

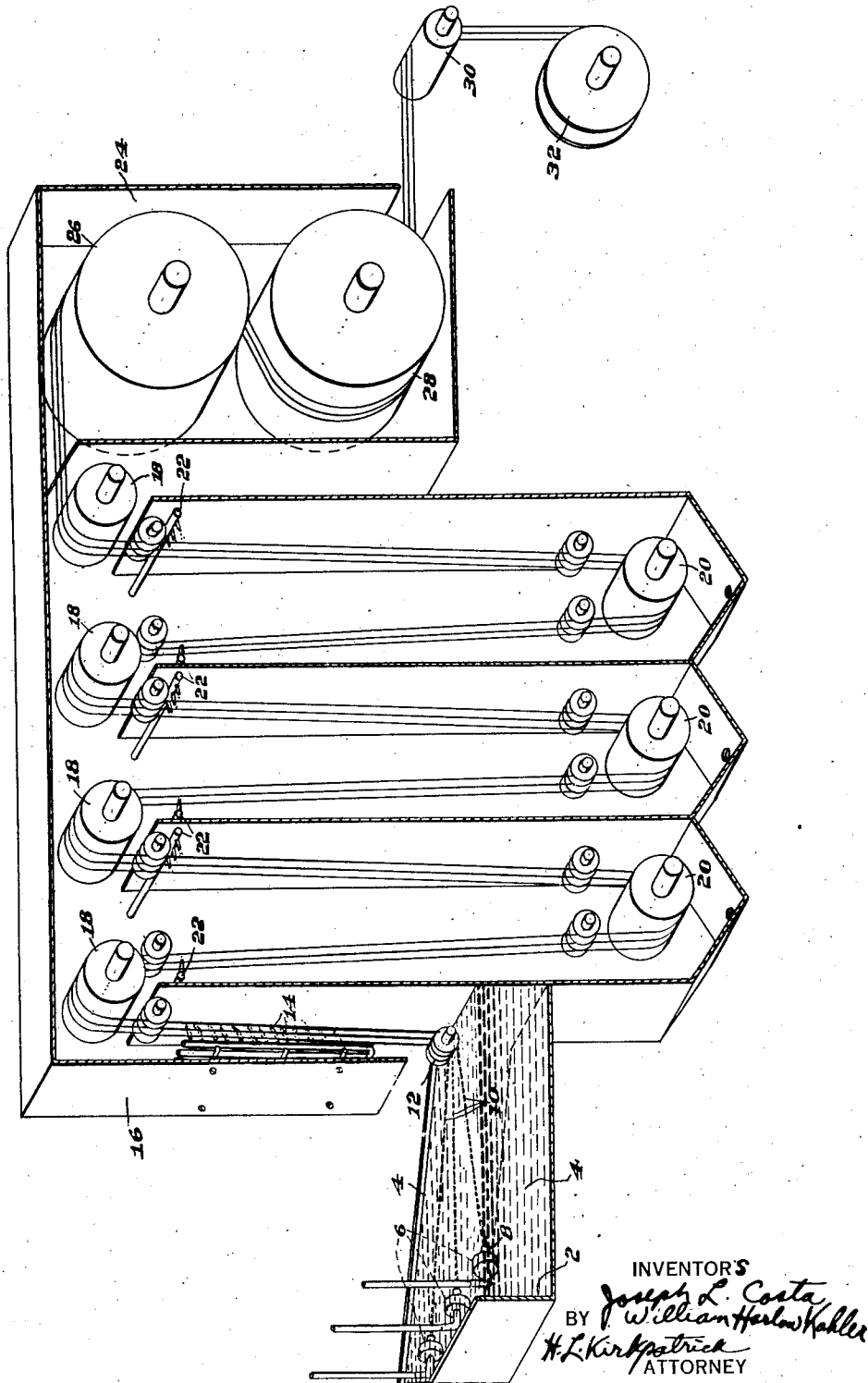
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APPARATUS AND METHOD FOR THE MANUFACTURE OF ARTIFICIAL FIBERS

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APPARATUS AND METHOD FOR THE MANUFACTURE OF ARTIFICIAL FIBERS

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This invention relates to the manufacture of artificial fibers from viscose or other cellulose derivatives as a continuous process, and has for its objects to provide improvements in method and apparatus whereby rayon fibers may be produced rapidly, cheaply, simply and with complete uniformity and excellence of product.

