Jan. 10, 1950

B. BORZYKOWSKI

METHOD FOR THE CONTINUOUS PRODUCTION OF SYNTHETIC FIBERS

2,494,468

Filed Nov. 12, 1943

7 Sheets-Sheet 1

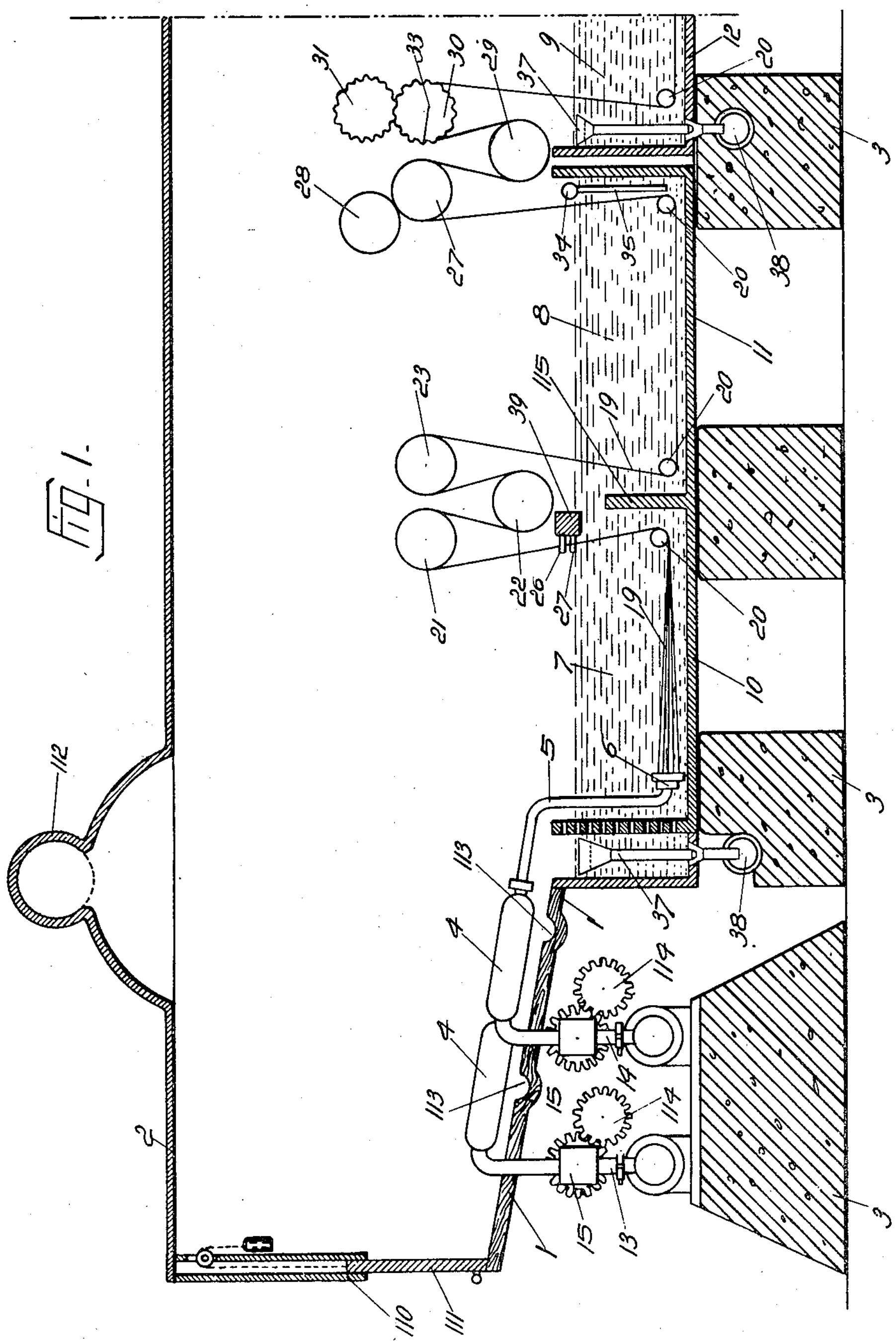

FIG. 1.

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Fig. 1a.

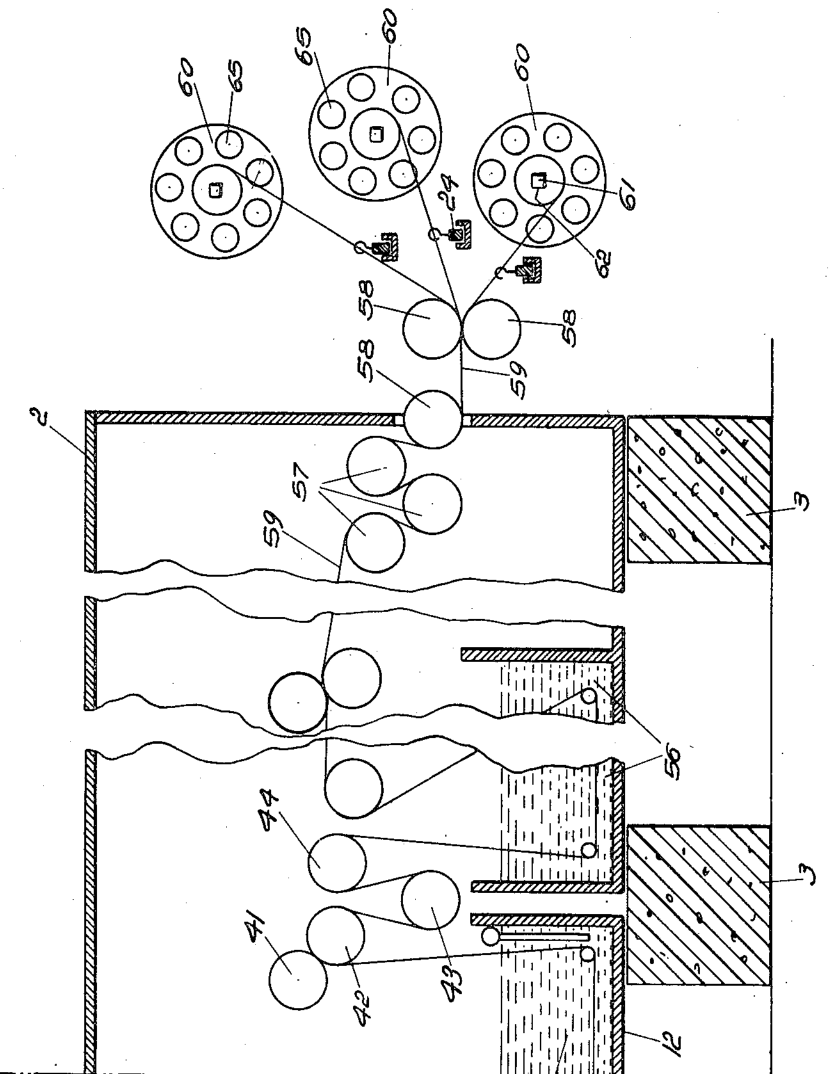
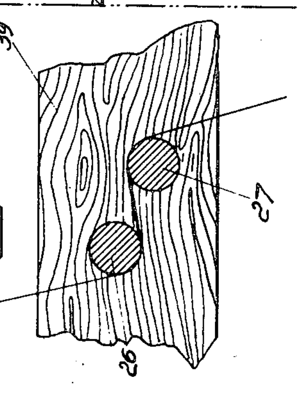


Fig. 10.



