Nov. 26, 1946. W. J. GUNDELFINGER 2,411,774

METHOD AND APPARATUS FOR MANUFACTURE OF CONTINUOUS FILAMENT AND LIKE STRUCTURES

Filed July 15, 1941 3 Sheets-Sheet 1

Fig. 2.

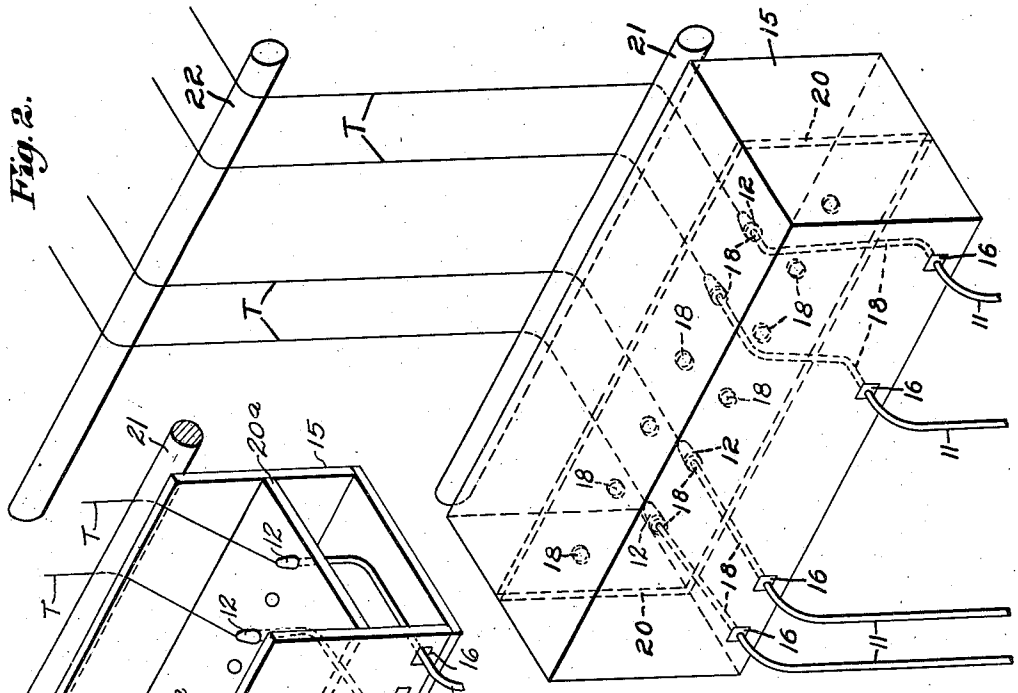
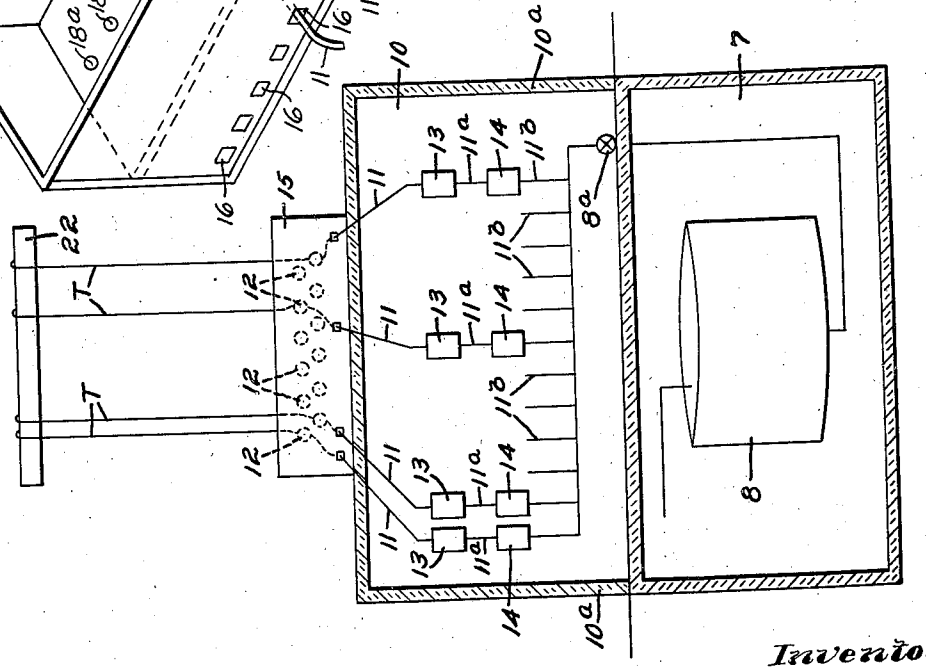


Fig. 2a.

Fig. 1.



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Filed July 15, 1941 3 Sheets-Sheet 2

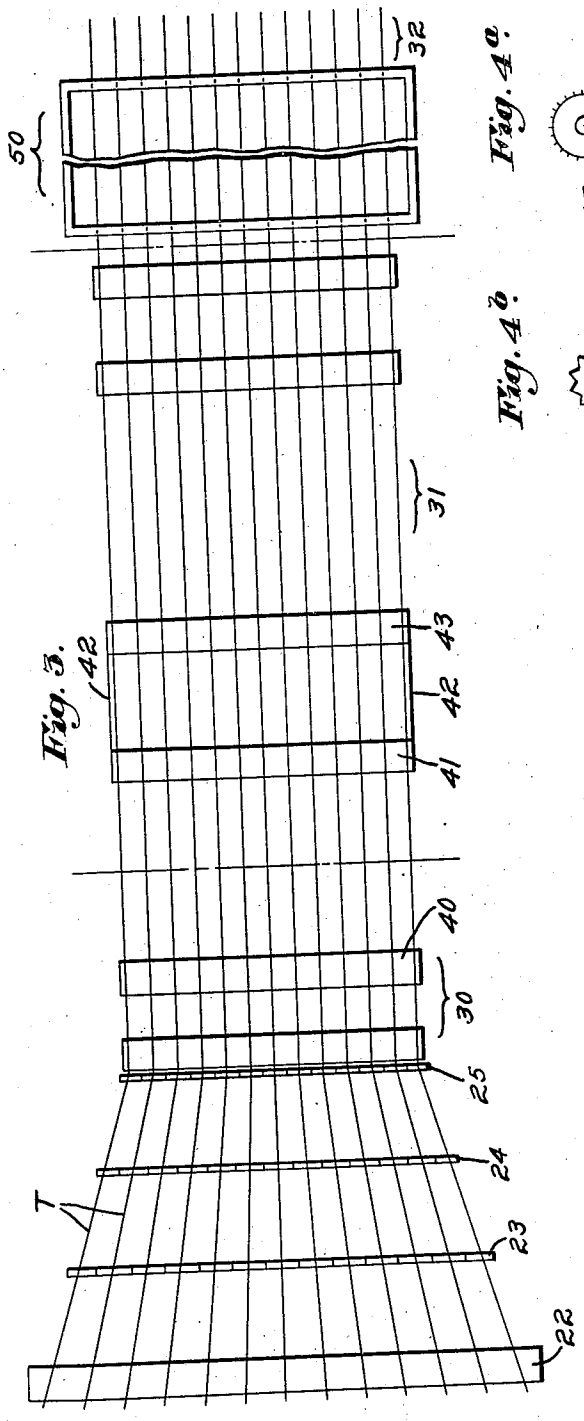


Fig. 3.

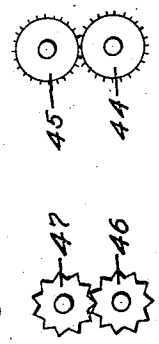


Fig. 4a.

Fig. 4b.

Fig. 4.

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Filed July 15, 1941 3 Sheets-Sheet 3

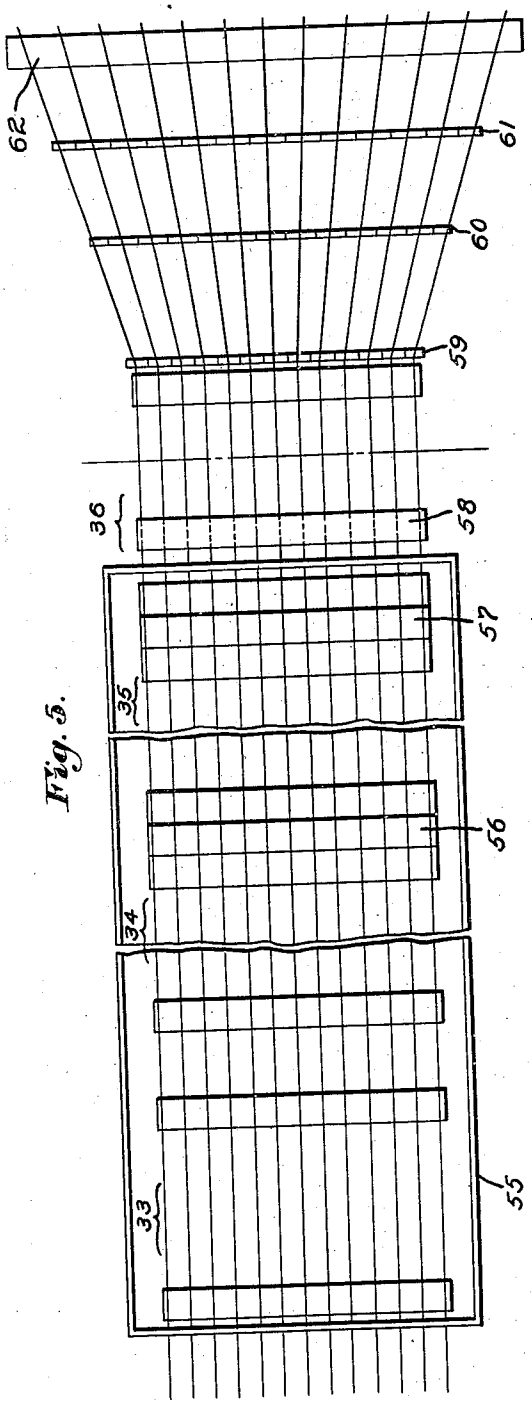


Fig. 5.