Up to and including the present time, commercial production of rayon yarn by the viscose process includes the conversion of cellulose (usually in the form of wood pulp or cotton waste or linters) into alkaline viscose solution; the extrusion of the solution as filaments into an acid bath appropriate for decomposition of the viscose to yield cellulose filaments; and the penetration of the acid bath solution throughout each filament so that the regeneration of any incompletely converted content of the filament becomes more or less complete. Following these steps having to do with the formation of the filament, it is necessary to wash, desulphurize, bleach and otherwise finish the completely regenerated filament which is followed by drying, twisting, and sometimes the cutting of the filaments thus twisted into staple fiber. In accordance with current general practice, the penetration of the acid bath solution requires a very substantial amount of time, in some cases even hours, since the acid solution only slowly penetrates by osmosis, diffusion, or otherwise through the skin of cellulose first formed on the surface of the filaments immediately on extrusion of the viscose solution into the acid bath. Ordinarily the partly regenerated filament is led from the bath a fraction of a second after extrusion and complete regeneration is effected by the adhering acid solution from the bath, the strength of the filament increasing with the degree of regeneration and, in proportion to the penetration of the acid into the filament. Washing and finishing cannot be conducted until regeneration is substantially complete or a weak and ill formed yarn will result. At the present time, practically all rayon manufacture involves the spinning of the freshly formed but incompletely regenerated fiber onto bobbins or into pots as the fiber emerges from the precipitating bath and the operation of doffing the yarn as collected in pots or on bobbins, the interruption of the spinning and subsequent handling of the partly regenerated thread, necessitated by the batch method to the point of complete regeneration have been and are expensive and time-consuming operations. As a result, processes have been suggested for continuously handling the extruded thread in this

form and treating it individually through the penetrating and subsequent steps, for example as described and shown in U. S. Patent No. 2,134,160 of October 25, 1938, to O. F. Von Kohorn Zu Kornegg, but the equipment requirements have been complex and expensive because of the time consumed in the penetration of the acid bath and the subsequent washing, desulphurizing, bleaching, etc., and the necessity of handling long lengths of thread in continuous mechanism. Also, the rate of spinning and handling of the freshly spun filaments by such mechanisms has been relatively slow because of above mentioned limitations, for example, at the rate of 60 yards per minute, or thereabouts. One such application of continuous spinning that has been practiced to some extent involves an apparatus wherein the thread is conducted in spiral form over a series of several cylinders for the viscose treatments, the first treatment for which a definite part of the equipment is arranged, consists of completing the regeneration of the thread on the rotating cylinders, followed by several other treatments, also conducted while the filaments are carried by slowly rotating cylinders. It is not practical and desirable to conduct the thread through too long immersion of spinning bath for various reasons, including the strain on the individual filaments necessary to drag them through long paths in the setting bath, which has not been found conducive to the best strength and other properties of the yarn. Generally, it is found desirable, as is evidenced by general practice, to cause the thread to leave the bath as soon as it is adequately regenerated, the reaction being slowly completed later by the adhering acid, but the problem of yarn structure and regeneration become increasingly acute if higher spinning speeds are attempted in a continuous process, though speeds of 100 yards a minute, or more, are easily attainable in a batch process.

