII

Conditions:

100 denier, 40 filament viscose regenerated cellulose yarn
35% stretch
Speed of draw off wheel—97.5 m./min.

Immersion	Vol. Bath Carried By Yarn, cc./min.	Dia. of Bath Column, in mm.	Weight of Bath/ In. Yarn, in Grams	Load on Ea. Filament/In. Length, in Grams
Inches				
¼	150	1.35	0.051	0.0013
½	225	1.65	0.076	0.0019
¾	305	1.95	0.103	0.0026
1	375	2.15	0.127	0.0032
1¼	440	2.30	0.149	0.0037
1½	420	2.25	0.142	0.0036
2	400	2.20	0.135	0.0034
3	380	2.15	0.129	0.0032
4	380	2.15	0.129	0.0032
5	400	2.20	0.135	0.0034

Dry Str., g./den.	Dry Ext., percent	Wet Str., g./den.	Wet Ext., percent	Qual. Index		Combined Qual. Index
				Dry	Wet	
2.36	19	1.39	27.5	44.8	38.2	83.0
2.28	19	1.38	26.0	45.3	35.9	81.2
2.42	18.5	1.36	24.0	44.8	32.7	77.5
2.30	17.5	1.34	23.5	41.8	31.5	73.3
2.30	16.5	1.37	22.0	39.5	30.1	69.6
2.38	16.0	1.28	20.0	38.1	25.6	63.7
2.21	14.5	1.20	18.5	32.1	22.2	54.3
2.30	15.0	1.16	17.5	34.5	20.3	54.8
2.11	14.0	1.14	17.0	29.5	19.4	48.9
2.08	14.0	1.08	16.0	29.1	17.5	46.6

This invention may be carried out with either pot or bobbin spinning or may be carried out with a continuous process where the filaments after being positively stretched are collected on thread storage reels and subjected to further liquid treatment and drying.

Referring to Figure 1 of the drawing in which a form of apparatus is shown whereby the invention may be carried out, reference character 1 indicates generally a trough containing a spinning bath in which is positioned a spinneret 2 mounted on a suitable rounder 3 or other suitable connection to a source of spinning solution. As shown the rounder passes through the bottom of the spinning trough through a seal which permits the spinneret to be positioned at selected distances below the surface of the spinning bath although other forms of rounder may be used. The filaments that are formed in the spinning bath are drawn upwardly through the bath to the positively driven draw off wheel 4 which is rotating in the direction shown by the arrow and remain in contact therewith for at least a portion of its periphery. The filaments lightly contact the directional guide means 5 positioned above the spinneret and between the surface of the bath and the draw off wheel. The guide means may be either rotatable or stationary and is inclined with respect to the horizontal so that any liquid removed from the filaments by the guide means will run along the guide means and away from the path of the filaments and may be collected. The speed of the wheel is a measure of the final spinning speed. As shown the spinneret is positioned relatively close to the surface of the spinning bath so that the immersion length is short, not more than two inches and preferably between 1¼'' and ⅛''. The draw off wheel may be rotated at normal peripheral speeds around 40 to 60 meters per minute as well as speeds greatly in excess thereof such as speeds of the order of 120 to 160 meters and more per minute. The filaments emerge from the bath without any turbulence at the surface of the bath and substantially all of the liquid withdrawn from the bath by the filaments is carried upwardly by the filaments without drip or back flow. The filaments pass from the draw off wheel to the positive stretching means which, as shown, comprises the positively driven godets 9 and 10, the godet 10 being driven at a higher speed than the godet 9. In those cases where it is desired to subject the filaments to a subsequent setting up treatment such as spinning bath, hot water or dilute acid the trough member 8 is provided. While the draw off wheel 4 may be slightly fluted in order to draw the filaments upwardly, the filaments are free to shrink in passing from the spinneret to the godet 9 either on the draw off wheel and/or after leaving the wheel. To enable the filaments to shrink on the wheel, the wheel may be tapered, with the

filaments passing over the wheel a plurality of times from the larger end toward the smaller end. To eliminate stresses on the filaments in excess of any bath drag and to permit further relaxing of the filaments, when the filaments are subjected to liquid treatment, such as in the trough-like member 8, the godet 9 may be driven at slightly lower speed than the draw off wheel 4.