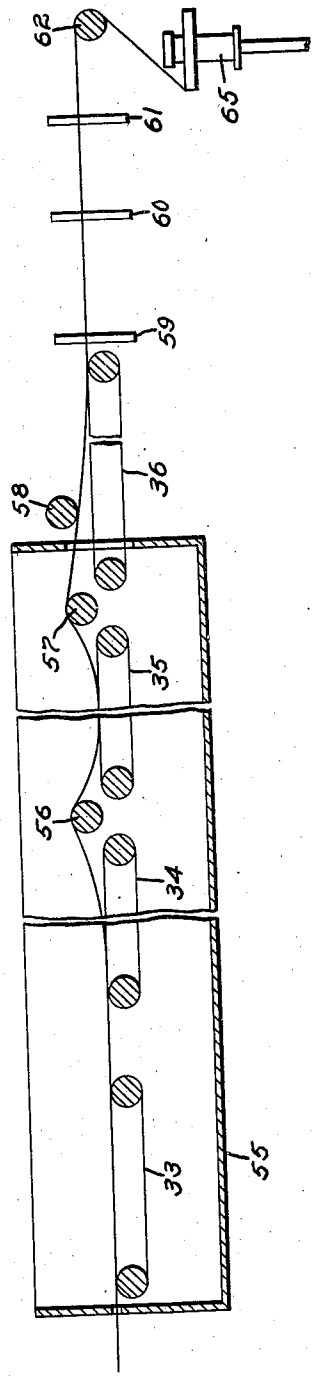


Fig. 6.

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Patented Nov. 26, 1946

2,411,774

UNITED STATES PATENT OFFICE

2,411,774

METHOD AND APPARATUS FOR MANUFACTURE OF CONTINUOUS FILAMENT AND LIKE STRUCTURES

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Application July 15, 1941, Serial No. 402,493

9 Claims. (Cl. 18—8)

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My present invention relates to the production, including the formation, treatment and finishing, of filamentary or other extrusion structures from derivatives of cellulose or other compositions of filament-forming and like materials and solutions. More particularly the invention aims to provide improved processes, methods and apparatus, including improved product-forming solutions or materials and coagulating mediums, whereby a comparatively large multiplicity, as for example up to 100, 200 or even more, of individual filamentary extrusion elements, individually composed usually of a multiplicity of filaments in groups termed thread bundles or threads, may be completely manufactured and finished, separately as to each such element, thread bundle or thread, but all of them as a single or common production and processing unit and in which all of the numerous individual production elements may have a more nearly absolute uniformity among themselves and as to their various characteristics, whatever the latter may be in the given instance. Thus in accordance with the system of the invention a relatively large number of the individual filamentary elements, thread bundles or threads are treated or handled as a single manufacturing or processing assembly, which multi-thread assembly I will at times herein refer to as a multi-thread unit, thread group or band. All the individual elements or threads of such multithread group, unit or band are subject throughout and at any given point, stage or time of the process as a whole to a substantially identical and uniform formation, travel, manipulation, processing and treatment completely up to, if desired, the final product in readiness for commercial delivery and use, all in the course of a continuous uninterrupted manufacturing, treating and finishing method or process.

In addition to the improvement in uniformity, with its resulting advantages of more even dyeing, and others, the invention contemplates the numerous improvements and makes possible the various operating and production economies as will be evident from the following description and in connection with the drawings. Among such improvements and advantages inherent in the present invention, to refer here but briefly to some of them, are the avoidance of objectionable effects due to the force of continuous sprays or showers on the delicate threads, also those due to the failure of such sprays or showers, in previous methods using them, as not infrequently caused by clogging or other inadvertent reason;

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also the overcoming of various difficulties heretofore due to lack of definite control of viscose solution after it leaves the ripening room which prevents uniform ripening and homogeneous consistency of the spinning solutions at the product forming point, device or apparatus. The invention also provides for simultaneous uniform increase or decrease in the tensions of the several filamentary thread elements or threads of the multithread unit group or band, uniformly throughout the group at any given time or location, also for a speeding up or slowing down of their rate of travel again uniformly throughout the multi-thread group or band as regards any such given change in rate of movement, and for the introduction of various special effects upon the product as may be desired, here again uniformly throughout the manufacturing group or unit.

In various aspects certain substance of my present invention is related, common to or within the scope of that of my earlier copending application, Serial No. 187,488, filed January 28, 1938, now Patent No. 2,251,931 the present application being in part and as to all such common subject matter a continuation of said earlier application.

In the drawings illustrating by way of example and largely schematically or diagrammatically, a typical system or embodiment of the apparatus of the invention and whereby the process thereof may be practiced:

Fig. 1 represents two adjacent and temperature-controlled enclosures and contained apparatus as herein contemplated up through the spin bath;

Fig. 2 shows on a larger scale and again diagrammatically the spinning bath such as appears at the upper portion of Fig. 1;

Fig. 2*a* is a partly diagrammatic view similar to Fig. 2 showing another form for the spinning stage including auxiliary temperature control means for the spinning solution;

Figs. 3 and 4 illustrate diagrammatically respectively in plan and in elevation or vertical section the path or course of the filament group or bundle and of the associated traveling plural-course sectioned or segmented conveyor means during processing subsequent to emergence of the filaments from the spinning bath;

Figs. 4*a* and 4*b* represent special forming or surface-modifying means, such as rolls and the like; and

Figs. 5 and 6 are in effect continuations respectively of Figs. 3 and 4 illustrating typical

further completion steps of the process of the invention up through certain drying apparatus and completion of the finished product as for example by the action of a twister.

In the manufacture of artificial filamentary material (for which the term rayon will herein be understood as generic) the cellulosic or other synthetic spinning solution is led through equipment including pipes or pipe manifolds, metering pumps, candle filters, and the like before it is fed or extruded into a spinning or coagulating bath or "trough." The candle filters and also spinneret filters are intended to remove dirt, scale, and the like, and particularly the gelatinous or partly gelled or over-ripe particles from the spinning solution. These over-ripe particles cause frequent stoppages of the filament structure because they quickly clog the spinneret orifices, necessitating a frequent change of spinneret equipment, with resulting broken or weakened threads because of unequal filament formation and interior changes in thread structure. Such weakening in turn prevents or more certainly reduces the normal or desired spinning tension or the after tension that is usually permissible with purer and especially with more uniformly ripened spinning solutions; that is, solutions free from an excessive number of "weak" or of over-ripened spots due to the mixing of unequally and non-uniformly ripened particles. Adequate spinning tensions on the freshly produced gel threads are, among other things, essential for producing better yarns with higher tenacity.

Heretofore, inadequate attention has been given, in the manufacturing of viscoses, to the control of the viscose ripening after it leaves the viscose ripening room, and it is after leaving the latter that irregular ripening intensively occurs. Thus unavoidable irregularities in spinning viscose are in general due to this irregular after-ripening, which in turn is engendered by the irregular and high heat transferred to the viscose piping, manifolds, gear pumps, etc., in the warm spinning room, presenting more or less greatly over-ripened viscose particles at the spinneret orifices and the acid bath. Some of these particles become so over-ripe they clog the candle filters and spinneret orifices after comparatively short periods of operation.

To reduce the necessity for changing or replacing clogged equipment due to this cause is one of the purposes of this invention, other improvements in the yarn characteristics also resulting from my proposed definitely controlled spinning solution to the point of extrusion, with more uniformly ripened and homogeneous spinning solutions. For example, when the uniformity between differentially ripened viscose particles (that pass through the spinneret together) even slightly exceeds previously established spinning values, unavoidable variations in lustre, dyeing capacity and appearance show up in the finished products. This is cogent evidence that more uniform or improved ripening is highly desirable and essential, particularly up to the point of spinning, as the spontaneous decomposition of viscose splitting off to form complexes or secondary products along any exposed or warm surface of equipment containing viscose results in different and varying degrees of ripeness. If all such warmer or exposed surfaces can be kept at low and controlled temperatures, over-ripening due to "after-ripening" is repressed and stabilization of viscose, that is, arresting of the hydrolysis or splitting off can be attained.

In the past, ordinary viscose has not permitted a very high continuous or a step-wise application of tension during the spinning process. Efforts have been made to insure a viscose that withstands the high spinning tensions as well as any after-treatment tensions necessary in the continuous rayon process. However, under existing operating conditions, the uniformity of the ripening or spinning index between very small portions in a given quantity of viscose (because of small over-ripe pockets) leaves much to be desired. Usually the NH_4Cl index or any salting point index shows considerable variation and where the difference in ripening index happens to be large and unsteady there we find corresponding variations and irregularity in the finished yarn. A principal cause of such detrimental yarn variation or non-uniformity is the non-homogeneity of the spinning solution due to the inclusion or over-lapping of varying percentages of over-ripe, ripe and to a rarer extent under-ripe viscose particles that are generally found in spinning solutions at the extrusion point even under most carefully regulated operating conditions today.

Spinning of rayon generally speaking partly consists in the de-plasticization or coagulation of the dissolved cellulose in viscose and functions according to the degree of hydrolysis, that is, the ripening index at the time of spinning. A greater overall uniformity of this index, or in other words, a substantial elimination or reduction of the over-ripe particles, would remove the defects due to this cause. In viscose ripening xanthate groups are believed to hydrolyze, being replaced by hydroxyl groups. Ripening or hydrolysis commences immediately after the viscose is made and it is a continuing reaction, until gelation finally takes place. This hydrolysis or ripening is sharply retarded or replaced by low temperatures, and is very rapidly increased by warming, with reference to ordinary ripening room temperatures as the general norm. In viscose rayon production the final stage or step of this hydrolysis, called spinning, is carried out in a hot acid medium. But here again the reaction though very much faster than in ripening, is not instantaneous but is a continuing chemical-physical action progressively throughout the extruded filament and perhaps may require 25 to 50 seconds more or less for completion, that is, to irreversibility, depending upon the viscose analysis, ripening index, acid baths, and other not yet clearly defined phenomena.

The relation between the spinning or ripening index and the corresponding coagulation or deplasticizing bath is carefully adjusted and must be maintained to produce the desired uniformity and other commercially valuable yarn characteristics. The already described instability of viscose because of its progressive hydrolysis introduces great difficulties for maintaining it at a sufficiently constant index during the spinning cycle. With a given spinning bath or other set of operating conditions, the degree of ripeness is co-ordinate or in equilibrium with reference to the regenerating or hydrolyzing power of the bath; any change, such as increase of the viscose ripening index, immediately disturbs the situation previously set up for any given spinning cycle. A very slight increase in ripeness causes parts or pockets of the viscose to regenerate or coagulate faster and unless compensated for adversely affects the finished thread.

Accordingly under present conditions many different degrees of ripening are produced, in other

words, the number of xanthate groups per 100 cellulose mols (C_6) varies widely, but regardless of these differences the given body of viscose must be extruded into the same acid medium.

Thus it is evident that even small over-ripe portions in normal viscose can affect the quality and uniformity of finished yarns. If allowed to proceed too far as when unavoidably localized on warmer container walls after leaving the cool ripening room, an over-ripening results which is detrimental in spinning and in the final product. As stated, it is a purpose of this invention to reduce or substantially eliminate such over-ripening of the viscose after it leaves the ripening room.