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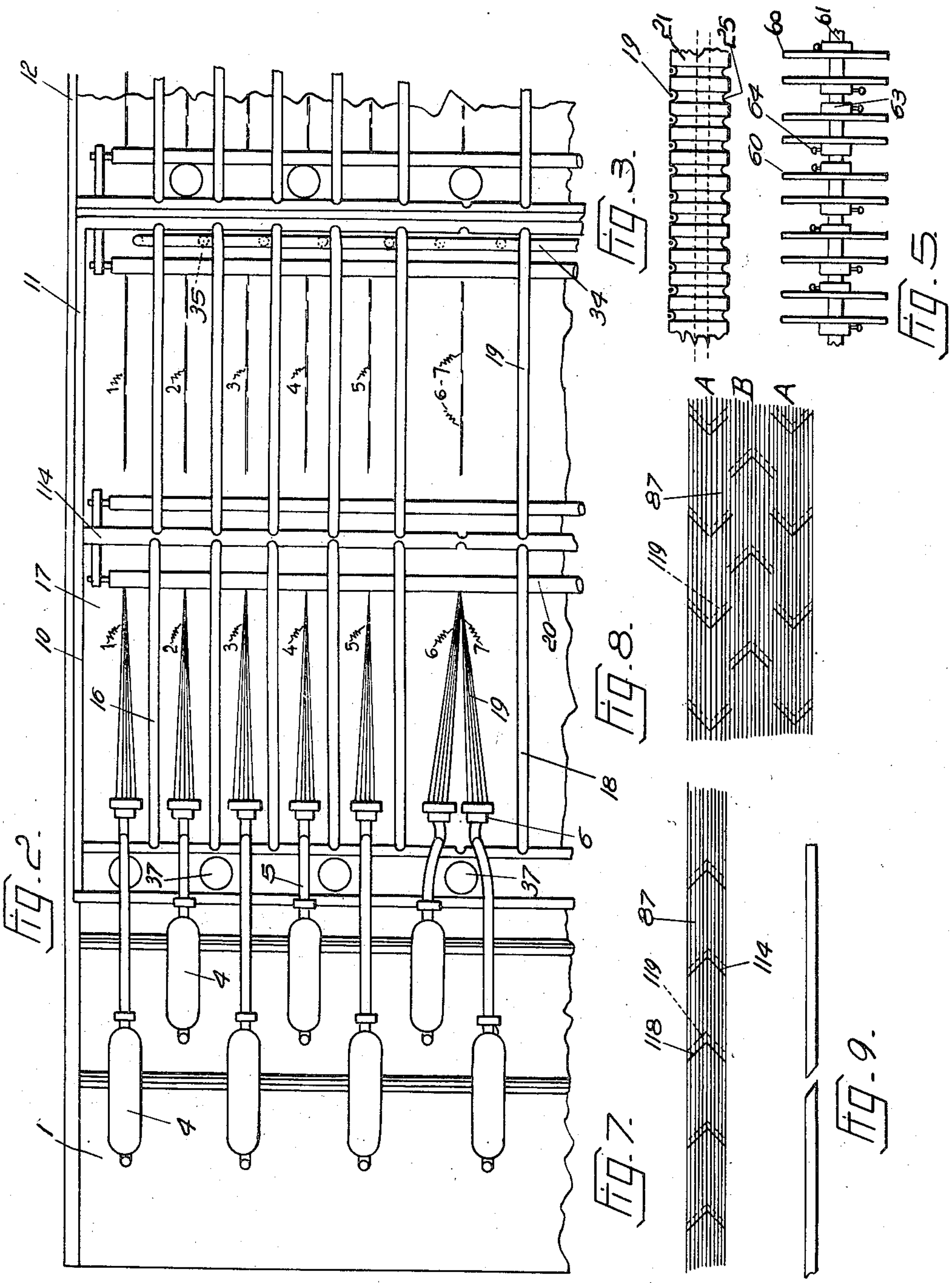


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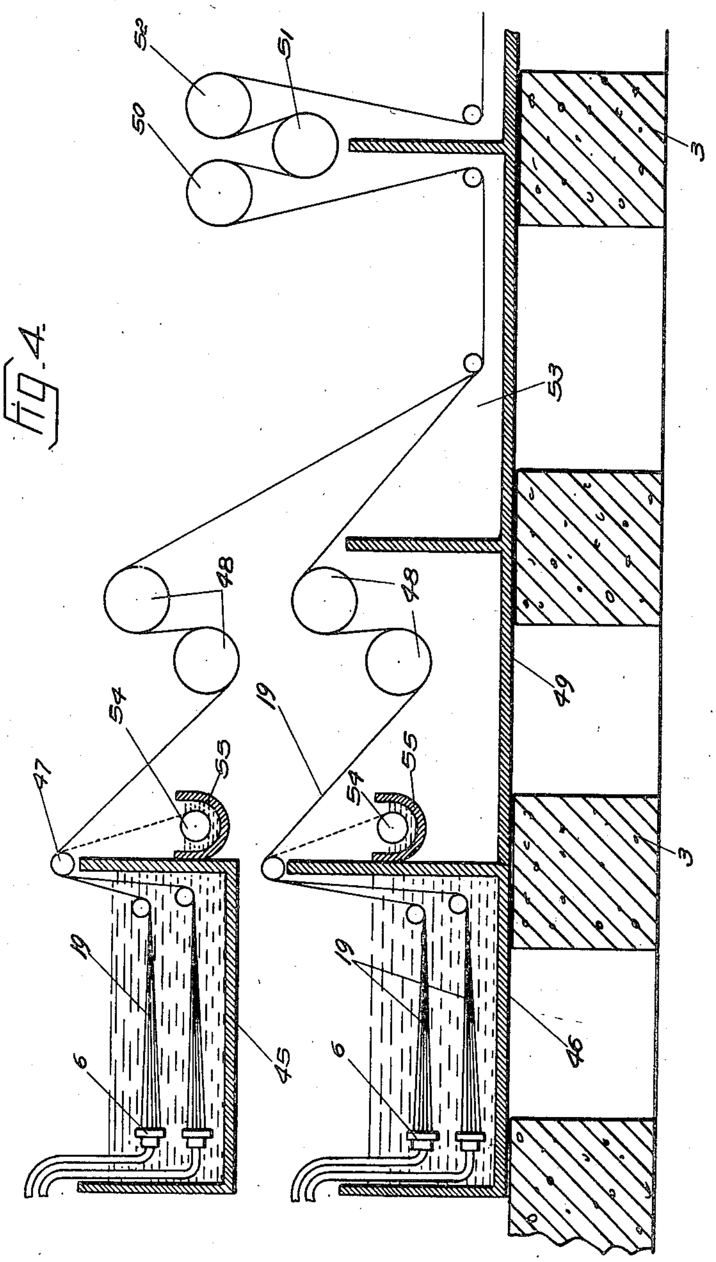


Fig. 4.

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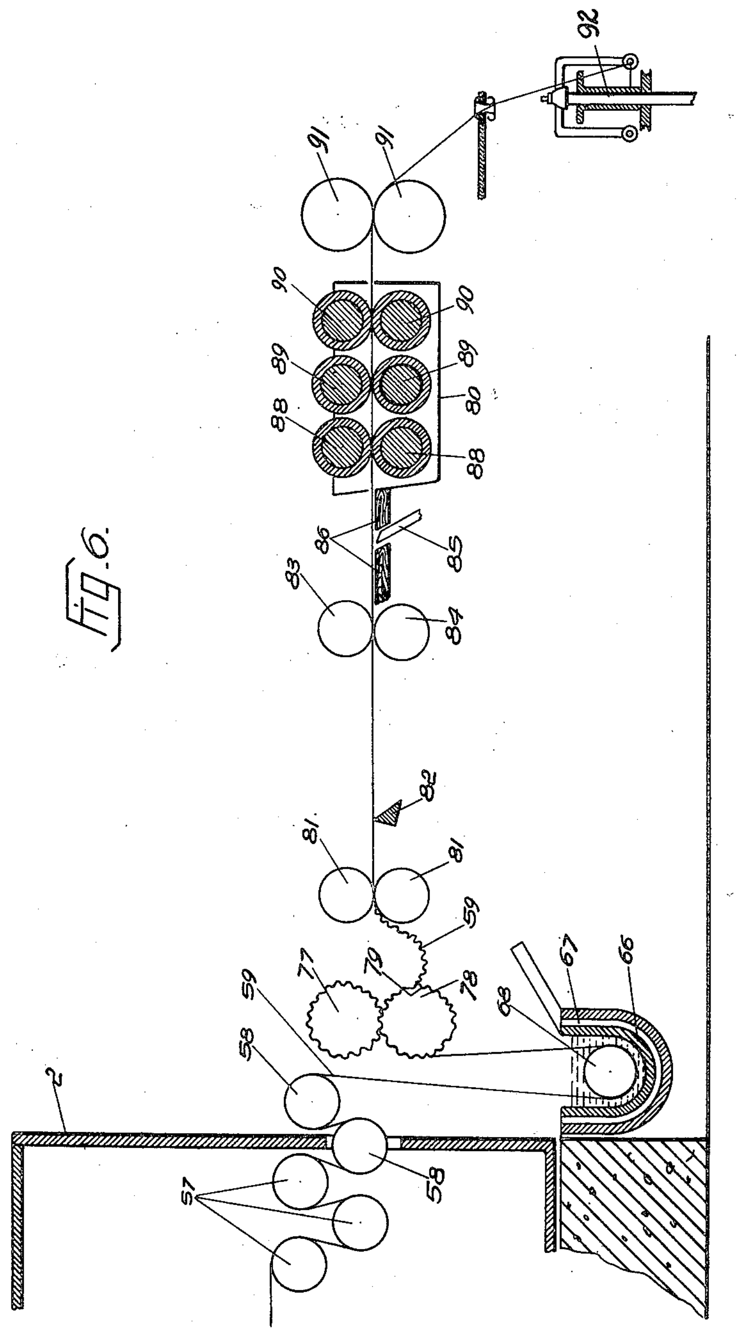


Fig. 6.