In the form of apparatus shown in Figure 2 of the drawings, the parts and their arrangement are substantially the same as in the apparatus shown in Figure 1 except that the filament directional guiding means 7 is between the surface of the bath and the draw off wheel and laterally spaced from the spinneret. The guide means may be either rotatable or stationary and may be inclined with respect to the horizontal so that any liquid removed from the filaments by the guide means will run along the guide means and away from the path of the filaments and may be collected. The path of the filaments through the spinning bath from the spinneret 14 which is the same as the spinneret 2 shown in Figure 1 is short, not more than 2'' and preferably from ⅛'' to 1¼''. Liquid is withdrawn from the bath and carried by the filaments without drip or back flow along the filaments.

Referring to Figure 3 of the drawing in which another form of apparatus is shown whereby the invention may be carried out, reference character 16' indicates generally a trough containing a spinning bath in which is positioned a spinneret 12 mounted on a suitable rounder 13 or other suitable connection to a source of spinning solution. As shown the rounder passes through the bottom of the spinning trough through a seal which permits the spinneret to be positioned at selected distances below the surface of the spinning bath although other forms of rounder may be used. The filaments that are formed in the spinning bath are drawn directly upwardly without the use of guides or the like to the positively driven draw off wheel 24 which is rotating in the direction shown by the arrow and remain in contact therewith for at least a portion of its periphery. The distance between the bath surface and the point of contact of the filaments with the wheel indicated by reference character H in Figure 4 of the drawing may be from 6 to 30 inches but is preferably in the range of 12 to 18 inches. The speed of the wheel is a measure of the final spinning speed. As shown the spinneret is positioned relatively close to the surface of the spinning bath so that the immersion length is short, not more than two inches and preferably between 1¼'' and ⅛''. The draw off wheel may be rotated at normal peripheral speeds around 40 to 60 meters per minute as well as speeds greatly in excess thereof such as speeds of the order of 120 to 160 meters and more per minute. The filaments emerge from the bath without any turbulence at the surface of the bath and substantially all of the liquid withdrawn from the bath by the filaments is carried upwardly by the filaments without drip or back flow until the filaments contact the draw off wheel at the position shown by reference character 15. The spinning bath tends to remain with the filaments on the draw off wheel until the point where the filaments leave the draw off wheel shown by reference character 16. The liquid is thrown off the wheel by centrifugal force at substantially this point and is collected in the trough-like member 17 that surrounds a portion of the bottom of the wheel and the side opposite the side to which the filaments are directed from the bath. The spinning bath collected in the trough 17 may be sent by the pipe 22 to a bath reclaim or may be discharged as waste. The filaments pass from the draw off wheel to the positive stretching means which, as shown, comprises the positively driven godets 19 and 20, the godet 20 being driven at a higher speed than the godet 19. In those cases where it is desired to subject the filaments to a subsequent setting up treatment such as spinning bath, hot water or dilute acid the trough member 18 is provided. While the draw off wheel 24 may be slightly fluted in order to draw the filaments upwardly, the filaments are free to shrink in passing from the spinneret to the godet 19 either on the draw off wheel and/or after leaving the wheel. To enable the filaments to shrink on the wheel, the wheel may be tapered, with the filaments passing over the wheel a plurality of times from the larger end toward the smaller end. To eliminate stresses on the filaments in excess of any bath drag and to permit further relaxing of the filaments, when the filaments are subjected to liquid treatment, such as in the trough-like member 18, the godet 19 may be driven at slightly lower speed than the draw off wheel 24.

The filaments emerge from the spinning bath and move directly to the draw off wheel. The path of the filaments may be vertical or inclined to the vertical so long as the path of the filaments from the spinneret to the draw off wheel is direct, straight and free and guide means are not used.

In Figure 5 of the drawing is shown a plan view of the face of the spinneret that is found useful in the practice of this invention. In this spinneret the holes are grouped close to the center of the spinneret with the distances between the holes in the same circle shown by reference character A and that between holes in adjacent circles shown by reference character B kept to the minimum allowed in the manufacture of the spinneret. It is found in actual practice that preferred results are obtained where these dimensions are of the order of 0.005 to 0.015 inch.

In general this invention comprises spinning artificial filaments by extruding filament forming material into a liquid bath and drawing the filaments from the bath to a draw off means with substantially no tension on the filaments. The invention is practiced with an immersion length, speed of the draw off means, distance of draw off means to the surface of the spinning bath and spacing of the holes in the spinneret such that spinning bath is carried by the filaments out of the bath with substantially no appreciable back flow along the filaments or drip of the bath from the filaments after they have emerged from the bath.