Viscose as such as already explained may, however, be kept in an unripened state for an indefinite period if kept cool enough, progressive hydrolysis being thereby checked so that any over-ripening in modern plants is almost wholly caused by heat transmitted (including pipe friction) to the viscose in its warmer passage to the extrusion point after it leaves the cold ripening room. In the industry ripening, which customarily requires up to several days at usual room temperature is enhanced or retarded by changes in ripening room temperature; a difference there of but one or two degrees produces very pronounced effects in the velocity and degree of ripening. But the temperature of the spinning room frequently is as much as 10° to 15° warmer. The longer any viscose solution, during its passage to the spinning device, remains in this region of high heat transfer the more rapidly does it ripen, the heat causing or producing a gelation of a part of the viscose. And under existing practice that is what happens to viscose in its travel from the cold ripening room to the spinning device. Those thin surface portions or layers of viscose close to the warmer pipe surfaces (which surfaces are relatively large compared with the total pipe volume) and in other room-warmed apparatus containing viscose on the way to the spinning machine, will ripen very much faster than the colder inside portions. Also the distances travelled by the viscose in this piping is variable. In this way nearly always a definite amount of objectionably over-ripe viscose is unavoidably mixed with the otherwise normal viscose and taken to the product-forming device or extrusion orifice. As already pointed out, such over-ripe particles clog the spinneret orifices. They cause an even more rapid clogging of candle and spinneret filters.

But under existing methods control of after-ripening has not been attempted, possibly by reason of structural impediments inherent in present spinning machines, involving the conduction of the viscose for various distances on the spinning machines and various periods of time in the warm spin room, and so far as I am aware the continuing definite temperature control of ripening has never been attained after the viscose left the ripening room.

Spinneret orifices and candle filters remain clearer and freer much longer when over-ripe or gel particles are reduced or eliminated. Such reduction in replacement of equipment is of extreme importance at any time, but tremendously more so in any continuous process machines or methods because after once started, interruptions such as due to frequent candle filter or spinneret filter changes, are much more costly than in bobbin or centrifuge spinning methods. Also, under the heretofore proposed high zinc spinning baths, wherein the high zinc bath is at and around the mouths of the spinnerets greater ripening uniformity is imperative for smooth spinning, in fact, difficulties usually develop should any under-ripe viscose pockets be extruded with normal, ripened viscose, after high zinc baths have once been established.

References herein to usual or normal solutions, baths, and various attendant conditions such as temperatures, degree of ripeness and others will be understood by those skilled in the art. As to ripeness, reference may be made for example to the explanatory footnote on page 1 of Bradshaw Patent No. 2,087,016.

Under this invention, as with that of my co-pending application, Serial No. 187,488, now Patent No. 2,251,931, the coagulating threads or filaments are positively conveyed or transported along, in or with liquids that move or travel along with the threads. The nature of the filaments or thread and the characteristics being produced or changed depend on the baths or mediums used or changes made in the traveling baths during the coagulation cycle or while or before complete conversion to cellulose hydrate takes place and according to the degree or degrees of tension concurrently imposed or horizontally applied without being subjected to gravitational pull or influences or merely to one single non-varied tension throughout the process. Hence under this invention differing degrees or varying operations during processing may be widely altered to control or produce those characteristics principally desired.

I am aware that heretofore a freshly formed artificial thread has been subjected to a form of stretching during manufacturing or spinning operations—as by pulling or drawing the single unsupported threads by or between rolls or godets through channels or upwards through air or open spaces while imposing tension; or by drawing or pulling a single thread through or between relatively long open or unsupported distances while concurrently drip treating or spraying the freshly prepared threads; or while drawing or pulling the threads through or drawing threads between stationary liquid or like treating bodies; or by passing freshly prepared coagulating threads around conical or other reels and the like which may produce a slight or gradual tension depending upon the slope or surface gradient. Another method had proposed to stretch the threads after regeneration viz., during after-treatment, by gripping moving threads between separated groups of rollers to prevent lengthwise contractions. None of these prior methods or processes propose, include, impose, or permit the imposition of, or definite changing of, controlled tensions during the coagulation or hydration cycles of spinning while the threads are traveling supported and while moving along in coagulating or treating baths which are capable of being suddenly removed, replaced or otherwise varied.

It is known that the locking together of the molecules or micellar particles is dictated by their chemical and physical nature and attendant binding forces. The bath temperature or sudden changes in bath temperature or in the specific gravity, or acidity or pH value, or the zinc content of the surrounding liquids profoundly alter the forces that determine tenacity, elongation ratios and other characteristics in the finished yarn. Heretofore such liquid changes were made by means of passing the threads from one immersion bath or spray to another and so far

as I am aware no method or apparatus was known to change or replace the bodies of liquid traveling with a group of threads during processing other than as disclosed in my copending application Serial No. 187,488, now Patent No. 2,251,931.

My invention however is effective to stretch the threads in one or more degrees or reduce the tension therein in definite controlled degrees while the threads are surrounded and being conveyed or transported laterally or horizontally in a liquid which is itself propelled on a conjugated thread-conveying or thread-advancing means and so adapted to definitely and uniformly change the tension on 100 or more separate threads simultaneously, if desired, with changes, substitution or removal of the medium then traveling with the threads without changing the direction of thread travel such as would be necessitated by passing the thread or threads around rolls, reels, guides, cones, and the like. All such imposition or variation of tension is under the present invention imparted unitarily and simultaneously to a multiplicity or band of substantially separated individual multifilament threads traveling together and being treated as a unit on the conveyer means. This is of great importance because considerable differences in tenacity, elongation and dye absorption are now found between threads produced on the same spinning machines as currently used. Wide differences in thread structure or characteristic have been found, for instance between those threads produced or extruded at the end of current spinning devices and those extruded near the center or the opposite end. Such variation may be due to slight differences in spinning bath, or more likely are due to differences in ripening index occurring in the variable manifold or pipe lengths that convey the viscose on or to the spinning devices; also to differences or variations between bobbin, reel or centrifuge speeds on the same filament producing unit. Also under the prior methods the accumulated layers as they are wound, when spun on single thread or unit processing packages, vary considerably as between the various layers and are the cause of unavoidable variations in the final thread.

The above causes of variation and lack of uniformity are substantially completely eliminated under the present invention where the viscose is kept under definite temperature control after it leaves the viscose ripening room and until it is extruded. Also when the 100 more or less, separate threads are coagulated, treated, and stretched as a single unit, a greater uniformity is found possible than where single, widely separated threads are produced in separate, single thread processing package units. These factors are of special value in the development or composition of those characteristics that are desirable in certain thread formations; for instance in threads or cord used in tire fabrication where the uniformity, tenacity, elongation, heat-resistance and internal structure are of prime importance. Improved filaments or threads may be produced from viscose wherein the cellulosic base has not been degraded or broken down during alkali cellulose aging—the resulting higher viscosity spinning solutions, instead of being pumped or metered, may be forced by direct compression through larger holed spinnerets or orifices and the thread then drawn out or attenuated and thereby oriented during this tension or drawing out process. Under the present invention it is

possible to extend or draw out the filaments or threads indefinitely and under one or more chemical conditions or processes thereby permitting a wide but controlled development of many characteristics in a manner not heretofore been disclosed or possible under existing methods and equipment. These variable but controllable processing operations and steps as disclosed herein and in related applications not only are of value in the viscose or other regenerated thread fields but also with any other type of extrusion or thread spinning masses or solution for elastomeric or other type threads, including those directly extrudable into atmospheric or gaseous mediums and which may further be continuously liquid processed to produce or change the yarn characteristics. This also applies to evaporative or solvent spinning methods where, after the thread is formed, it may be further treated or processed on the conveyer means to improve or induce desired final characteristics in the thread or yarn produced.

Referring now more particularly to the drawings, in Fig. 1 the ripening room is indicated at 7, containing one or more viscose storage tanks such as 8. The temperature in the ripening room or at least that of the contents of the ripening tank is carefully controlled and refrigerated. All the equipment following the ripening tank in the ripening room 7 and up to the extrusion point or spinning bath to be referred to, is condensed and afforded temperature control arrangement within a relatively small space or enclosure indicated by the numeral 10 and to be referred to as the intermediate or pre-spinning room. It will be understood, however, that in various instances the actual spinning point or bath may be enclosed with the apparatus in the room 10. In Fig. 1 the horizontal dividing line of indeterminate extent between the ripening room 7 and the apparatus room 10 represents any desired or convenient proximity or spacing between such rooms.

As pointed out in connection with the preceding explanation, the invention contemplates a complete and continuing control of the viscose ripening, after leaving the ripening room, continuously up to the spinning point. Such control preferably is effected by continuing the same temperature control as for the ripening room fully up to the extrusion or spinning point. And such continuing control is herein made feasible and economically possible, in accordance with the continuous process and apparatus of the invention, through a novel construction and arrangement of the spinnerets and compact disposition of a large multiplicity of individual thread spinning positions, such for example as 100, 200 or more, together with all necessary equipment intermediate the ripening room and the spinning point, all enclosed in the room 10, which in actual practice I find requires a floor area, for approximately 100 spinnerets, of not more than about 12 sq. ft. And in further accordance with the invention the entire enclosure 10, as made feasible by its limited area and space, is entirely heat-insulated as indicated at 10a and subject to refrigeration and temperature control. Thus the intermediate room 10 and all the equipment therein, up to the spinning point, can be kept at the optimum temperature in comparison to that maintained in the ripening room and can be raised or lowered to any degree necessary to obtain the stated objectives. While in general I find it desirable to operate with substantially the

same temperature conditions for the intermediate or controlled room 10 as for the ripening room, under some circumstances some temperature differential may be appropriate, such as a reduction to retard what I have termed after-ripening, and the provisions for insulation and temperature control of the intermediate equipment room 10, in accordance with my invention, make such differential available. For example, under some conditions, the difference in temperature between the acid bath and the viscose may be too great for smooth spinning. In such case, with the apparatus and under the process here disclosed, the viscose could be warmed, directly in place before it is extruded.