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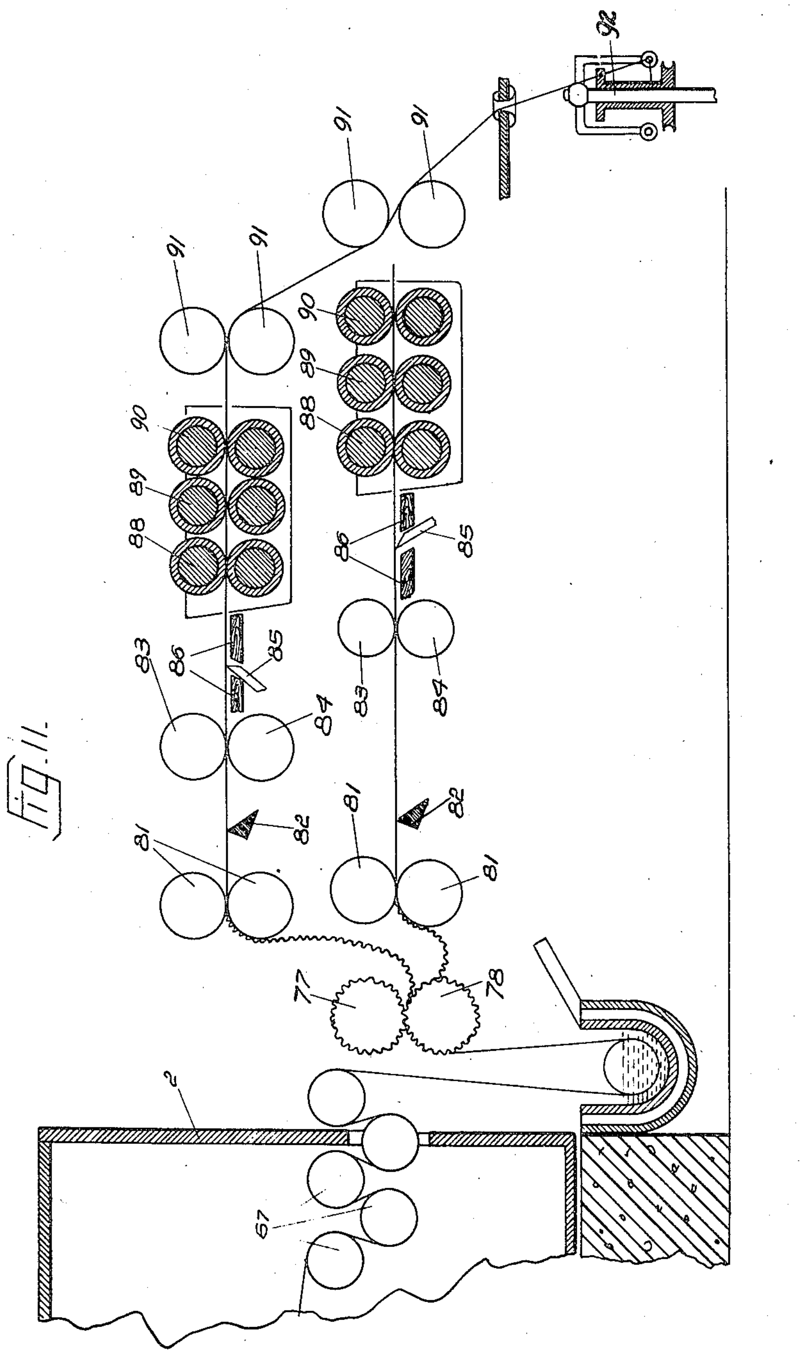


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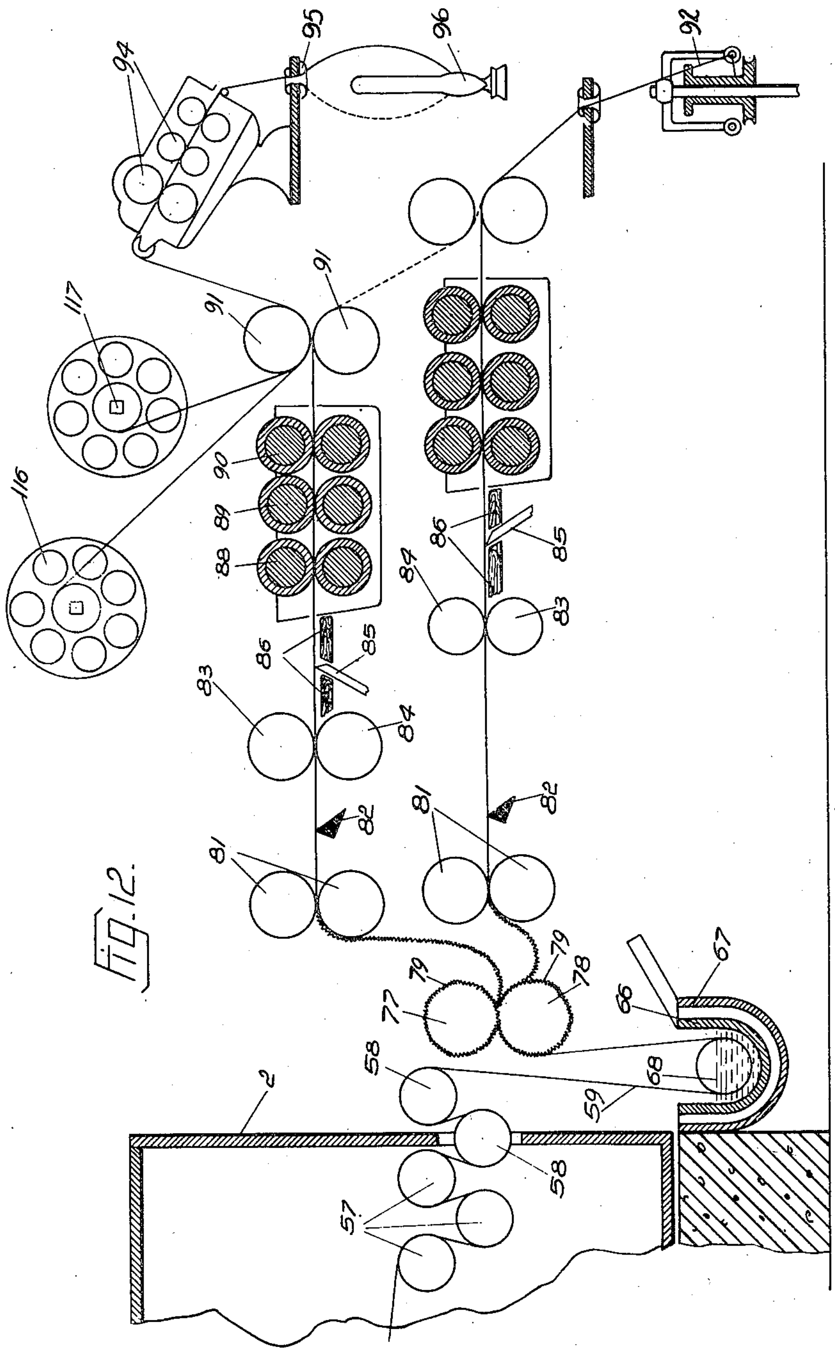
7 Sheets-Sheet 7

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Patented Jan. 10, 1950 2,494,468

# UNITED STATES PATENT OFFICE

2,494,468

## METHOD FOR THE CONTINUOUS PRODUCTION OF SYNTHETIC FIBERS

Benno Borzykowski, New York, N. Y., assignor to Swiss "Borvisk" Company, Wilmington, Del.

Application November 12, 1943, Serial No. 510,004

4 Claims. (Cl. 18—54)



This invention relates to a method for the continuous or direct production of synthetic twisted or untwisted fibers and yarns suitable for direct use on textile machines.

The term "direct" or "continuous" used in this specification with regard to the herein described manufacturing process indicates that from the moment the spinning mass is extruded through the forming orifices the formations are conducted through a plurality of treating phases and converted into endless finished fibers, cut staple fibers and staple fiber yarn intermediates, staple fiber yarns and finished endless threads, without having been previously wound on drums, reels, bobbins or into cakes, packages or the like.

The term "solidification" used in this specification includes any kind of conversion of a suitable basic not solid raw material, for instance, also a molten spinning mass into a solid filament.

The term "filament" denominates the products obtained by solidification of the extruded spinning mass formations while being in an unfinished state. The articles obtained in an untwisted form after the solidified filaments have been subjected to finishing treatments are termed in this specification "finished fibers." The twisted finished endless fibers are termed "threads." These fibers may be converted within the framework of this invention into staple fibers, staple fiber yarn "intermediates," such as tops, slivers, rovings and finished staple fiber yarns of a predetermined denier and with a predetermined number of individual fibers.

This terminology is not different from the one customarily used in the art; however, it has been considered advisable to create a clear situation with regard to the technical nomenclature used in this specification in order to exclude misunderstandings.

Since the birth of the art the production of synthetic fibers and threads has been and is still being carried out as follows:

The spinning masses or spinning solutions are extruded in an approximately round, flat or similar shape from a single orifice, such as a capillary tube, or from a number of openings in the nozzle or spinnerette, and the formations are conducted either through appropriate media, for instance heated air, when working according to the so-called dry spinning process, where the volatile solvent is evaporated, or cold air where the spinning mass formations are chilled, or through a coagulation bath in the wet spinning process.