With this procedure, it is preferred that the immersion depth, speed of draw off and spacing of holes in the spinneret be such that the load of spinning bath carried by each filament after leaving the spinning bath does not exceed from 0.002 to 0.0025 gram per inch of length per filament between the point of contact of the filaments with the draw off wheel and the surface of the spinning bath and is preferably between 0.00025 and 0.0015 gram per inch of length per filament.

With the short immersions described in this invention it is possible to spin at bath temperatures greatly in excess of those normally used. As the filaments emerge from the spinneret and can be lifted by a simple hook, the operators do not subject their hands to the harmful effects of the spinning bath.

Because of the short path of travel of the filaments through the bath, viscose regenerated cellulose filaments may be spun in a spinning bath at a temperature up to 75° C. and above. In the short period the filaments are in the hot bath the hot bath does not have a harmful effect on the filaments.

While preferred embodiments of the invention have been shown it is to be understood that changes and variations may be made without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. The method of producing artificial filaments comprising continuously extruding streams of filament-forming material with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into a liquid coagulating bath wherein the streams of filament-forming material produce by-products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance up to two inches and then through space to a position above the bath, removing by-products from the coagulating bath as they are produced, by forming by-products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, removing by-products containing liquid from the filament bundle at said position above the bath, collecting the liquid as it is removed from the filament bundle, directing the removed liquid away from the coagulating bath, and stretching the filament bundle.

2. The method of producing artificial filaments comprising continuously extruding streams of filament-forming material with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into a liquid coagulating bath wherein the streams of filament-forming material produce by-products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance up to two inches and then through space to a position above the bath, removing by-products from the coagulating bath as they are produced, by forming by-products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, removing by-products containing liquid from the filament bundle at said position above the bath by centrifugal force, collecting the liquid as it is removed from the filament bundle, directing the removed liquid away from the coagulating bath, and stretching the filament bundle.

3. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into a dilute acid coagulating bath wherein the streams of viscose produce reaction products in

their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance up to two inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, removing reaction products containing liquid from the filament bundle at said position above the bath by centrifugal force, collecting the liquid as it is removed from the filament bundle, directing the removed liquid away from the coagulating bath, and stretching the filament bundle.

4. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of the adjacent streams spaced between 0.005 and 0.015 inch apart into a dilute acid coagulating bath wherein the streams of viscose produce reaction products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance of from ⅛ to 1¼ inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under condtions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, removing reaction products containing liquid from the filament bundle at said position above the bath by centrifugal force, collecting the liquid as it is removed from the filament bundle, directing the removed liquid away from the coagulating bath, and stretching the filament bundle.

5. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of the adjacent streams spaced between 0.005 and 0.015 inch apart into a dilute acid coagulating bath wherein the streams of viscose produce reaction products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance of from ⅛ to 1¼ inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinty of the traveling filaments into a smooth continuous column of liquid weighing from 0.00025 to 0.0015 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, removing reaction products containing liquid from the filament bundle at said position above the bath by centrifugal force, collecting the liquid as it is removed from the filament bundle, directing the removed liquid away from the coagulating bath, and stretching the filament bundle.

6. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into an acid coagulating bath wherein the streams of viscose produce reaction products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance up to 2 inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, and removing reaction products containing liquid from the filament bundle at said position above the bath.

7. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into an acid coagulating bath wherein the streams of viscose produce reaction products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance of from ⅛ to 1¼ inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing up to 0.0025 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath when and around the filament bundle to said position above the bath, and removing reaction products containing liquid from the filament bundle at said position above the bath.

8. The method of producing artificial filaments comprising continuously extruding streams of viscose with the centers of adjacent streams spaced between 0.005 and 0.015 inch apart into a coagulating bath wherein the streams of viscose produce reaction products in their vicinity as they are coagulated to form a bundle of filaments, drawing the filaments as they are coagulated upwardly in a straight free path through the coagulating bath a distance of from ⅛ to 1¼ inches and then through space to a position above the bath, removing reaction products from the coagulating bath as they are produced, by forming reaction products containing coagulating liquid of the bath in the vicinity of the traveling filaments into a smooth continuous column of liquid weighing from 0.00025 to 0.0015 gram per inch per filament flowing entirely under conditions of viscous flow from the surface of the bath with and around the filament bundle to said position above the bath, and removing reaction products containing liquid from the filament bundle at said position above the bath.

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