Despite the desirability of this complete and continuing temperature control of ripening, it heretofore has not been found feasible or practical to carry out, because of the difficulties, previously noted, involving the cooling of large areas and spaces. As can be easily understood by those skilled in the art, to cool or refrigerate the spin room or even the entire length of existing type spinning machines in order to control the ripening although possible is manifestly unfeasible as well as prohibitive from an operating and cost standpoint although the ripening index can be controlled if this is done. The detrimental defects in yarns due to the at present uncontrolled variations in the ripening index is a problem which has dictated the many past steps taken and the many efforts now made to attain better control over this variable in the viscose industry, prior art methods so far resulting only as a partial control and not preventing over-ripening after leaving the ripening room. The method of mixing or blending of certain small amounts called "heels" (that sometimes in the past were discarded entirely) of over-ripe with under-ripe or with normal viscose as practiced in the prior art in attempting to reduce these defects, may assist or result in the dispersing of any over-ripened particles, "heels" or pockets throughout any normally ripened viscose but this action does not prevent nor even tend to prevent their formation, nor does it substantially change the ratio of over-ripened xanthate groups per 100 cellulose mols usually found in small pockets, which is of great importance, especially where the viscose is later subjected to the unavoidable conditions of unequal heat transfer or temperature increase as above mentioned. Any addition of chemicals or sulfur containing compounds to the viscose to retard ripening is only a partial, one-way control because they permeate the entire viscose system and the chemical effects are removed only with difficulty—the viscose therefore is partially out of control because after such chemicals are once added the index cannot be easily changed or advanced quickly should, as is frequently the case, an increase be desired.

Referring now to Fig. 2, and also to Fig. 1 in connection with it, in contrast to the usual spinneret positioning of 8, 10 or more inches apart, together with the customary rigid connections, I herein place or enclose a large number of spinneret or spinning positions with an extremely small area and volume of spin bath. One such bath, "trough" or tank is seen at 15 in Fig. 1, and on a larger scale in Fig. 2. In association with it, I provide a novel highly flexible connection or "goose-neck," referred to herein as a mass connection, represented at 11 in said figures. This construction makes possible the described close location of the large multiplicity of spinning positions, in a relatively small bath, and also their disposition in multiple rows or layers, in parallel, staggered or other preferred arrangement.

These flexible mass connections 11, best seen in Fig. 2, extend between the spinnerets or spinning positions 12 and the candle filters 13 of room 10, in cases where such filters are used. As represented in Fig. 1 at the tubular connections not necessarily flexible extend at 11*a*, between the candle filters 13 and the metering pumps 14, and also at 11*b*, from said pumps back to the common or other inlet 8*a* for the viscose supply line from the ripening tank 8. By means of these flexible mass tube connections, all piping, manifolds, metering pumps, candle filters and other viscose-carrying equipment, at the pre-spinning room 10 and the extrusion points 12 are enabled to be compacted in closely spaced relation in a relatively small enclosure such as schematically shown in Fig. 1. And by insulating this space and controlling the temperature therein as in the ripening room the continuing definite control of this important function of ripening is attained and maintained; it can be retarded or advanced as required by changing the temperature in this space as found necessary. Hence the mentioned unequal heat transfer to be viscose now unavoidable in existing machines and processes is eliminated. Thus completely controlled viscose (throughout the entire system) is delivered to the product-forming device. This improved viscose is essential for the newer spinning technique for producing stronger yarns as well as for the greater tensions now used or proposed in spinning.

Noting now more particularly Fig. 2, it is again emphasized that the spinnerets 12 should be spaced in extremely close relation to facilitate the exercise of the over-ripening avoidance and maintenance of viscose uniformity features of the present invention. The described adequate flexibility of the goose-neck or mass tube and its connections permits the extreme closest spacing of the spinnerets consistent with a capacity to be changed individually of each other in the acid bath trough. And instead of leading the connections up to, across and down over the top edge of the acid bath trough as heretofore customary, (although such may here be done if preferred) the spinneret orifices or heads 12 desirably are inserted at openings in a wall or walls of the spin bath trough 15, either the bottom or side walls, or both, suitable attachment devices being provided in association therewith as for example a soft rubber or similar replaceable gasket, or a screw-fitted device, as indicated at 16. Leakage of the spin bath from the system is thus prevented, save for such slight momentary leakage as occurs during changing of a spinneret. If preferred the trough containing the active spinning bath may be disposed over another or auxiliary trough, which latter serves as a drainage or drip device. In Fig. 2 the open bath trough 15 is illustrated as provided with a vertical partition or diaphragm 20 defining at opposite sides two solutions or baths, such as at the entering side the low zinc bath and at the other side the relatively higher zinc bath elsewhere herein referred to. The spinnerets 12 as indicated in Fig. 2 discharge into the first bath, extruded filaments passing from them through apertures 18 into the adjacent bath. In Fig. 2*a* there is represented another form of spinneret arrangement and support including a false bottom 20*a* in the tank or trough

and having apertures or sockets 18a in which the spinnerets 12 are individually removably set. By provision of such auxiliary or lower trough, through which the flexible connections make entry, the bath content may there be kept in a temperature state adequate first to raise the temperature of the viscose in the flexible tubes before it is extruded in the actual spinning bath of the upper tank, should the temperature difference be such as to be detrimental.

From X-ray diagrams it is indicated that a better orientation of the internal fiber or micellar particles is effected if the freshly extruded or gel filaments are stretched strongly during certain periods of the final step of the hydrolysis, called spinning, and the value of such stretching is further substantiated by the improved final yarn characteristics if the filaments are sufficiently stretched, but under controlled conditions (and with properly prepared alkali cellulose) to prevent embrittlement. It is fairly well established or indicated that tensioning during these last stages of hydrolysis lines advance up the micellar chain lengths or particles (and which are more or less at random at the spinneret face when the viscose is extruded into the usual acid-salt baths) into a structure of parallel oriented crystallites or ultimate particles. The greater or more continuing such controlled tension is during this final hydrolysis the greater is the improvement in particle orientation, care being taken, as already noted, to prevent embrittlement. Although the mechanism may not be fully understood the effects are clearly distinguishable, the tenacity among other things being some function of the spinning or gel thread tension applied. By suitable treatment and manipulation during manufacture, viscose products can be obtained in many different states from a hard brittle non-extensible form to an extensible material with satisfactory or greatly increased elasticity and tensile strength for textile or other commercial uses. Any such manipulation, that is, changes in tension with concurrent changes in coagulating bath or after-treatment bath concentration and temperature, results in definite changes in the internal structure which in turn induces differences in the final products as shown by confirmatory facts observable in dyeing, tensile strength, sharpening of X-ray diagram patterns, etc.

Accordingly, heretofore in both discontinuous or continuous rayon production methods efforts have been made to impart as much stretching or tensioning on an individual or single thread as was possible in the relatively short linear distance between the spinneret and the take-up device used, this distance generally being limited to proportions of approximately 20 to 45 inches more or less depending on the use of a bobbin, reel, cone or centrifuge spinning system. In some prior art instances, by pulling or drawing the freshly extruded individual thread back and forth through or above the spin bath and around the periphery or peripheries of a system of guides, godet wheels or of rotors rotating in or above the spin bath, the shorter linear distance of the thread path of travel through the bath and between the spinneret and the take-up, that is, the draw off or collecting device, has been increased or elongated to as much as 10 feet for the purpose of stretching the thread.

When the draw off speed under these conditons approaches 200 or 250 feet per minute the thread would require between 1 and 3 seconds after extrusion but while still in the spin bath, in order to travel any such extensive distance through the spin bath, that is, before being collected by the take-up device which then prevents any further stretching action. In any high or concentrated stretching or tension is desired beyond this incipient solidifying or preliminary coagulation, it could not take place, save possibly for a slight gradual stretching by using frustum or conical cylinders or reels for the thread collecting and storing or the take-up device. In fact, as soon as the tension stops, especially during the coagulation cycle, a certain retractive effect or a creep recovery takes place on bobbins, reels, cones or centrifuge cakes. Such recovery, evidently due to incomplete regeneration into cellulose form, has been sufficient to cause an irregular alignment or displacement of the thread coils of such bobbins or cakes and resulting undesirable conditions. Also the collecting on reels or cylinders before complete regeneration coupled with other variations set up between spinneret and draw off device show up as irregularities in the finished fibers. Other systems as noted propose gradually to stretch single threads at a time using conically shaped cylinders or reels for both the drawing off or collecting and the stretching of such a single thread after it emerges from the spinning bath, but here again the thread approximately one second more or less after its extrusion is then wound upon such conical thread storing devices or reels, and any further stretching is limited to very slight and gradual amounts depending upon the gradient or the increase of the conical cylinder diameter. Such relatively slight or gradual stretching after it is wound upon any cylinder is less adapted to cause desirable orientation of the micel'ar structure than when extremely large and concentrated degrees of controlled tension are applied which in some cases may approach the breaking point during earlier stages of the coagulation cycle.

But under the practice of my invention and as disclosed and claimed in the broad or common concepts of my prior copending application, Serial No. 187,488 now Patent No. 2,251,931 mentioned, any such subsequent higher and concentrated degrees of tension that are desirable can be applied repeatedly and/or increasingly during the permissible range on an entire group or band of 100 or other number of distinctly separate multifilament threads or bundles all acting as a single unit, uniformly and simultaneously, while all are concurrently subjected to the same common progressive fluid, liquid or gaseous, treatments and while all are being transported and conveyed side by side.

Also, in the use of cones, cylinders or reels for storing each single thread during each processing step, there are required eight, ten or even more of such conical or cylindrical storing devices, with a like number of individual solution feeding and also individual solution removing ducts, for each thread, all involving much costly equipment and substantial power consumption per individual thread unit. In lieu of such procedure it is an object of my invention to provide a method and apparatus for strongly and quickly stretching during liquid treatment or processing, a large plurality of individually extruded gel or similar threads, under controlled conditions at one or more points during the coagulation or setting process, while avoiding conical or cylindrical reels or any similar thread storing devices that require each single thread to be passed

there-around or stored thereon in order to be stretched or to be processed.