The freshly coagulated filaments are guided vertically to carriers, such as bobbins, reels, or



they are led vertically to godets which pull the filaments with a certain speed from the solidifying phase to individual pots driven at a high speed wherein the filaments are thrown by centrifugal force against the pot walls; thereby the filaments are twisted together and with the aid of a special guide simultaneously assembled in a cake.

For many applications synthetic fibers of a high tensile strength are required; this is obtained when the fibers are stretched during their formation by means of positively driven stretching devices; as described in my U. S. Patents Nos. 1,401,943 and 1,450,131. Fiber bundles of a heavy total denier having a high tensile strength and high flexibility are of great importance in the production of, for instance, rubber tire cords for heavy loads where threads of 2400 and possibly 4800 deniers preferably directly spun in one jet, are required. If using bobbins or pots, 250 gram packages will, therefore yield threads of a continuous length of only 800 m. in 2400 den. and of only 400 m. in 4800 den., whereas to avoid as much as possible big knots which such heavy deniers will produce in the cords, tire-fabrics and similar articles threads of many thousands of meters in length should be used.

The use of larger bobbins or pots to obtain threads of greater length having less knots is impractical and uneconomic for the following reasons:

Larger bobbins or pots will cause a considerable reduction of the number of threads which would be produced per standard size spinning machine, and the larger cakes will complicate the finishing treatments and result in the formation of threads of inferior physical properties due to the constant reduction of the diameter of the collecting space in the pot, causing uneven tension of the thread.

The present day spinning machines which due to the complicated system of individual driving devices for each bobbin, each godet or each pot cannot be built at costs as low as other thread producing machines, and furthermore, the short life of said spinning machines and the high power consumption are further adverse factors.

Although in my U. S. Patents Nos. 1,401,943 and 1,450,131 I have shown the manner how to stretch the filaments during the coagulation by means of positively driven cylinder rotated with a higher circumferential speed than the cylinder which draws the fibers from the coagulation bath, the threads produced on the vertical spinning machines do not possess the properties obtainable by using the process and apparatus of the present invention, namely,

(a) a very high uniform tenacity throughout the entire length of each of the threads produced at the same time on a machine,

(b) very little elasticity and elongation, but high tensile strength and flexibility which properties are necessary, for instance, in the production of rubber tire cords and for similar purposes.

The reasons for this deficiency are, as stated previously, the relative short precipitation path in the coagulating trough. If a thread of, for instance, 1200 den. is spun with a speed of only 50 meters per minute, the thread in formation will remain in contact with the coagulation liquid in the trough for a fraction of a second only, which is not sufficient for such a heavy denier. The difficulty to add drawing godets to the standard centrifugal pot spinning machine for the purpose of obtaining positive stretching actions between two godets is obvious, and it is also evident that the machine must become more complicated and crowded, when such a great number of godets are provided for these purposes; furthermore, it is a highly inefficient procedure to wind each thread around each drawing godet and each stretching godet and to provide in order to prevent the threads to fall off from the godets or to slip upon the same glass or similar individual guides for each thread near each godet as this causes uncontrollable and uneven frictions and consequently variations in the orientation of the miscelles, of the tensile strength etc.

In order to fully understand the advantages of the invention particularly for the production of high tensile strength synthetic fibers, a description of the present methods used in the art seems appropriate.

In accordance with the present practice, the so-called high tenacity rayon threads are, after having been dried and wound on bobbins, hereafter warped in a second operation in an untwisted or only slightly twisted stage on standard or special size rayon beams. Several hundred threads are spread out between the heads of the beams placed apart approximately 54 inches. The weight of the yarn on the beam varies depending on the denier and number of the threads wound on the same, but it may well be assumed that the same will be about 800 lbs.

The reasons for the customary supply of said so-called high tenacity rayon threads on beams are that better mechanical properties are expected to result when the threads of the rayon warp are treated with an aqueous dispersion again on another specially built machine, stretched in the course of said treatment, again dried and wound on another beam. Without going further into the question whether the quality of the finished product can actually be improved by a second wetting, stretching, drying and beaming, there can be no doubt that even if this would be a simple procedure but could be avoided by my process and apparatus, there would be an important advance in the art of production of high tenacity rayon.

However, the complicated and unpractical procedure above referred to is considerably increased when the following is considered:

From a beam of 54 inches upon which, as stated, several hundred threads are wound, the threads must be conducted to as many twisting spindles to be provided with the required twist for the tire cords. Several hundred spindles in a row require many times the space of the beam even if smallest size twisting spools are used in order to bring the spindles closer together; this again causes much more knots in the cords in comparison with the use of big size spindles and twisting bobbins.

The object of the invention is the production of synthetic fibers by the wet or dry spinning process from any kind of raw material, by using a special simple and inexpensive equipment for the formation and, if required, stretching, neutralizing, impregnating, drying or for other treating steps by conducting horizontally all of the great number of the filament bundles produced on the entire machine to a common and not to an individually driven device for each bundle and leading the same from the moment the filaments are extruded from the spinnerettes through all the required treating stages with a great production speed and by winding the same in the finished form in practically endless length as single or plied bundles of capillary fibers in untwisted form on special reels suitable to form, if required, a beam or on any other carrier suitable for the direct use on textile machines.

A further object of said new process and equipment is, as above stated, to produce said threads with a much higher tensile strength, greater flexibility, thorough impregnation with latex containing dispersions, perfect adhesion of the same to the threads and with other valuable properties, as for instance water repellency.

With the process and apparatus disclosed in my U. S. Patents Nos. 1,401,943 and 1,450,131, I have obtained strong and uniform synthetic threads with a great number of capillary fibers extruded from one or a plurality of spinnerettes and assembled to one bundle by stretching the same between positively driven rollers in a manner that a greater length has been wound on the collecting device than extruded per time unit from the spinnerette and hereafter coagulated in the precipitation medium. Upon further investigation confirmed by practice I was surprised to find that much better results are obtained when the following rules are observed:

That in the viscose (cellulose xanthogenate) process, for instance the spinning solutions have a higher concentration than normally used, namely at least 8% preferably 10–12% cellulose contents.

That the viscose be fresh or in the first stage of its maturity, namely $C_{12}$ or $C_{18}$ stages. Under no circumstances shall the viscose change into xanthogenate:

$$C_{24}{:}CS\begin{matrix} \diagup (C_6H_9O_5)_4 \\ \diagdown SNa \end{matrix}$$

or into a higher polymerization described as a necessity, e. g. in German Patent No. 187,369 and still used in the industry.

That the precipitation (coagulation) must not be sudden but slow so that the filaments shall remain in a semi-plastic stage during the several stages of stretching and elongation, as hereafter more fully described. In the case of fresh viscose to produce 300 den. with a speed of 150–180 meters per minute, a precipitation bath containing the usual salts but only so much sulphuric acid as required to neutralize the alkali contained in the viscose but not an excess which might convert the cellulose xanthogenate into cellulose hydrate will give good results if the bath has a specific gravity of at least 25° Bé, a temperature of approximately 50° C. and the filaments passing a coagulating path of at least 100 cm.

The percentage of the acid present in the bath solutions will vary depending on the number of filaments to be coagulated in a given space; but in the case of the above example a 10% acid content will be sufficient if the bath is adequately renewed.

The grade and the manner of stretching or elongation of the plastic thread will depend on the size or denier of each capillary filament and the size or denier of each bundle of filaments and further depending on the tensile strength, flexibility and elasticity required in the final product; at any rate, the stretching shall be carried out in two or more stages whereby between the first and second and the subsequent stretching stages the thread shall be given a chance to shrink or contract to a certain extent.

For certain purposes, as for the production of cords for rubber tires, rubber belting, skating rollers and the like, the filaments must be treated with suspensions containing latex, resins etc.

The difficulty which the rubber tire producers have in obtaining a thorough impregnation even of cotton threads having more or less fuzzy or rough surfaces with rubber and the proper adhesion of the same to the filaments is well known. These difficulties are increased considerably when synthetic, e. g. viscose fibers, having a smooth surface are treated with such rubber suspensions. Numerous processes have been proposed to overcome these obstacles. According to British Patent 435,395 a suggestion is made to wind the fibers on perforated beams and treat the thus produced "cheeses" by soaking the latex through the same and removing the excess latex with air pressure and thereupon double and twist the undried threads by machines of the flyer or ring traveler type.

While investigating the problem of treating synthetic threads with dispersions I found that these difficulties may be avoided by using the process forming another object of my invention which comprises as an important object

(1) Impregnating the fibers with dispersions in such a manner that each individual filament is subjected to this type of treatment. This aim is achieved at a time when the capillary filaments are yet untwisted, lie parallel to each other and are not dried as yet. Sometimes it may be of great importance that the threads should be impregnated and at the same time stretched or shrunk, thereupon dried and wound, beamed untwisted or twisted in the same continuous operation and hereafter, eventually also in the same continuous operation united under certain temperature and pressure with other materials.