The present invention involves a radical change in the manufacture of artificial fibers whereby a superior and uniform product is produced continuously, very rapidly, both spun and finished, in a relatively short period of time, of the order of seconds, and in relatively cheap and simple apparatus. Moreover, the method and apparatus has proved in actual practice to represent a very substantial advance in all these respects. In accordance with the present invention, regeneration is completed within a few seconds after the filament has been led from the conventional acid coagulating and regenerating

bath and while it is being so led, thereby reducing the danger of injury to and the expense of handling the filament while in its incomplete regenerated state, the further chemical treatment then follows as a continuous process, rapidly performed in simple apparatus instead of requiring the interposition of a hand operation or the use of delicate complicated and expensive machinery. The present process is characterized by the application of a radical degree of heat, as compared with prior processes, and preferably the direct application of flame to the fibers as they emerge from the bath whereby regeneration is completed in a matter of a second or two as the filaments are led from the bath at the rate of 75 to 100 yards or more a minute, which may be and preferably is followed by rapid treatment of the continuously moving fibers, including a desulfidizing bath of radical concentration and temperature, for example, a twenty percent solution of sodium sulphide at boiling temperature, as compared with conventional practice involving the use of solutions not to exceed one or two percent concentration at 50 or 60° C. Though it might be supposed that such violent treatment would ruin the structure of the filament, it is found that by careful control and sufficiently rapidly moving of the filaments, the violence of the treatment may be carried far beyond the bounds of present day rayon manufacture. The ability to operate differently in this single process results initially from laying out the thread for treatment as a single thread, all threads being treated alike as compared with the bobbin and pot spinning process, wherein a package of one form or another is involved. However, if a cake, bobbin skein or such package were treated as violently as in the present process, some of the yarn would be irreparably ruined before other portions of the yarn were adequately treated, and moreover, the thread, due to differences in time and exposure, would vary in structure a great deal. Such batch methods, though the spinning speeds are fairly high, inevitably involved characteristic non-uniformity in the subsequent treatment of the yarn. Whereas, the prior continuous treatments, though achieving fairly good uniformity of treatment, have done so at the expense of speed, the spinning rate being about one half of that of current pot or bobbin spinning practice. Moreover, the continuous processes heretofore used have involved very expensive and cumbersome machinery. The present invention, on the other hand, achieves both uniformity and speed in a very simple, inexpensive and easily practiced process.

For a more detailed description of the invention, reference is made to the drawing in which the figure represents, more or less diagrammatically, a side view in isometric projection with the near side wall removed, illustrating the steps in the process and the apparatus that may be employed in the practice of the invention.

Referring to the drawing, which illustrates the preferred process and apparatus, the conventional spinning bath container 2, bath 4, and spinnerets 6 are shown with the filaments 8 leading therefrom, which are gathered to form the yarn 10 at the roller 12, following which the yarn is immediately regenerated by passage through a series of flames 14 as from a series of gas jets, though other suitable flame, radiant, or heat-producing means may be employed provided that the temperature thereof be sufficiently high: the best results require a temperature of

at least 500° C. and preferably the temperatures are of the order of those provided by free flames as from ordinary gas jets which have been found a convenient and effective means for rapidly regenerating the fibers at spinning speeds somewhat in excess of 100 yards per minute. In any event, the temperature must be in excess of the boiling point of the treating bath and preferably twice that temperature. In this case, the time interval during which the yarn is in contact with the flame is of the order of $\frac{1}{4}$ to $\frac{1}{2}$ a second. As the yarn 10 continues past the jets 14 it enters an enclosure, preferably a glass box 16, and thence over and under a series of upper driven rollers 18 and lower driven rollers 20 (the rollers 18 and 20 being driven in unison by means not shown), the flights of thread thereover being separated by a series of partitions to divide the enclosure into separate compartments of which there may be as many as six or eight, or even more, but three being shown for convenience, though in practice somewhat more are usually employed, depending on the number of treatments required for the exact characteristics it is desired to impart to the yarn. At each side of the partitions near the top thereof is provided a jet or shower head 22 through which the appropriate solutions are discharged and circulated, the solutions being collected at the bottom by means not shown, and returned to the respective shower heads 22 to provide separate continuous fluid systems. A feature of the process as previously mentioned, consists of the violence and high temperatures of these treatments by which it is found that the treatments may be sufficiently expedited so that the spinning may be conducted at a rate as high as 100 yards a minute, or even substantially more.