The but one to three seconds that the freshly extruded thread generally travels under prior practice before being collected or wound on a cylinder is but a small fraction of the coagulation and regenerating time, for instance, a 10, 20 or even 30 second interval that elapses or might be required for the whole coagulation and regeneration cycle, that is, the complete hydrolysis to irreversibility of the viscose filament. Under my invention such entire longer 10, 20 or 30 second interval is made available for stretching and other treatment features, whereas, as noted, under the prior practices the thread is collected in a cake, bobbin or on a storage reel or cylinder almost at the outset of the coagulation cycle and before regeneration is complete and hence while still plastic and while still in condition in which it could be further strongly tensioned or drawn out. My invention, as stated, makes available the entire coagulation and regeneration period for stretching and other treatment of the threads, as by means of my segmented or sectioned traveling bath conveyer means. Also, the space necessary for each thread in the spin bath or above it under some such methods, is relatively large and greatly reduces the number of spinning positions possible in a given area. As indicated, it is a purpose of this invention to increase to a maximum the number of threads or individual spinning positions that can be extruded or placed in a coagulating bath of a given area. Further, as in my copending application, because of the non-restricted distance or period during which the freshly extruded threads may, when desired, be subjected to stretching anywhere in their travel (during all or any part of the entire coagulation cycle if desired), and by reason of the simplicity in changeabiltiy or exchangeability of any concurrently applied spinning or fixation baths or after-treatment baths without disturbant spraying or showering while the threads are in constant forward travel on the segmented or sectional courses or stages of the conveyer means, a much greater, more concentrated, and a more extended stretching and liquid treatment under control of all those factors necessary to produce better yarns can be utilized; such as the degree of stretching, time of stretching, point of stretching, bath immersions, concentrations and temperatures, and other treatment features. The large multiplicity of individual threads nevertheless, as in my prior application, may be conveyed during or with long extents of predetermined baths or bath segments on the conveyor means substantially without draught except at points where tension may be clearly fixed and definitely and deliberately applied. Thus under the invention completely controlled stretching or tensioning or any other manipulation may take place during the plastic or the reversible state and can be changed or continued indefinitely or as long as desirable, for 50, 75 or 100 feet, or even longer, while traveling on the conveyor means, and in either a continuous or a step-wise manner or if desired a release in tension can be made either before or after coagulation, or even beyond, during the after-treatment, in order to overcome any detrimental retractive tendency or after-shrinkage. Such change or tension release or recovery can be permitted wherever operating conditions dictate it in order to improve the elongation characteristics of the finished thread without reducing the tensile strength or vice versa. So far as I am aware, such greatly extended, repetitive or continued and clearly fixed stretching operations or similar manipulation of threads while traveling on a sectioned or segmented conveyor means under controlled methods and without substantial friction or rubbing are not possible with currently known methods and apparatus.

The means or apparatus for thus accomplishing any variable and also high stretching of the simultaneously produced plurality of individual, single or multifilament threads, in an endless moving group or parallel band supported on a conveyor means and while subjected to immersion baths or any other vapor, liquid or gaseous treatment while on the conveyer means (which latter may be as disclosed and claimed in my copending application, Serial No. 187,488, now Patent No. 2,251,931) comprises devices which cause the freshly produced gel threads while so conveyed in the course of coagulation or regeneration (and/or after treatment), to travel, a longer or a somewhat different path of travel, including more or less temporary and deliberate deviation from solidly supported conveyance. Such change in the length of thread path of travel with reference to the conveyor means path of travel can be applied or made anywhere in the thread (or the conveyer means) path of travel and in varying degrees. The endless group or band of individual, end-wise transported gel threads are caused to pass over a movable guide or roll or through a series of adjustable rolls, squirrel cage reels, aprons or any device placed in proximity above or near the conveyer means, disposed so that when the band of threads pass end-wise over, through or along said devices it will be caused to travel a longer or a different path than of the conveyer means and thereby uniformly and simultaneously stretched, the degree of stretch can be determined and varied depending upon the location and the speed of the rolls or aprons over which the threads travel or pass while on their continuous course of travel on the conveyor means as a whole. The stretching also is applied, as stated herein, by passing the threads from slower to faster moving sections of the conveyer means, thereby causing stretching in variable but deliberately controlled amounts. This flexibility or variability in the linear speed of each segment on the conveyer means offers wide possibilities for all degrees of stretching of the threads travelling on the conveyer means. In this way the entire group of separate threads can, as a single manufacturing and processing unit, be placed under repeated joint tensions; that is, all threads are tensioned alike simultaneously on the common or unitary stretching devices, and between the variably moving conveyor segments, and all are processed together in common or unitary liquid or gaseous media and all or dried together in the travelling conveyor means under the same tensions on a common or unitary drying apparatus, but are twisted and collected later in the operations, however, as individual threads. The tension applied on the band of gel threads may be solely due to the increase in thread path of travel or it may partially result from the burden of the threads turning the frictionless rolls or aprons as they pass over them thereby collectively propelling each roll or apron or device which can be definitely weighted, this in turn effecting a uniform tension on all the threads with a simple operation that is partially self-acting; or the

aprons or rolls or similar devices may be driven at any desired speed in oredr to develop any degree of higher and controlled tensions through increasing or higher linear thread speeds, and the course or segments of the conjugated conveyer means may be varied as to linear speeds. Such control can be adjusted to prevent any over-tension of the threads or up to a point just below the breaking point of the tensioned gel threads. In a like manner in any liquid processing step where shrinkage is likely to occur, for example, as in desulfurizing, or especially in drying before the twisting operation, the tension on the continuously traveling thread could be released or a slack condition developed as by the described passing of the threads to slower moving conveyer segments so that any advancing lengths of thread could be allowed to shrink in any degree with or without substantial restraining forces. Should the arc of contact under certain operating conditions not be sufficient to prevent slippage as the threads pass over tensioning rolls, a secondary roll or apron can be placed in a position to cause a gripping or binding effect on the band of traveling threads to prevent slippage. Such double rolls or aprons operating in timed relation with the articulated conveyer means, that is, the aprons or rolls with linear speeds either greater or less than adjacent traveling segments of the conveyer means, offer the assurance of perfectly uniform predetermined tension on all of the threads at the same time at the points chosen in the process.

Thus under the present invention, in the drying of a large group of separately or individually produced threads as a unit, the regulated slack in tension during drying is imposed uniformly on all the threads and the differential shrinkage usually found in threads dried separately or individually or in packages is eliminated. This differential shrinkage heretofore found either in package or single thread processed yarns are a cause of the so-called "bright-picks," in the finished fabric, as well as of marked differences in color or dye absorption or affinity between one thread and another.

The entire group of threads can be stretched or released simultaneously as they are moving along in baths on the conveyer means which is articulated or operated in sectionally timed relationship with the travel of the threads. The adjustable tensioning devices arranged in juxtaposition with the conveyer means can be placed above, in, or between any of the separately traveling baths or other treatments, in or with which the threads may be conveyed or at any other place while on the conveyer means so that high tensions may be applied at the proper points, preferably shortly after extrusion, that is after an incipient or sufficient coagulation has been first effected in order thereafter to permit any desired very high tensions, either consecutive or graded, to be applied. By properly spacing and by regulating the peripheral or linear speeds of the tensioning devices, and of the traveling segments on the conveyor means, increasing or decreasing tensions, or repeated tensions can be applied depending upon the finished yarn characteristics desired and depending also upon the degree of ripeness and the type and temperature of the coagulating or treatment baths used. The threads after emerging from the usual or normal acid baths as already described under certain conditions may be allowed to retain sufficient acid bath or other coagulants either to just start or to complete the hydrolysis so that the threads may be stretched as they travel along without any further addition (sufficient care being taken to prevent sodium sulfate crystal formation in or on the threads), or if desired, additional warmer or colder acid baths, fixation baths or vapor or gaseous treatments may be utilized on the continuously moving threads in order to attain the reaction effects desired. This also would apply to all other treatments, such as washing, desulfurizing, surface altering, bleaching, soaping, tinting, or dyeing, in definite predetermined lengths of the continuously advancing threads while either stretching or non-stretching may be taking place, and according to any predetermined procedure. For instance, it is well known that when 1% zinc sulphate is used in spinning baths, the lustre of threads shows an increase as the viscose ripeness increases, but with a green viscose (Hottenroth at about 11) dull, milky, matt surface threads result and higher zinc concentrations in a spinning bath, generally tend to increase dullness unless otherwise compensated for.

Microscopic studies practically confirm that any such dullness is almost entirely due to the gases generated during spinning. It is obvious that any gases generated in the interior of the filamentary or gel thread structures have to penetrate or pass out through the surface or cylindrical skin that is then forming and such penetration or passing through has a perforating action and consequently a somewhat weakening effect on the particles or composition of the filament skin and if spinning conditions are adjusted or if the spinning operations can be prolonged or extended (before the threads are collected or taken up) in such a way that the deleterious acting gases are given an opportunity to leave before the skin or film development is too advanced, there will be less weakening of the filament as well as a better lustre.

The method and means of the invention among other objects and advantages avails of the fact indicated by experimental study that the strongest skin or film may be developed by arranging spinning operations which have the most suitable ratio of coagulation velocity versus gas formation or xanthate decomposition combined with concurrent stretching to improve the particle orientation.

As the molecular chain bundles, through tension, orient themselves parallel to each other or to the cellular walls, attractive forces gradually build up, such forces increasing it is believed as the particles approach each other and such improved tenacity may be substantially retained provided the internally developed gases are substantially removed or reduced before orientation is completed. Under the instant invention, because the threads are not wound or collected until regenerated, extended or continued spinning operations are possible under controlled conditions in the traveling spin bath, as well as through changes in extrusion rates, the ratios of corresponding bath composition, etc., it is possible to combine the advantageous effects mentioned above.

In cases where too high a temperature difference exists between a spinning solution in the spinneret and the coagulating medium in the area immediately following and surrounding the jet orifice or the extruded gel threads, detrimental effects sometimes have arisen because the suddenly reduced viscosity with its resultant changes in surface tension tended to disrupt the continu-

ity and uniformity of the spinning solution flow. In order to reduce any detrimental effects due to this difficulty the temperature of the spinning or coagulating medium may be widely varied or reduced at differing points or areas as the spinning trough can be divided into two or more contiguous sections by means of baffles or separating diaphragms in the spin bath trough with openings therein to permit the threads to travel in an uninterrupted and continuous manner and while continuously immersed, through two or more areas or distances each of which can be maintained at temperatures or concentrations to be determined by each spinning requirement or by the final product desired.

Herein, and in my copending application methods and apparatus are disclosed for producing, processing, and especially changing the tension or stress concurrently and uniformly on a large plurality of individually produced threads at a time (instead of on a single thread) after they have been extruded and while they are all traveling together on the conveyer means in or with any coagulant treatment or any other normal processing cycles, with complete uniformity in operating control over all the separate threads, acting substantially as a single unit from the extrusion point until they are dried under uniform tension. It is also apparent in the process that by changing or varying the degree and the points at which any high tension is applied on the threads either in the gel state or thereafter, coupled with concurrent variation or changes in processing solutions, all while the threads are in constant forward movement on the sectional conveyor means, the characteristics and physical properties of the finished yarn can be changed or developed uniformly and according to the pattern desired and adding to these controlled operations a greater uniformity or control in the ripening index a large number of variables may be combined and brought under better control in the instant invention all of which admittedly have a preponderating influence in the improvement in quality and in the tenacity-elasticity ratios in the finished yarn. Since these characteristics are principally molecular in nature, and thus subject to some rearrangement while in the colloidal state, they may be changed and controlled by proper tensioning in concurrent coordination with the chemical treatment and manufacturing stages so as to produce a more uniform chemical or physical structure.