(2) Adding to the spinning mass, for instance to the viscose solution, one or a mixture of several ingredients usually employed in the latex dispersion which are soluble or remain in colloidal form in said spinning solutions, but after precipitation of the formations adhere firmly in and on the individual capillary fiber forming a rough surface or a somewhat porous surface if leached out from the formations.

A very small admixture of these agents to the spinning mass suffices for these purposes inasmuch as the aqueous latex dispersion due to the present invention is applied on each capillary thread before the filaments are dried, viz. immediately after the washing and before desulphurisation, but after squeezing out the surplus of the washing liquid from the filaments by rollers or other means as hereafter more fully described. The latex dispersion penetrates easily into the soft, not entirely solidified filaments and adheres strongly to the rough surface threof.

Latex dispersions usually contain in addition to other ingredients sulphur, carbon black and zinc oxide; 2–3% of these substances in admixture with a barium compound calculated on the weight of the cellulose in the viscose solution emulsified and finely dispersed therein will in most cases be sufficient to produce a rough surface on each capillary filament. The latex dispersion will penetrate quite deeply into each capillary filament even without using an appropriate wetting agent.

I do not limit myself to the above recited agents nor to the quantities thereof to be suspended in the viscose or other spinning masses as the same can vary considerably depending on the requirements and the applications of the final products.

The admixture of a barium compound to the viscose solution given by way of example only shows to the man skilled in the art one way how to obtain a proper anchoring of the latex dispersion not only on regenerated cellulose but also on other synthetic fibers, such as acetate, cellulose ether, resin, protein and even on natural fibers, by incorporating into the starting material or by the impregnation of the finished fibers with bodies having the characteristics of the barium compound, i. e. to remain finely dispersed in the spinning or impregnating solutions and upon a precipitation of the same to form coarse grains of an insoluble precipitate, such as barium sulphate on and in the fibers which after thorough washing to remove the soluble salts, remain practically insoluble in water.

(3) In addition to or independent of the above cited process to procure a proper anchoring of the latex dispersion to the synthetic fibers, the fresh formations after having undergone the stretching or positive elongation, but before they are entirely set, being subjected in course of the further operation to a mechanical surface crimping action, for instance passing the same over grooved rollers, as more fully described hereafter, to impart to each fiber in its entire length rings or similar deformation without weakening the fiber at the deformed places.

(4) The use of a continuous synthetic thread containing cut or staple fibers of synthetic or natural origin, particularly as produced by the hereafter more fully described method on the equipment forming a part of this invention, which thread due to the cut fibers incorporated therein has a kind of a fuzzy surface, also facilitates a proper anchoring or adhesion of the latex dispersion.

As apparent from the above, it is the main object of the invention to obtain in one single continuous operation continuous synthetic fibers, threads, staple fiber intermediate and staple fiber yarns in a wound form ready for immediate use in textile machines.

It is a further important object of the invention to greatly simplify the manufacture and improve the quality of synthetic fibers and yarns and to accordingly enhance the economy of the production.

It is an equally important object of the invention to obtain the finished synthetic fibers, threads and yarns as substantially endless and knotless bodies.

It is also an object of the invention to carry out the treatments adapted to convert the endless fibers into staple fibers, staple fiber intermediates, such as tops, slivers and the like, and staple fiber yarns, when they are still untwisted and in substantially parallel alinement.

It is an essential object of the invention to produce chemically and mechanically uniform articles.

It is an important object of the invention to exclude manual handling with its accompanying injuries to the fiber and to accomplish the manufacture of the final articles in one continuous operation.

It is also an object of the invention to improve the mechanical properties of the synthetic fibers, threads, intermediates and yarns and particularly their tensile strength and flexibility, absorptiveness for surface roughening agents, and to reduce brittleness.

It is an important object of the invention to provide a manufacturing method which permits an easy variation of the working conditions and in conformity therewith of the mechanical properties, of the denier of the finished threads, of the surface characteristics, without an interruption of the continuity of the manufacturing procedure.

It is also an object of the invention to modify the surface configuration of the threads in the regular course of the manufacture for a specified use.

It is an object of the invention to improve the sanitary conditions of the manufacturing installations and to prevent contamination of the air with fumes and sprays emanating from the various treatments.

It is another object of the invention to increase the working capacity of the manufacturing appliances or spinning units.

With these and further objects in view which will become apparent as this specification proceeds, the invention is illustrated by way of example in the attached drawings in its application to the production of substantially endless and knotless synthetic untwisted or twisted fibers and wound up fiber bodies and to the conversion of the fibers into staple fibers, staple fiber intermediates and staple fiber yarns, in a form ready for use on textile machines.

With the above recited purposes and other purposes in view which will become apparent as this specification proceeds the invention is by way of example illustrated in the annexed drawings as applied to a wet spinning process.

It is, however, well understood that any not solid spinning masses may be employed in conjunction with this invention adapted to be converted by solidification into filaments, fibers and fiber bundles.

In the drawings,

Figs. 1 and 1*a* is a vertical sectional view of a part of a spinning machine to be used for the production of synthetic finished fibers in conformity with this invention,

Fig. 2 is a top plan view of a part of the machine shown in Fig. 1,

Fig. 3 is a front elevation of a conveyor roller for use in the operation of the machine,

Fig. 4 is a vertical sectional view of a modification of a part of the spinning machine shown in Fig. 1, including superposed coagulation baths,

Fig. 5 is a vertical front elevation of a reel assembly for upwinding the finished fibers,

Fig. 6 is a vertical sectional elevation of my machine to be used for the conversion of the finished fibers into staple fibers, staple fiber intermediates and staple fiber yarns as wound up fiber bodies,

Figs. 7 and 8 illustrate schematically on an enlarged scale the finished continuous fibers after being cut into staple fibers,

Fig. 9 is a side view of a cut filament on a grossly exaggerated scale,

Fig. 10 is a front elevation of an auxiliary device for use in the treatment of the filaments,

Figs. 11 and 12 are vertical sectional elevations of two modifications of the machine shown in Fig. 6.

*The solidifying zone*

As shown in the drawings my horizontal spinning machine comprises a table 1 and a plurality of coagulating and treating troughs supported on foundation blocks 3 and encased in enclosure 2. Openings 110 are provided in the walls of the enclosure 2 which is closable by slides 111; a dome 112 is located in the ceiling of the enclosure for the accumulation of gases and vapors which are withdrawn therefrom. Grooves 113 provided in table 1 serve to collect and to discharge waste liquid.

Candle filters 4 for the final filtration of the spinning solution are mounted on table 1 which extends transversely through the entire operating width of the machine.

Pipe systems 13 and 14 for the supply of the spinning solutions are located underneath table 1. Pumps 15 driven by gears 114 are connected with supply pipes 13, 14. Pipes 5 connect the candle filters with the spinnerettes 6 which feed into the coagulation baths.

According to the present exemplification of the invention three coagulation baths 7, 8, 9 are provided which are located in direct succession in the longitudinal direction of the machine, and contained in troughs 10, 11, 12. Each of these coagulation troughs extends transversely through the entire operating width of the machine or of the adjacent spinnerettes. The troughs are divided by removable partitions 16 in adjacent compartments 17 to receive the filaments produced by the individual spinnerettes.

If it is desired to increase the productive capacity of the spinning machine without enlarging the operating width two sets of pumps and fed systems, double sets of filters located on the table in staggered relationship may be installed as shown in Figs. 1 and 2.

This arrangement is particularly useful if instead of, for instance, 1100 denier 2200 denier fibers with the double amount of filaments are required for certain purposes such as the manufacture of tire cords.

In this case partitions 16 are removed and larger compartments 18 are formed, receiving two bundles of filaments 19 from two spinnerettes which are united by a guide cylinder 20 to form one filament bundle.

This modification of the invention may be advantageously used in combination with the staggered arrangement of the candle filters.

Conveyor roller aggregates composed of a plurality, for instance, three rollers 21, 22, 23 are mounted above coagulation bath 7. These rollers extend transversely to the longitudinal extension of the machine through its full operating width, the operating with of the machine substantially corresponding to the operating width of all spinnerettes.

The conveyor roller aggregates perform functions which are highly important inasmuch as the size and the properties of the fibers are largely influenced by their specific operation. The location of the conveyor roller aggregates is adjustable in the longitudinal direction of the machine; this makes it possible to vary the distance thereof from the spinnerettes or the coagulating path between the spinnerettes and the conveyor rollers. Needless to state that other ways may be used to vary the coagulating path.

The coagulating path may be constant if a specific fiber or yarn with certain properties as to its tensile strength and elongation or other properties is to be produced at a predetermined speed; if, however, different types of fibers, threads or yarns with different properties or of a change of the production speed is desired, the distance of the roller aggregate from the outlet of the spinnerettes may be adjusted by displacement of the same or by displacement of partition wall 115 in the longitudinal direction to shorten or lengthen at will the operating path or length in the coagulating baths.