In the manufacture of standard rayon filament yarn, for example, following the accelerated regeneration, the washing is conducted with boiling water followed by desulphidizing with a solution of a concentration of 15-20%, in any event more than 10%, sodium sulphide at boiling temperature; then another washing with boiling water; a treatment with a sour bath consisting of a hot sulphuric acid solution; a final boiling water wash, and a soaping with a hot aqueous soap solution. Following the successive treatments with these various solutions, the yarn is passed into a further compartment 24 over driven rollers 26 and 28 for the purpose of drying the yarn, the compartment 24 being heated (by means not shown) to a temperature of say 80° C. The yarn, thus dried, is passed over a roller 30 and out of the drier and is collected upon a suitable driven roller 32, as is well known in the art, following which the yarn is ready for use with or without softening treatments, as may be desired. The total treatment of what may be termed a standard rayon filament yarn thus occupies but about 30 seconds, and, if it is desired to produce a yarn for cut staple which need not have so much tensile strength, the treatment as above described can be materially shortened and simplified. It is found, for instance, that thread satisfactory to be cut into staple wet but requiring no further washing or chemical treatment, may be completed in as little as 20 seconds, and, if rayon filament yarn for tire fabric, the treatment may include even more complete desulphidizing of the thread and still produce a neutral satisfactory thread in about 15 seconds.

The regeneration of the thread or yarn may be regarded as having two phases, skin-forming

and regeneration, which determine the properties of the yarn, depending, first, on the actual rapidity with which the initial skin is formed upon extrusion into the bath, and second, the speed and manner of continuing the regeneration after the thread leaves the bath. The second phase, comprising the characteristic feature of this invention, is the much more important of the two as regards strength, uniformity, and appearance of the yarn, the appearance having to do primarily with "miliness" in which the threads, instead of having a transparent appearance are more translucent or opaque and resemble, so-to-speak, the lustre of an opal rather than that of a diamond. This tendency to miliness is an optical property and differs greatly with the process employed, and is different, for example, in the pot-spun yarn than in the bobbin-spun yarn. Miliness is not only considered an undesirable property of rayon but has been regarded usually as a necessary evil, probably resulting from the non-homogeneity of the interior structure of the yarn.

In the present process a very satisfactory structure and appearance are provided due primarily, it is believed, to the rapidity of the regeneration flight of the yarn which may be reduced to a matter of a second or so at the most for the average size thread, such as 150 denier, 40 filament, by the impinging thereon of direct flame from the gas burners (as is preferred) as heretofore described, depending somewhat on how hot or intense a flame is used. It is found in practice that the regeneration which takes place is complete within a matter of a fraction of a second with the direct application of flame, as thus described, and further, that the yarn as so handled is as completely or more completely regenerated than are normal pot or bobbin-spinning process yarns when subjected to finishing treatments.

Apparently the very high temperature, quite contrary to what might be expected, has the effect of continuing the regeneration consistently with the formation of the skin already started in the spinning bath, though giving a pronounced "skin effect," thereby reducing the tendency of the yarn towards miliness or other undesirable phenomena. The exact chemical and/or physical mechanism of what occurs is not fully understood and it has not been found possible to study the exact reactions that take place when the filament, surrounded with spinning bath adhering to it, is subject to such temperatures, as by the direct flame impinging on it, but it is undoubtedly a complex phenomenon, as not only heating is taking place but also evaporation, tending to concentrate the bath thereon and accelerate the evolution of gas from the filament. It is believed that the action, for instance, of a flame on the filament or unusually high temperature on the thread is not susceptible to simple analysis in the light of present knowledge, but that it does effect an immediate regeneration compared to current practice, and that this is accompanied by a structural improvement of the yarn.

Regarding the matter from the standpoint of structure, it may be considered for instance that the cellulose on the surface or skin has been sufficiently set so that the subsequent stretching results in a definite orientation of the cellulose while the internal portion is plastic and forming a more heterogeneous structure. The border line between the two is often the state of unusual structures such as colloidal sulphur in local spots,

or cellulose having characteristics different than either the outside or inside, as is evidenced by a varying index of refraction when seen under the microscope. Under the influence of intense regenerative treatment, an improved yarn results because the rapid setting admits of a greater part of the whole structure being orientated during the stretching of the filament that inevitably takes place to some extent at this stage of manufacture.