When more extended stretching, such as is possible under the instant invention, is carried out over an extended period of, for example, from 2 to 10 seconds or even more (with a slower or partial suspension of coagulation), after thread extrusion, a slightly or sufficiently less degree of ripeness together with any other necessary known or preferred compensating changes can be established in the spinning solution and in the spinning baths than for instance when the extruded threads are collected, rolled or wrapped around any device or holder within one to three seconds after extrusion, and which is the usual or normal procedures when bobbins, cakes, cones, rolls, or conical cylinders are used for storage or containers. Under the process and apparatus of this invention it will be possible to work with much larger individual streams or volumes of higher viscosity viscose (due mainly to a less degraded cellulose base) which may be extruded by means of larger sized and more widely spaced spinneret orifices. Such more voluminous, and more viscous filaments can then be more strongly drawn out or extended for a much longer period, down to any proper or desired denier—also for the same reason, that is, the utilization of larger more voluminous, more viscous gel threads, the likelihood of breakage or thread rupture (that arises when longer, higher or abnormal stretching is done on smaller less viscous filaments), can be reduced or eliminated, because the concentrated or high tensions (as now generally found necessary) in present methods and equipment in the relatively short distance between collecting device and extrusion point are, under the instant invention spread or distributed over a very much larger or lengthier range, that is, the very high stretch spinning need not be completed within one or two seconds (practically at the spinneret face) as when using bobbins, cakes, helical containers, etc., as at present, because stretching, under this invention can be evolved relatively gradually or progressively at first during a momentary, incipient, or partial coagulating reaction with modified liquid baths until the filaments acquire a sufficient initial tenacity to withstand or permit more abrupt or repeated intensities of stretching within a permissible range for the purpose of inducing under controlled tension a degree of micellar or building unit particle orientation in the cellulosic group that encourages the highest degree of tenacity in the finished yarn without sacrificing any necessary elongation, it being well-known that control of such stretching during the manufacture of natural and synthetic structures and protein-like structures effects the tenacity-elasticity relationship of the finished yarn. The elasticity of yarns can be improved if excessive stretching is avoided immediately at the spinneret face in coordination with controlled viscose ripeness and other spinning bath factors. Some of the complex factors affecting coagulation or the time of coagulation are; original concentration, degree of diffusion, the particle size, any solvated layer around the particles, and differences in chemical saturation.

Although more stretch as a rule can be given to lesser-ripened viscose, it is a fact that too unripe viscose causes a development of undesirable "milkiness," unless changes in coagulation and plasticization compensate for it. Tensions of more than 50% applied to normally ripened viscose as a rule usually require more than one coagulating treatment. In the instant invention, because of the separately traveling and changing coagulants and liquids moving with the gel threads over definite courses on the conveyor means they can be suitably extended or the intensity of treatment or stretch can be distributed over a much longer range during the coagulation cycle. The strength of carefully oriented threads is especially high.

"Gaps" or weak spots may be partially attributable to an unequal progressive hydrolysis (and a concurrent partial saponification) because of localized temperature differences during the ripening of viscose. Any of these "gaps" if they are due to unequal or non-uniform ripening or hydrolysis as a result of an unequal viscose ripening temperature developing in certain areas after leaving the viscose ripening room before it is extruded, can be rectified as herein specified.

Apparently the cellulosic chain length or building unit is also partly controlled by the type and proportions of reactants used and partly by the choice of operating and tensioning conditions—longer molecular chain lengths re-

sulting in tougher, stronger final products. Evaluation of optimum intensity, time and the point of stretching or mechanical stress of the viscose or other filaments through concomitant balancing of the proper degree of viscose ripeness and the temperature and concentration of the final hydrolysis, is determinable by experiment with the viscose or whatever other variables are involved—this obviously applies also to other later type filaments, that is, casein, the alginates, and paraffinic or carbohydrate protein like bodies. Under the instant invention all ranges or wide degrees of stretching during any concurrent liquid or gaseous treatments can be imposed on the threads while they are in constant forward travel—the speed of the conveyer means and all articulated parts being gaited or integrated according to the final characteristics desired, all of which when used in predetermined and coordinated combination, implement markedly any particular effects desired in the finished yarn.

Whether due to small pockets of over-ripe viscose in otherwise normally ripened viscose or whether due to excessive amounts of chemically produced degradation products, it is readily understood why the presence of an intermittent, perhaps very small, number of any such weaker spots in regenerated cellulose along a rayon thread greatly reduces the value of such a thread for more than a general small mean reduction in strength along the entire length of a thread or yarn. It is one of the purposes of this invention to reduce or substantially eliminate the causes or the number of such weaker spots that may be due to the already mentioned causes—the main purposes of the invention being to add new or improved methods and apparatus for the treatment and concurrent continuous production of filaments, threads and/or structures having improved qualities including also improved and apparatus for the production and delivery of improved quality viscose as they pertain and appear in the course and scope of the invention.

Any resultant higher viscosity (arising among other things from decreased or controlled alkali cellulose degradation) in the spinning solution, would, in order to insure smoother operating conditions, and perhaps through necessity require larger individual orifices in the spinnerets to reduce distortion because of the excessive pressures resulting and because of any increase in size of the impurity particles. However such larger spinneret orifices would be practical or usable only where the resultant considerably more voluminous individual viscose or gel filament bundles can thereafter be drawn out sufficiently without excessive rupturing, as under the invention, before hydrolysis or coagulation proceeds too far, for instance, to 25 feet, 50 or even 100 feet or more if desired, or for example from 500 denier down to 250 denier or even 100 denier depending upon the temperature, type or modifications of the baths used. Such more voluminous, more viscous filaments could hardly be drawn out enough or properly extended if they are rolled around or collected on a cylinder, cone, cake or helical container within one or two seconds after extrusion, as heretofore customary.

The invention contemplates that, subject to limiting factors set forth, this extra strength and toughness obtainable from the use of longer chain length or less degraded cellulose

particles will be incorporated with my coordinated tensioning methods to produce improved films and filaments. The regulation of the relative size, number and spacing of the spinneret orifices with relation to the increased viscosity of slightly or even non-degraded cellulose can be adjusted according to the viscosity and thus used to improve the softness and the covering power of finished products and spinneret distortion due to higher pressures from any higher viscosity can be reduced to satisfactory operating limits. Likewise more widely spaced orifices in a spinneret help to insure that any larger more slowly drawn out streams or viscose filaments initially issuing from the spinneret, remain separate and distinct—not liable to run together before coagulation starts—in the transition between purely viscous and partially hydrated state. Also the liquid movement or the current of the spinning bath at the spinneret face can be forced or directed upward in the trough or moved along in the same direction as the thread travel in order to overcome fluid resistance and buoy or carry initially heavier threads along and thereby assist in reducing one of the causes of filament rupture that sometimes occurs at the spinneret face or immediately thereafter, especially in high speed spinning.

It is therefore apparent, and the invention contemplates, that in lieu of continuous high speed stretching, that is, high linear draw off speeds directly at or from the spinneret face, that under the methods and apparatus of the instant invention a substantial reduction may be made in the said orifice linear or draw-off speed, namely, in the tension of the gel threads immediately at the spinneret face in the hot spinning bath which in turn, other things being kept normal or proportional, momentarily and abnormally increases the size or volume of the individual viscose stream or filament bundle then issuing into the usual salt-acid (or a modified or any other type) spinning bath, this thread group being at this moment only slightly stretched or drawn (with reference to the rate of viscose extrusion) which co-incidentally results in a decrease in the number of thread or filament ruptures at this point, and then directly after this, during further coagulation or a partially suspended coagulation, strongly stretched to any degree short of rupture. The time factor is of great importance in the migration or orientation of particles undergoing stress or energy changes, the orientation not being immediately but usually requiring an element of time—this interesting phenomenon indicating that better orientation results if the particle migration or rearrangement proceeds by degrees or stepwise—this being especially true of protein bodies.

Any stoppage due to undue orifice clogging or through any avoidable thread rupture is necessarily wasteful in any spinning operation but it is extremely more costly where continuous thread manufacturing processes are involved and still more expensive where in any such continuous process each thread is taken or handled singly through a train or series of successive operations on single thread containing conical rolls, helical reels, etc., for each processing step, because of the laborious and expensive details of starting up or hand re-threading a single thread through the entire chain or train of individual processing, treating or the drying operations.

Under the present invention this is eliminated. Any one of the approximately 100 or more closely adjacent threads in constant or normal operation may have any new starting threads or loose ended filament bundles easily attached or temporarily fastened to one (or more) of the adjacent normally operating thread positions which thereby takes the new thread with it through all the joint or unitary processing operations and is thereafter removed, detached or separated at or before the point of twisting operations and then attached to or started on its proper or individual twisting spindle. Necessity for overall stoppage of extrusion apparatus or machines is now reduced very considerably. Optical methods can be used to detect when specific spinning positions should be changed, thus eliminating the necessity of wholesale changing of all spinnerets as formerly a regular procedure.

The maintenance of fairly high viscosity values at the spinneret face and the space immediately thereafter reduces the tendency of gel thread rupture or breakage at the orifice because of the resultant greater inner cohesiveness due to the maintenance of such higher viscosity and under this invention such higher or better viscosities need not be destroyed or detrimentally reduced because of high temperatures adjacent to the spinneret face but are maintained by spinning or extruding the filaments as already explained into a container or trough having two or more baths side by side which are kept substantially separate by baffles or diaphragms which have small openings therein but large enough to permit the threads passing therethrough from one bath to another while always immersed or submerged. Then by maintaining the bath right at the point of extrusion at a relatively lower or low enough temperature and if desired also low concentration, the viscosity of the issuing gel threads may be kept within limits so that any gel thread breakage that may be due to sudden lowered viscosity is reduced—the thread being drawn or conveyed thereafter through the next or ensuing normal or if desired hotter spinning baths or any other treatment and it is characteristic of the process that the gel threads may then be given an abnormally high stretch during any such extended spinning operations, care being taken with spinning bath and immediately following treatment to prevent a too rapid coagulation or formation of the surface film of the filament.

The combined effect of higher viscosity, larger sized initial or gel filaments (giving an increased relative initial strength) and of the momentarily slower draw off speeds at the spinneret face may be used for reducing the possibility of the thread rupture that, as has been found in practice, arises more often (due to the greater shrinkage and dehydration and other less understood effects) when higher than normal, (that is, approximately one per cent) concentrations of zinc sulfate were used in the viscose process spinning bath. These restricted upper limits of zinc sulphate, if exceeded, produce, as is well known, faulty yarns unless any detrimental effect due to high zinc sulfate content can be overcome or compensated for. Any higher concentrations of zinc sulfate however, where, by suitable viscose manipulation, it becomes possible to use higher concentrations, do produce, in addition to other things, finished yarns with increased tenacity and toughness.