A further important function of the rollers which are partly positively driven is to exert a stretching action upon the filaments which in a general way is recited in my Patents 1,401,943 and 1,450,131; this stretching treatment adds in a specific manner greatly to the success of the present continuous process, as explained in a later part of this specification.

All filaments extruded from all spinnerettes of the machine are transported by roller 21 through coagulation bath 7 and maintained underneath its level by guide cylinder 20; instead of the guide cylinders other suitable guiding devices such as guide hooks may be used.

The conveyor rollers are made from materials which are not attacked by the chemicals used in the process, such as organic solvents, oils, etc.; they should preferably have a sufficiently large circumference so that the filaments will not slip or slide thereon.

Roller 21 draws all the filaments 19 produced in the machine with a predetermined speed from the coagulating solution without any or with a very small tensioning action in order to avoid breakage of the tender semi-gelatinous filaments.

Roller 22 rotated at a greater circumferential speed than roller 21 will stretch or elongate the filaments accordingly, whereas roller 23 will, depending upon the changing requirements, be either rotated with a somewhat lower speed to reduce the stretching action or with a higher circumferential speed than roller 22 to exert an additional stretching or elongating action.

If, for instance, roller 21 draws 100 m. of the filaments per minute from the coagulation bath, roller 22 may be operated to draw 110 meters per minute; this will result in an elongation of 10%. If roller 23 is then driven to draw only 109 meters per minute, the shrinkage or retraction of the filaments between rollers 22 and 23 will be one meter and the total elongation 9%.

This retraction is very advantageous if, depending on the denier of each capillary filament, a high tensile strength in addition to an average elasticity of the finished fibers is desired; if, however, a lower elasticity is required and a higher tensile strength, an additional elongation between the rollers 22 and 23 may be advisable.

Depending upon the number of the capillary filaments to be assembled in the individual bundles and on the tension imparted to the same when conducted through the various producing stages, the conveyor rollers may be provided with grooves 25, Fig. 3, which also prevent the filament bundles from being entangled.

To further assist and to promote the action of the grooves and to prevent the slipping out and breaking away of the individual filaments from the bundles a device is located in the traveling path of the filaments before they reach the conveyor rollers 21, 22, 23, which I prefer to denominate as a "false or incomplete twister."

This device, shown in Figs. 1 and 10, is composed of two rods 26, 127. These rods are mounted on a beam 39 extending through the width of the machine; the rods are staggered as shown in Fig. 10. The change of the traveling direction imparts to the filaments a slight twisting action.

Partition wall 115 may be made displaceable in the traveling direction of the filaments, which displacement serves, as previously explained, to vary the coagulation path.

The adjustment of the coagulation path which may be obtained by any other suitable means is of great importance for the operation of my continuous process because the longer or shorter contact with coagulating liquids of different composition, for instance acidity, greatly influences the coagulating procedure and correspondingly the final properties of the coagulated filaments.

The filaments discharged from roller aggregate 21 to 23 are conducted into coagulation bath 8 and kept therein under the level of the coagulating fluid by means of cylinders 20. The filaments are then drawn from this coagulation bath by rollers 27, 29, 30. In conformity with the above remarks the coagulation in the first bath 7 can easily be adjusted to obtain an uncomplete coagulation, whereupon the filaments during their passage through roller aggregate 21—23 are stretched between rollers 22, 23 shrunk or additionally stretched between rollers 22, 23 and then conducted into the second coagulation bath 8.

Roller 27 acts as a mere transport means. Roller 28 pressing by inertia on the filaments is rotated by friction and removes in cooperation with roller 27 excessive coagulation liquid. Roller 29 is driven at a greater circumferential speed than roller 27 and therefore exerts a corresponding stretching action upon the filaments, whereas roller 30 is operated in a manner which is similar to that of roller 23, that is with a higher or lower circumferential speed than that of roller 29.

A permanent orientation of the miscelles is hereby effected in the fibrous filaments.

Roller 31 cooperates with roller 30 in the same manner as roller 28 with roller 27.

Rollers 30, 31 may be provided with projections or teeth 33 to produce on the incompletely solidified filaments surface irregularities in the form of rings or grooves before they are conducted into media adapted to convert the same into the finished fibers. The subdivision of the coagulation into individual stages or baths which renders it possible to control the same in such a manner that the filaments in the first stage or bath are incompletely coagulated and that the coagulation is then continued and completed in the additional baths or coagulating stages is, as already previously stated, an important element of the invention. Whereas in the first stage 7 of the coagulation practically no or so little pull or tension is exerted on the freshly formed filaments that they pass through bath 7 in the freely suspended horizontal disposition, the filaments after leaving bath 7 are stretched on their way to the second bath 8 by rotating roller 22 with a circumferential speed in excess to the speed of roller 21. A further stretching or shrinking action may be applied to the filaments by adjustment of the circumferential speed of rollers 27, 29, 30.

A principle of feeding the coagulating liquid is employed in connection with my invention which as yet has never been and could not have been applied to the vertical manufacture of synthetic filaments, fibers and threads.

In accordance with this novel supply system the coagulating liquid is introduced into the coagulating troughs in countercurrent to the traveling direction of the filaments. The successful realisation of this feed principle is rendered possible by my continuous horizontal process.

The fresh precipitation liquid heated to the required temperature is preferably supplied at that end of the troughs which is opposite to the filament entering end.

The application of the countercurrent principle makes it possible to gradually reduce the alkalinity of the filaments, to contact the extruded spinning mass with a coagulating medium of lowest acidity which is gradually increased as the solidification of the filaments progresses.

The countercurrent feed of the coagulating liquid has resulted in a surprising improvement of the mechanical properties of the threads and particularly the tensile strength.

In accordance with the above explained principle supply tubes 34 for the coagulating liquid are mounted near to the rear end of the troughs, and vertical branches 35 extending into the troughs are connected to this main feed tube. The overflowing liquid passes into discharge funnels 37 and from there into discharge pipes 38.

The filament drawn from the coagulation bath meets the fresh coagulation liquid having the highest degree of acidity which gradually decreases in proportion to the increase of solidification. The feed velocity of the coagulating liquid and the acid concentration is so calculated that in the vicinity of the nozzles, where the jet of the spinning solution immerges into the coagulant, a state of near neutrality but of sufficient acidity prevails to prevent alkalization of the coagulant. Tis countercurrent feed system is not restricted to coagulation solutions, but is likewise usable with any other solidifying medium, such as hot or cold air, gas and the like.

The third and final solidifying bath 9 is equipped in a similar manner as the proceeding coagulation baths 7 and 8.

The third roller aggregate 41, 42, 43, 44, Fig. 1*a*, constructed similarly to roller aggregate 27 to 31, with the only omission of roller 31, draws the filaments out of trough 9.

A modified arrangement of the coagulation equipment is shown in Fig. 4, whereby the manufacturing capacity of the machine is greatly increased without enlarging the operating width.

For this purpose a plurality of superposed staggered spinnerettes 6 may be provided in trough 46, or a plurality of superposed coagulating troughs 45 and 46 with several superposed rows of spinnerettes 6 may be installed.

By extruding the spinning solutions into the coagulation troughs 45, 46 two superposed rows of filaments bundles 19 are produced which are conducted through the coagulating bath and emerge from the bath over guide rollers 47. The filaments are drawn from the baths by positively driven rollers 48 located in a dripping trough 49 and jointly discharged into a coagulation bath 53. They are conducted by a three roller aggregate 50, 51, 52 which is similarly constructed to roller aggregate 21, 22, 23, into another coagulation bath and subjected to further treatment in the same manner as described in conjunction with Figs. 1 and 1*a*.

If the threads are used for the manufacture of tire cords or for similar purposes, where they are treated with a sulphur containing rubber or latex dispersion, the spinning machine can be made much shorter as the desulphurizing, washing, bleaching, washing, acidifying and washing may be eliminated.

If the threads are used for standard weaving and knitting purposes requiring only standard tensile strength and elasticity and need not be purely white, the spinning machine can also be shortened by using another treatment step forming a part of this invention, namely the application of only one agent which will convert the coagulated unpurified filaments in one single operation in its purified form.

If, for instance, a viscose spinning solution is used, a treatment consisting of

(1) Washing the threads wound on perforated bobbins or collected in pots in the shape of cakes on special machines to absolute neutrality,

(2) Desulphurizing with a hot sodium sulfide solution,

(3) Washing with water until absolutely neutral,

(4) Bleaching with chlorine or the like,

(5) Washing with water until all the chlorine is removed,

(6) Treating with an antichlorine reagent to remove all traces of chlorine,

(7) Removing the antichlorine reagent by washing,

is replaced by passing the slightly rinsed, still acid filaments into a hot solution of sodium sulfite. The concentration of this solution may be varied in dependence upon the size (denier) of the individual filaments, the number of the filaments in each bundle, the speed of production and other working conditions.