From the above, it will be apparent that striking economies may be effected both in method and apparatus and with absolute uniformity in product as well as excellence of the yarn produced. Since each unit of yarn is moving at a constant rate and is subjected to precisely the same treatment, it is evident that uniform yarn is produced and the unique high temperature treatment results in a superior regeneration, though the reasons therefor are somewhat obscure.

Having described the invention, what is claimed is:

1. The method of manufacturing viscose fibers which consists in continuously and rapidly extruding into an acid regenerating bath an alkaline viscose solution to form at a rate exceeding 75 yards per minute a plurality of filaments and partially regenerate the same, then immediately withdrawing and gathering said filaments in yarn form from said bath, then passing said yarn while continuously so moving through a gaseous medium at a temperature in excess of 500° C. thereby substantially completing regeneration of the same.

2. The method of manufacturing viscose fibers which consists in continuously and rapidly extruding into an acid regenerating bath an alkaline viscose solution to form at a rate exceeding 75 yards per minute a plurality of filaments and partially regenerate the same, then immediately withdrawing and gathering said filaments in yarn form from said bath, then passing said yarn while continuously so moving directly through a burning gaseous medium thereby substantially completing regeneration of the same.

3. The method of manufacturing viscose fibers which includes the steps of continuously and rapidly extruding into an acid regenerating bath an alkaline viscose solution to form at a rate exceeding 75 yards per minute a plurality of filaments and partially regenerate the same, then immediately withdrawing said filaments from said bath and gathering them to form a yarn, then briefly subjecting said yarn and adherent bath while continuously so moving to a temperature of at least 500° C. thereby substantially completing regeneration of the same, and thereafter subjecting the yarn thus regenerated to various liquid treatments including an aqueous desulphidizing solution of a sodium sulphide concentration in excess of 10%, the yarn throughout said steps being progressed at said rate.

4. The method of manufacturing viscose yarn at a rate exceeding 75 yards per minute which includes the steps of continuously and rapidly extruding into an acid regenerating bath an alkaline viscose solution to form a plurality of filaments and partially regenerate the same, promptly withdrawing said filaments from said bath and gathering them to form a yarn, then briefly and continuously moving said yarn and adherent bath through a burning gaseous medium thereby substantially completing regeneration of the same, and continuously and rapidly passing said yarn in a series of free flights through a plu-

ality of compartments in which the yarn is briefly brought in contact with a series of treating liquids of a temperature in excess of 80° C.

5. An apparatus for the continuous production of regenerated cellulose yarn at a rate in excess of seventy-five yards per minute comprising a coagulating tank provided with spinnerets for the formation of a yarn, a burner adapted to provide a burning gaseous atmosphere in the immediate neighborhood of a rapidly moving flight of yarn immediately after said yarns leave said coagulating bath, compartments through which said yarn may be rapidly and continuously passed in free flights after passing through said burning gaseous atmosphere, and shower heads in said compartments adapted to bring hot treating liquids in contact with said free flights of yarn.

6. A machine for the continuous production of yarn of regenerated cellulose at a rate in excess of seventy-five yards per minute comprising a coagulating tank provided with spinnerets for the formation of filaments adapted to be gathered into a yarn, a heating unit adapted to produce a gaseous atmosphere of a temperature in excess of 500°

C. in the immediate vicinity of said yarn, a plurality of compartments, driven rolls in said compartments adapted to pass said yarn through said compartments rapidly and continuously in free flights between said rolls, and shower heads in said compartments adapted to direct hot treating liquids into contact with said free flights of yarn.

7. A method of manufacturing viscose fibers which includes the steps of continuously and rapidly extruding into an acid regenerating bath an alkaline viscose solution to form at a rate of the order of 75 to 100 or more yards per minute, a plurality of filaments and partially regenerate the same, then immediately withdrawing said filaments from said bath and gathering them to form a yarn, then briefly subjecting said yarn and adherent bath while continuously so moving to a radical degree of heat consistent with said extruding rate of the order of 500° centigrade, thereby substantially completing regeneration of said yarn.

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