As slower initial draw off or spinning in combination with considerably larger filaments

which are more strongly stretched after a slight interval of time, has not been possible under present methods or conditions of the prior art where the threads are collected at once, that is, within the usual two or three second interval previously mentioned, on bobbins or cakes or where they are passed around one or more godets or conical cylinders within one or three seconds after extrusion, the use of higher zinc sulfate concentrations where the spinneret under such conditions of spinning and collecting has presented difficulties well known to the art. Under the present invention with the metering pumps geared, for example at 80 meters per minute normal operation (based upon the capacity or speed of the final or twisting operations in the unit) the initial or draw off linear speed could be reduced momentarily for instance to 40 or under certain conditions even to 20 meters per minute more or less, such initial lower speed would thus reduce the tension on the larger than normal streams of viscose then issuing and later after the threads have been or as they are being transferred to or while being conveyed on the articulated conveyer system or means, the continuous and likewise articulated stretching means such as aprons or rolls over or through which the threads pass, can be speeded up or extended to the maximum desired in one or in repeated amounts during the early stages of coagulation to obtain the desired effect while the threads are being concurrently treated on the conveyer means with types of baths that suspend or slow up hydrolysis or that remove or reduce any detrimental or excessive shrinkage and dehydration effects caused by any higher zinc sulfate concentrations. As hereinbefore stated, under the present invention the zinc sulphate in the spinning bath at the spinneret face may be kept to a relatively low percentage, while in a subsequent bath or baths a higher zinc sulphate percentage may be presented. In a word, any kind or number of separate liquid, gaseous or vapor baths can be applied anywhere to the continuously travelling band of individual threads or thread bundles. As already noted, under certain conditions continuously sustained tension sometimes interferes with orientation taking place in the interface because of surface tension effects, while tensioning by degrees or stepwise permits a better orientation. Such graded, controlled stretching is provided for under the instant invention.

Referring more particularly to the exemplary apparatus of the drawings, the entire multiplicity of threads T coming from the spinning bath or trough **15** may be passed about a roll **21**, Fig. 2, and up around a godet or roll **22**, the latter seen also in Figs. 3 and 4. Thence the multiplicity or band of threads may be directively narrowed by passing between the dents of one or more reeds or comb-like narrowing guides **23, 24, 25**, the latter adjacent the travelling conveyer means. Said guides may be adjustable to guide the threads with the preferred degree of narrowing of their path as a whole.

It will be understood from the previous description that the conveyer means as a whole, and in any desired courses, stages, or zones thereof, may be the same as fully disclosed in my copending application, Serial No. 187,488, now Patent Nc. 2,251,931, and that any and all features of the apparatus of said application may be embodied here.

Accordingly the conveyer of Figs. 3 and 4 hereof, several individual courses of which are indi-

cated by the numerals 30, 31, 32, while represented diagrammatically, may be assumed as the fluid-supporting and moving-bath structure substantially as in said copending case, Ser. No. 187,488, now Patent No. 2,251,931, particular reference being made for example to the description therein as at page 4, column 2, lines 2 to 11.

In association with the bath segment or conveyer course segment 30, Figs. 3 and 4 illustrate an overlying free or driven roll 40, adapted to lift and uniformly simultaneously tension the entire band of filaments, in the manner explained. At another position, herein in association with another course 31, there is shown in Figs. 3 and 4 one form of variable and automatically or otherwise movable or oscillatory mechanism for the described controlled tension-modifying treatment of the whole multiplicity of threads. Said mechanism, as represented, comprises a movable (up and down, fore and aft or otherwise) roll 41 herein on a pivoted arm or frame 42 supported coaxially with a further roll 43. This frame is adapted to be swung to and between the positions such as indicated by the dot-line showing (merely as typical), automatically, as by cam or pattern means or otherwise. The numerous tension effects as described will result.

Paired with the roll 41, removable, so that it may be dispensed with when desired, is a roll 41*a*, adapted to be driven or free, with or without weighting, as desired. In Fig. 3 this over-roll 41*a* is assumed to have been demounted. In Figs. 4*a* and 4*b* are represented typical surface-changing devices in the form of rolls, for producing the effects elsewhere herein described. These comprise in Fig. 4*a* a pair of multi-pointed, spined, like-surfaced cooperating rolls 44, 45 and in Fig. 4*b* a pair of corrugated, fluted or like rolls 46, 47, the surface ridges or other formations of which may be of any desired height or fineness, generally rather small. These roll pairs it will be understood may be substituted for those at any desired conveyer course or location, herein for example, in the position of the roll pair 41, 41*a* of Fig. 4.

At the following or other course 32 the conveyer passes the strand or band of threads, uniformly, through ducts or immersion or bath chamber 50, where any desired liquid, gaseous or other treatment of the moving threads may be given. It will be understood that the fluid level in the duct or chamber 50 while indicated in Fig. 4 as appreciably above the moving threads, for diagrammatic clearness, may be but sufficient to cover them, so having a depth in some instances of but a fraction of an inch. Also it will be understood from the foregoing and by reference to said copending application Ser. No. 187,488, now Patent No. 2,251,931, that fluid retaining means is provided in connection with each of the articulated conveyer courses up to the drying treatment, that is, through course 32 as herein schematically shown in Figs. 3 and 4, such means as to any of said bath courses of the conveyer being either of the duct, immersion or bath chamber type as herein diagrammed at 50 in connection with course 32 or of the sealing belt type as fully disclosed and claimed in said copending application and patent identified.

In Figs. 5 and 6, which may be regarded as continuations of Figs. 3 and 4 respectively, I have represented the further series of conveyer courses 33, 34, 35 and a final course 36. These are shown in association with the uniform drying treatment, herein typified as carried out in a more or less extended drying chamber 55, closed or otherwise. And in conjunction with the drying, which may be controlled as desired, I have represented the controlled tension applying or tension modifying means such as the more or less elevated adjustable driven or free rolls 56 and 57, as well as a weighting or directive roll 58 in conjunction with slower traveling courses.

Beyond the conveyor course 36 wherever the multiplicity of threads emerges from the drier 55 they may be and desirably are spread, to any desired extent, through combs, reeds or guides 59, 60, 61, Figs. 5 and 6, and passed over a roll 62. Each thread of the uniformly treated group then individually passes to its twister and packaging or collecting means as represented at 65. At and along the various treatment courses an air removal duct, for conveying off any fumes and the like, may be provided. As previously indicated the conveyer means as a whole and in its various courses is correlated and timed to subject the continuously travelling threads to any desired increased or decreased linear speeds of travel, as for example from spinning face speeds of from 20 to 50 metres per minute up to speeds of 100 metres or more per minute in one or in several repeated stages and in any desired order of increase or decrease at the respective stage or zone, depending in part on the particular concurrent treatment at the given locality.

The same methods and apparatus can also be used for the continuous production of numerous novelty type yarns, if desired; for example, yarns with varying high and low denier in the same thread, through pivoting the draw off device or the front of the conveyer means (see Figs. 3 and 4) so that it can be moved up or down or back and forth while in operation. This deliberately causes unequal or thick and thin sections in the continuously produced individual threads early in the coagulation cycle.

Continuous filament yarns or structures having a slightly raised, roughened or a somewhat fibrous appearing surface without having any broken ends or any cut filaments can also be produced under the present invention by passing the continuously produced threads or thread structures over one or more aprons, rolls or cylinders or devices which have numerous very minute sharp or needle-like points on their surfaces (see Fig. 4*b*) and which are moving in the same direction and at the same linear speed as the threads in order to produce or impress a changed appearance and a dulling effect in the filament surface without the former severing, tearing, abrading, cutting, or rupturing the filaments as present in the hairy type yarns made by definitely severing or tearing some of the filaments at irregular intervals. Under the present invention, the sharply pointed surface (aprons, rolls, etc.) moves or travels concurrently with the endless band of freshly produced threads without cutting or tearing and by properly adjusting the degree of pressure as well as the number or the time of runs over a very fine pointed or needle-like surface a partial penetration or change of the filament surface may be impressed or effected and according to the softness or dullness desired but without tearing, cutting or severing filaments. When the threads are wet there is, within certain limits, less of a tendency to tearing or rupturing but a considerable increase in the degree of plasticity or penetration and when the threads are in the untwisted state they

provide a more flattened surface for the pricking or marking of the filament surface. Any surface modifying changes obviously may best be applied on heavy or coarse denier structures. With extremely heavy denier filaments, that is, 20 or 30 denier or more each, it becomes possible to penetrate entirely through such filaments without causing severance or rupture—the effective dimensions of any penetrating means in this case would approximate roughly 20 or 30 microns.

Any such surface modification or change which gives an effect or appearance of loft or a raised appearing surface (compared with unpenetrated filaments) is of course not really raised in the sense as when part of the filaments of a thread bundle are definitely cut, abraded or severed, and because these surface modified yarns are not cut in any way a naturally greater strength is retained over the abraded or cut filament yarns or staple fiber structures.

The terms yarn or filamentary structures as used herein include coarse or fine multifilament threads, or single bands, or horsehair and the terms are used in an interchangeable sense and include any fiber or structure that can be employed in or produced by the weaving or knitting industries although they are not limited solely to the textile industry. It is obvious that such above described changes or surface modifications are permanent in nature and not like the crimp or wave in certain staple fibers which sometimes almost entirely disappear through subsequent handling or through washing, and otherwise.

Crimp, wave, or any undulated effects (either alone or in combination with surface modifications) may be applied under the continuous process principles of the present invention by passing the continuously conveyed moving band or layer of threads during the process of manufacture over fluted, crenulated or similar rolls, aprons or devices (see Fig. 4a) operated in timed relation with the conveyer means and adapted to impart a crimp or a flat wave-like effect or undulation in the continuous filament structure. This crimp can be imparted along the longitudinal axis while the threads are still in the plastic state and while the number or ratio of xanthate groups is still high, as before coagulation or regeneration is complete and preferably without zinc in the spinning bath. If the threads, with the crimp or wave therein, are allowed to set substantially without tension while they are being conveyed on the conveyer means, such crimp effect is more permanently incorporated. The type, curve or amplitude as well as the number of waves per inch that can be imparted may be calculated according to the ultimate use for such finished structure, the herein disclosed control of such crimp effect resulting in extremely greater uniformity than when fibres, cut in short length, are floated, paddled or washed along in loose or random manner in liquid baths, resulting in an infinite variety and size of crimp effects.