The sodium sulfite dissolves the sulphur contained in and deposited on the surface of the filaments; on the other hand it reacts with the acid of the coagulation bath adhering to the filaments and neutralizes the same whereby one part of the $Na_2SO_3$ is decomposed under the formation of $H_2SO_3$ which exercises a bleaching action on the filaments. The sodium sulfite solution at the same time eliminates the salts contained on the fibers. A 2% sodium sulfite solution and a treating temperature of between 60 to 65° C. will in most cases give satisfactory results.

The thus treated filaments require only simple short rinsing with hot water; the above referred to long tiresome series of apparatus, operations, space of installation, power, injury of the fibers may thus be avoided.

Instead of sodium-sulfite another agent acting in the same or similar manner may be employed.

The same result is obtainable in the production of filaments from other starting materials, such as formations from a cuprammonium-cellulose solution which may be treated, as above described, immediately after the elimination of its copper content with sulphuric acid.

At the end of the finishing stage and before the filaments are conducted into the drying zone, the following important treatment constituting an additional object of my invention may be employed.

The tension of the filaments is loosened but only to such an extent that they do not contact each other or do not slide on the bottom of the treating trough into which they are conducted A hot emulsion or solution is kept in the trough in constant circulation in order to penetrate into each individual capillary filament from which liquids contained therein from previous treatments have been squeezed out as much as possible through rollers or other appropriate devices.

The type of emulsion or solution to be used for this treatment will depend upon the intended application.

If they are to be used

(1) For a high twist as required for fine stockings or the like an easily saponifiable oil or emulsion as usually used by throwsters to produce crape twist may be employed;

(2) For weaving warps the filaments may be sized with customary protein sizing compounds;

(3) For use in circular rashel or warp knitting machines a mineral oil emulsion will produce good results;

(4) For the direct production of a 100% spun rayon continuous yarn or a 100% partly spun and partly continuous rayon yarn produced in one simultaneous operation on my spinning machine, it is advantageous to use

(*a*) In case of bright rayon where no dulling agents have been added to the spinning mass a slightly alkaline hot soap and vegetable oil emulsion containing, for instance, a finely divided barium or similarly acting compound; the filaments are drawn through a bath made up of this agent and are then passed into an adjacent trough containing diluted sulphuric acid which precipitates an insoluble compound on the surface of the fibers giving the same a somewhat rough touch and dulled luster.

This treatment improves the adhesion of the cut staple fibers to each other and the conversion of the same into spun rapon threads as hereafter more fully explained.

(*b*) In case "dull" threads are spun from solutions or masses into which oils and/or fats with an addition of a barium or similar compound has been admixed, it is sufficient if the threads after having been freed from the residual fluids of foregoing treatments are drawn through a trough containing a hot sulphonated oil emulsion to prevent complete drying of the loose untwisted capillary filaments in the drying zone and to render the same more pliable and flexible for further specially mechanical operations.

In order to start the operation of my horizontal spinning machine either provided with a series of successive single coagulation troughs, as shown in Figs. 1 and 1*a*, or with a multiple of superposed coagulation troughs having a multiple of superposed rows of filaments as shown in Fig. 4, each individual bundle of capillary filaments emerging from the coagulation baths may first be wound on reels 54, shown in Fig. 4, which rotate in troughs 55 containing sulphuric acid to convert the threads in cellulose hydrate.

As soon as all threads from all spinnerettes have been wound on these reels, the entire row of filaments is caught by a bar or the like and conducted through the successive coagulating and treating baths, the drying zone and the subsequent stages of my machine, which will be more fully described as this specification proceeds. As soon as all rows of filaments have been set into operation in this manner, the work is continuously carried out without interruption, the troughs 55 with rollers 54 being discarded from the regular operation of the machine.

The fibers wound on the reels 54 may be used for the production of staple fibers or other suitable purposes.

In case the spinning of a bundle of filaments is interrupted, the restarting of the continuous spinning of the respective bundle may be carried out in the following manner:

The filter or the nozzle or both are replaced; the extruded fresh filament bundle is attached to an adjacent continuous bundle at a suitable point after the extrusion and carried by the same through the entire machine; there it is wound on a new reel or bobbin or knotted together with the broken end.

### *The finishing and drying zone*

The continuous successive horizontal system of treating the filaments which dominates the solidification zone is also maintained in the finishing and drying zone. The filaments are drawn into this zone from the coagulating trough 9 by the roller aggregate 41, 42, 43, 44, Fig. 1*a*.

Treating troughs and baths for washing, desulphurizing, washing, if desired bleaching, washing, impregnating, sizing and otherwise treating the filaments constructed similarly to the coagulating troughs and extending transversely through the entire operating width of the machine are located in this zone in direct horizontal succession.

Treating liquids are supplied to the troughs according to the individual requirements. Only one trough 56 is shown in Fig. 1*a* for purposes of illustration. The filaments are conducted through these finishing troughs by the same type of roller equipment and guiding means used in the solidifying zone.

A drying installation of customary construction indicated in the drawings by cylinders 57 is arranged in direct horizontal succession to the finishing troughs.

Conveyor rollers 58 are provided to discharge the finished dry bundles 59 from enclosure 2.

Any modern drying equipment driven at a speed synchronized with the above described part of my continuous spinning machine will work satisfactorily if precautions are taken to properly deal with continuous untwisted fibers and provisions are made to have variable speed drives to control the stretching and shrinking of the filaments passing through the dryer in the manner as this is carried out in the case of rayon warps.

### *After-finishing zone*

Contrary to the customary procedure used in rayon manufacturing plants where the threads are wound on bobbins from which rayon warps are made on special machines whereby many hundreds or some thousands of threads are wound on a common beam from which, as described above, all the threads are led through another machine to be sized, dried and again wound a second time on beams, three alternative ways dealing with the dried continuous untwisted fibers or fiber bundles are provided in conformity with my invention signifying a marked deviation from and a considerable advance in the state of the art.

(1) If it is the intention to utilize the threads in the untwisted state, for instance, for further conversion into rayon cords, the dried fiber bundles 59 eventually treated with a latex dispersion are wound on reels illustrated in Fig. 1 and Fig. 5, to assemble thereon great lengths of fibers.

This device comprises a plurality of reels 60 of a rather large diameter; the reels are mounted adjacent to each other on square shafts 61. The reels are provided with square recesses 62 which are so dimensioned as to be easily slid onto shafts 61. Spacer rings 63 fastened on shafts 61 by screws 64 are provided to hold the reels on the shafts in such a manner that their center is in alinement with the center of the thread guide.

In order to be able to wind several bundles and larger quantities of the threads on each reel and to work without interruption if the reels are filled with the desired length of threads a plurality of superposed reel carrying shafts may be arranged as shown in Fig. 1. When one shaft with reels is working, the other can be provided with empty reels and when the latter are put in operation, the shaft with the filled reels can be stopped and the full reels exchanged against empty ones. Instead of square shafts with square recesses a common shaft for each row which will turn each reel by friction devices will in certain cases be desirable, for instance, if different lengths of threads are required on some of the reels, or if a fiber bundle was broken and restarted after a certain lapse of time so that the respective reel will hold less yarn when the thread was restarted; a uniform tight winding of the threads on the respective reel could not be achieved with square shafts and square recesses, as all the reels would turn with the same speed.

The consumers of the yarn, for instance, cord producers, mount as many of these reels on similar shafts and run as many fibers from individual reels if required through dispersions or solutions as can be accommodated in the impregnating machines, leading hereafter the fibers from one or several adjacent reels directly and in straight line to the ring or similar twisting devises to obtain the required twist. Thereby not only the previously described unpractical way of twisting the threads which are unwound from big beams, but also the packing and transporting of the same is avoided. The reels 60 may preferably be made of light materials and provided with recesses 65 to reduce their weight.

(2) When twisted threads are required, the bundles of the capillary fibers emerging from the drying zone are directly conducted to ring or similar well known twisting devices, which can also be installed in two or three superposed levels whereby increased space for bigger spools is obtained and the exchange of the spools filled with yarn against empty spools is facilitated.

(3) My above described new horizontal continuous spinning system affords also a most efficient way for the direct production of synthetic fibers of an hitherto unknown entirely new construction, namely of an endless 100% direct denier spun staple fiber yarn of a predetermined denier and predetermined number of individual filaments.

The cut fibers produced by the wet spinning process are neutralized, washed, purified, for instance desulphurized, or decopperized, and treated by many other fluids in the same manner as described above when dealing with continuous fibers, before they can be properly dried. This drying of wet cut staple fibers requires complicated and expensive devices, upkeep etc., due to the unfinished or embryonic stage of the filaments, because in order to convert the same into finished fibers suitable for the various manipulations prior to and during the real spinning in the cotton, wool, worsted, flax spinning mills on cotton or other spinning machines, preferably all the moisture content must be removed uniformly throughout the layers in the dryer, otherwise the fibers are damaged during the opening.