Any permanent set, as herein described, of such undulations or crimp reduces the tendency for it to cork screw or come out during handling or washing. Such crimp effect or undulations may herein be still more firmly fixed or set by further treatment under the continuous process, with resins or similar bodies adapted to improve the rigidity and crush resistance as well as increase the resiliency of the continuous filament which is desirable for auto upholstery fiber and similar hard usage. Any such continuous filaments may be later cut into fiber lengths—one of the purposes of the invention being the production of such improved special fibers at lower cost because of the continuous process principle of the instant invention.

In the continuous production system herein outlined the various improvements derive mainly from the innovations whereby a unified or better control of certain variables hitherto not controlled, under existing or prior art methods and apparatus, it has not been possible beneficially to utilize such innovations in a continuous organized unit for producing finished products or structures by a continuous process and also maintain a substantially unvarying uniformity in the same, as accomplished by the present invention as herein disclosed.

While the invention has been described with particular reference to the manufacture of regenerated cellulose threads, bands, tubes or structures of all kinds or rayon from cupro-ammonium or viscose type solutions, the principle is equally applicable to the production of all kinds of continuous filament artificial silk, rayon or other threads or of any naturally occurring organic or synthetic materials including also the alginates, casein, soya bean, or other protein-like or carbohydrate bodies that may be extruded from orifices in any conventional dry or wet spinning procedure and which are subjected to controlled tension or non-tension during the spinning thereof or thereafter using either liquid, gaseous or vapor baths or spinning mediums with either a plasticizing or a non-plasticizing action and there is no limitation to any one process to be implied because the descriptive illustrations pertain principally to the viscose or cupro-ammonium processes.

Under the instant invention the threads or structures may be spun or continuously produced in any customary or present manner and then without interruption, conveyed, while solidly supported on an articulated conveyer system or means, subject to or with any necessitous or subsequent treatments or zones of treatment which develop, improve or complete with an unvarying uniformity the desired characteristics in the threads or structures in one uninterrupted continuous process. Included within the scope of this invention are the yarns or threads showing a changed, modified or fibrous-like appearing surface as well as fabrics or articles made from, formed, knitted or woven of or containing any such surface modified filaments.

The objects herein mentioned and the improved methods and means to accomplish the same being set forth as described, the drawings show elevation and plan of suitable apparatus for carrying out the invention but I do not limit myself to said drawings or schematic descriptions.

It is understood by those skilled in the art that any bath treatment or other necessitous manipulation as now or heretofore carried out can be carried out in improved form under the instant invention as well as in the same or any improved order of operations. Driving mechanisms are omitted in the drawings because many such mechanisms are available and easily applied to the present invention. Many further changes and construction details are possible, which may be varied through wide limits without departing from the principles of this invention.

By way of summary of the inventive subject matter, including various of the features thereof which are related or common to that of my copending identified application, the process com-

prises, and the apparatus provides for, the production, handling and processing of a large multiplicity (as 100 or even 200) of separate distinct threads, (uni- or multifilament) all in common and as one manufacturing and processing unit, although the threads during manufacture may always be substantially separate. They are formed by the metered extrusion of any suitable mass into a common bath or trough. Each separately formed thread after being drawn off simultaneously with the rest of the group then being extruded, is unitarily passed or transferred with the thread group up, over or down either directly or by means of suitable godets or aprons to the thread receiving end of a generally longitudinally conjugated multisegmented conveyer means travelling and conveying the threads in a mainly horizontal and in a usually but not necessarily rectilinear path or in courses. While being conveyed or advanced through a chain or sequence of processing, any number, type or zones of liquid or gaseous treatment or any other manipulative steps can be performed on all the threads or the like in the group in a simultaneous uniform manner while they are generally side by side and in continuous motion or forward travel and undergoing concurrently and unitarily any sequence of liquid or gaseous treatment or while all are being dried together under the same uniform and controlled tension. Such common or unitary treatment and handling in combination with a more uniformly ripened viscose as described, results in substantially identical finished products with more uniform characteristics in any products so produced.

While some methods have heretofore been suggested by others to improve the ripening index of viscose—as by the saving of or the mixing in of what are termed viscose "heels" with other viscose, no method or apparatus that obviates or eliminates the formation of local overripening or unequal ripening of the viscose after it leaves the line tank in the viscose ripening room has been heretofore proposed so far as I am aware except as disclosed and claimed by me herein or in related applications.

Spinning and processing tension in the freshly produced threads to enhance the tenacity or the elasticity uniformity can be imposed or controlled unitarily as disclosed in detail herein. While the vehicle adapted for a conveyer means to accomplish the desired uniformity and at economical or lower production costs, may be widely modified without departing from the principles of the invention, a convenient vehicle may be a conjugated conveyer means, generally waist high from a working floor level and having a width within arms length so that all parts are in view and easily accessible from either side, which permits complete freedom of movement of any manipulative steps, handling or inspection of the travelling threads as the operator always working from the floor level may walk either along or between each course of conveyer travel or conveniently visually observe across a row of such conveyer means during each or any step of the processing or the finishing operations and in this way have under the same convenient visual control perhaps several hundred individual threads, all in constant forward movement together, with or in the same baths or treatment steps or under the same tensioning steps instead of having to follow or inspect any single thread travelling alone through the same or a similar sequence of treatment steps as is now the usual or normal

practice. The invention is not limited to the continuous manufacture of viscose artificial silk thread. Any of the foregoing descriptive matter, explanatory or technical expressions which relate to apparatus and to methods of the production, liquid processing or any other manipulative steps leading to the production of substantially identical finished threads, yarns, rayon threads or other artificial structures in a continuous uninterrupted process shall be construed as in furtherance and not in limitation of the outlined scope or general purposes and principles of the invention as set forth in my following claims.

I claim:

1. A method of continuously producing a multiplicity of continuous individual artificial cellulose threads, comprising the steps of collecting and supportedly conveying such multiplicity of freshly extruded gel threads as a common treatment group along a path of advance presenting a plurality of successive traveling liquid bath immersion stages each subject to independent control as to bath content and linear speed of advance, predeterminedly and controllably stretching the thread group unitarily prior to complete regeneration by imparting thereto at least at one traveling-bath immersion stage an increased linear speed of advance, further immersively and supportedly advancing the thread group through a following independently controllable traveling-bath conveying stage, drying the thread group uniformly by continuously forwarding it along an independently controllable supported conveying stage and reducing the linear speed of travel for the group thereby to subject it to reduced but definitely controlled tension, and thereafter twisting each individual thread and collecting it into individual package form.

2. A method of continuously producing a multiplicity of continuous multifilament artificial threads and structures which comprises the following steps: extruding and initially coagulating a multiplicity of gel threads in a first spinning medium, imposing concurrently on the multiplicity of threads a uniform tension, collecting the threads into a flat band-like group of individually separate threads, supportedly advancing such thread group along a plurality of successive traveling liquid immersion treating stages each subject to independent control and concurrently at any of such stages and before regeneration is complete applying a non-rupturing stretching tension similarly to all the traveling threads during their treatment at the selected stage or stages and while continuing the general direction of thread advance, thereafter processing, treating and drying the entire thread group as a work unit while in continuous advancing movement, and then twisting and packaging each thread individually.

3. An improved method of manufacturing continuous filament viscose threads comprising extruding a multiplicity of individual gel threads from individual thread-forming extrusion points into a spinning bath, gradually coagulating and passing the threads from their extrusion points at a linear velocity greater than that of their extrusion while uninterruptedly introducing them as a group to a first traveling fluid bath immersive treatment, continuing to advance the thread group through further sequential traveling fluid bath treatments and in the course of at least one such treatment tensioning and stretching all the threads alike substantially up to the point of rupture, further liquid-treating and supportedly con-

veying all the threads as a unit along a continuing path of advance, drying the threads under reducing tension during further continued supported conveyance, and separately twisting and winding each thread of the group to provide finished thread packages, all in one continuous operative process.

4. In the production of filaments or threads in a continuous process, the steps which comprise: extruding a multiplicity of threads into a spinning bath each at the same rate of linear advance; causing travel of a liquid bath and supportedly conveying the threads therein; then increasing the linear velocity of the threads and thereby proportionately tensioning them all uniformly to an extent short of thread rupture; thereafter continuing the supported conveyance of the threads and subjecting them to further treatment including bleaching and washing; further supportedly conveying the threads and drying them under reduced tension; and thereafter individually twisting the threads and collecting them into separate package form, all in a continuous organized process.

5. In the production of filaments or threads in a continuous process, the steps which comprise: extruding a multiplicity of threads into a spinning bath each at the same rate of linear advance; supportedly conveying the threads in a liquid bath uniformly as a group; then reducing the linear velocity of the thread group while continuing its travel and thereby reducing the tension on the traveling threads, similarly as to each; thereafter further supportedly conveying the threads and subjecting them to treatment including washing and bleaching, similarly as to each thread; and thereafter individually twisting each thread and collecting it into package form, all in a continuous organized process.

6. In the production of filaments or threads in a continuous process, the steps which comprise: extruding a multiplicity of the threads similarly and as an operational group into a spinning bath; effecting travel of a coagulating and regenerating liquid bath and supportedly conveying the threads initially into, along with and finally out from such traveling bath; tensioning the threads uniformly

as to the entire group to an extent short of rupture and between their initial entrance into and final emergence from such traveling bath thereby correspondingly to stretch them uniformly as to each; thereafter continuing the supported conveyance of the threads and subjecting them to further treatment including bleaching and washing; then drying the threads under reduced tension while further supportedly conveying them; and thereafter twisting and packaging each thread individually, all in a continuous operational procedure.

7. Apparatus for the continuous production of a multiplicity of individually extruded threads, comprising, in combination: a rotary draw-off device of adequate axial extent to receive in side-by-side relation the multiplicity of freshly extruded threads; traveling liquid bath conveyor means serially disposed substantially horizontally in separately controllable zones each adapted to receive the thread multiplicity and to subject the same each uniformly to immersive liquid treatment as selected for the given zone; means associated with said traveling liquid bath conveyor means for tensioning and stretching the threads during their travel within at least one of said zones, each thread to the same extent throughout the entire multiplicity thereof; means for uniformly drying the thread multiplicity while continuing their forward travel; and means thereafter individually to twist and collect each thread into separate package form.

8. Apparatus according to claim 7, wherein the thread tensioning and stretching means comprises a bodily movable guide element commonly engageable with the thread multiplicity for imparting a controlled tension-modification uniformly as to all the threads.

9. Apparatus according to claim 7, including means whereby the several zones of the conveyor means are correlated and timed to subject the continuously traveling threads to linear speeds which are the same for all threads at any given zone but are controllably variable as to different zones.

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