As long as such staple fibers have been used for blending or mixing with natural fibers or other synthetic staple fibers, for instance viscose with wool, to diminish the quantity of wool and/or to obtain cross dyeing or other effects, it was comprehensible to a certain extent that the in parallel alinement produced synthetic fibers after having been cut into staple fibers were tangled up and thrown crosswise in all directions because the natural and synthetic fiber with which the staple fiber is to be blended must be well divided and mixed and therefore undergo anyhow the usual carding, combing, several drawing stages and rovings before the yarn can be spun on the ring spinning frame or a self-acting mule.

However, since a very large percentage of staple fibers is at present converted into and can be sold in large quantities as a 100% staple fiber yarn, this invention solves the following important problem. This problem comprises the direct production in one continuous operation on the synthetic filament spinning or coagulating equipment and without recourse to the usual preparatory and reel spinning machines now used in the textile industry of the following new type of synthetic spun fibrous articles:

(*a*) A continuous synthetic yarn made from any kind of proper starting material by solidifying, hardening or coagulating, treating the filaments, if required, and simultaneously converting the same eventually in the same operation into a 100% finished spun yarn of a predetermined number and size of the individual filaments and diameter or denier of the finished yarn.

(*b*) The same yarn as described under (*a*), but consisting partly of fibers cut into staples and partly of a continuous synthetic thread made at the same time from the same starting material on the same equipment.

(*c*) The same yarn as under (*b*) in which at the same time of producing the capillary filaments there is embodied another thread or threads made from another kind of cut or continuous synthetic or natural fibers.

(*d*) A continuous synthetic staple fiber roving, top or sliver of predetermined number of filaments for a predetermined yarn number wound in endless packages or appropriate reels, spools or the like, suitable for further conversion on standard spinning machines into yarn, cords, breeds, etc., as such or in combination with other synthetic staple fibers and continuous threads and/or natural fibers and threads.

An apparatus for carrying out this important embodiment of my invention is exemplified in Fig. 6 and will be described hereafter with reference to its above recited four variations.

### *Variation* a

The apparatus is located in direct horizontal succession to the spinning machine shown in Fig. 1. All the fiber bundles 59 produced on the entire machine are discharged from housing 2 and conducted by conveyor rollers 58, if the produced capillary threads do not possess a sufficient rough or crimped surface or the required interfiber friction to obtain a strong yarn, into a trough 66 which is provided with a jacketed heating wall 67. A cylinder 68 is rotatably mounted in the trough to transport the fibers through the same. An appropriate oil, for instance an oil used in blending wool, is charged into the trough and maintained therein at a suitable temperature and at a constant level. A finely divided non-slip resin or a similar compound may be added to the oil capable to assist in the production of the above mentioned surface configuration. The fiber bundles are further transported by a pair of rollers 77, 78. These rollers squeeze out the surplus oil. They are provided with heating means and with teeth or projections 79 which exert upon the fibers passing between them, if required, a crimping or goffering action.

When the yarn to be produced does not require oil treatment or treatment with similar agents, it may be nevertheless advisable to use rollers 77, 78 in order to produce the above referred to crimping action.

The fiber bundles 59 are then transported to a roving or drawing frame. The type of this frame may be chosen in conformity with the length and the character of the staples to be cut and the kind of yarn to be produced. Before entering this drawing frame 80 the fiber bundles are conducted in an unstretched state by smooth transport rollers 81 to a conically shaped smooth bar 82 which segregates or spreads out the fibers of each bundle, and brought with the aid of rollers 83, 84 working in cooperation with an adjustable transport device 86 to the roving frame 80 to effect the further transport of the fiber in each bundle in a substantially straight parallel alinement into the frame 80 which is provided with three pairs of rollers 88, 89, 90.

Before the fibers of each bundle reach the drawing frame 80 they are cut by cutter 85 into staples of desired length. The knife is adjustably mounted on its support in order to cut the fibers of each fiber bundle separately into equal sections 87 of a required length, which are diagrammatically shown in Figs. 7 and 8; during the passage of the cut fibers over the transport device 86 a lengthwise mutual displacement is effected of the same whereby overlapping ends are produced, shown by dotted lines 119 in Figs. 7 and 8. This purpose may be accomplished by varying the circumferential speed of rollers 83, 84 and of the first pair of rollers 88 of the drawing frame 80. The formation of the overlapping ends of the cut fibers is important as this results in a greatly improved coherence of the staple fibers.

The cutter for each fiber bundle may be provided with two inclined cutting edges forming between each other an approximately right angle; accordingly shaped cuts 118 are produced, as shown in Fig. 7.

The staple fibers of each individual bundle or a plurality of the same provided with overlapping ends forming a kind of a ribbon are conducted separately into the drawing frame represented by three roller pairs 88, 89, 90 where a synthetic fiber intermediate, such as a top, sliver, roving, respectively is produced from each of the ribbons. The intermediates are transported by a pair of transport rollers or other transport devices 91 to twisting spindles of customary design, such as flyer 92 where they are converted into yarns.

For special purposes, e. g., the production of very fine spun synthetic fiber yarns of, for instance, 150 den. two installations of the type shown in Fig. 6 may be arranged in vertically superposed relationship one above the other. This modification of the invention is shown in Fig. 11. The cutters 85 of the two superposed installations are so mounted as to cut in diagonally opposite directions.

Numbering adjacent fiber bundles with current numbers 1, 2, 3 and so forth, as shown in Fig. 2, the fiber bundles with numbers 1, 3, 5 each composed, for instance, of 50 fibers to produce 50 den., are cut in the lower equipment and produce bands of parallelly alined staple fibers cut in a shape indicated as group A in Fig. 8. The fiber bundles numbered with even numbers 2, 4, 6 ff. are cut in the upper equipment where the cutter is located nearer to the rollers 83, 84, and, therefore, severs the fibers at a shorter distance from the rollers than in the lower equipment; the bands of staple fibers produced thereby are illustrated schematically as group B in Fig. 8. In order to obtain yarn of 150 den., the bands of the staple fiber bundles 1, 2, 3 are combined after emerging from the transport rollers 91 of the upper equipment (Fig. 11), to form a sliver consisting of two bands shaped as shown in group B and one band shaped as shown in group A and sandwiched into a staggered product which is converted into a twisted yarn by the flyer 92.

The twisting may also be accomplished with a ring twisting spindle 95, the roving being brought directly through the drafting rollers 94 to the twisting spindle 95 and wound on the bobbin 96 shown in Fig. 12. The thus alined overlapping sandwiched and staggered staple fibers which with their spliced ends grab the neighboring fibers in the manner of fangs, will even in the case of a fine product, as a 150 den. spun staple fiber yarn is, result in the production of a thread having a tensile strength and evenness which is not obtainable with any other system producing spun fibers.

### *Variation* b

Yarns of partly cut fibers and partly of continuous fibers can be produced:

(1) By using only the lower cutting equipment and cutting in the same, for instance the uneven numbered bundles 1, 3, 5 ff., sandwiching between two of them one continuous fiber bundle of the even numbered bundles 2, 4, 6 ff. from the upper system, and conducting the same directly to the twisting device,

(2) By using one band of cut fibers and one continuous fiber bundle,

(3) By using two uncut continuous bundles and one band of cut fibers,

(4) By cutting with the upper or lower or both equipments all bundles and guiding the bands of one or more fiber bundles through the respective drawing and roving frames, adding before or during the twisting of the same a continuous untwisted or twisted thread of the same material fed from reels 116, 117, shown in Fig. 12.

### *Variation* c

In case the thread to be produced should consist of, for instance, 25% wool, 50% viscose and 25% of acetate and the finished thread to be of the size corresponding to, for instance the size of a thread of 1000 den., then the fibers to be extruded from each spinnerette to be of 250 den. and each of the two rovings or slivers wound on appropriate bobbins or reels 250 den. The two kinds of rovings are united with the band of fibers and lead simultaneously through the drawing, roving and twisting devices, as shown in Fig. 12. In this case the roving consisting of the three different materials after leaving the upper rollers 91 are led through the lower rollers 91 to the flyer 92 as indicated by the dotted line, and not to the upper twisting spindle and bobbin 94, Fig. 12.

*Variation* d

It is obvious from the foregoing that my invention embraces also the manufacture of products listed as variation *d* even though the same are not converted into finished spun yarn, the essence of my invention being the production by an uninterrupted direct or continuous process on a new type of equipment at a high speed of endless or continuous untwisted synthetic fibers with the enumerated properties which are wound simultaneously in great length on special carriers and without unwinding can be used as such directly on textile machines or simultaneously twisted and wound as finished threads in great length on appropriate carriers for the direct use on textile machines; furthermore, after having been eventually crimped, dried, etc., during their production cut into staple fibers and transformed in the same operation into staple fiber intermediates, such as rovings or slivers possessing a predetermined number of fibers and denier, the production being carried out in a horizontal equipment on which the path of coagulation, the degree of stretching, shrinking, the time of treating, drying, etc., can be varied at will.

Due to the continuity of my horizontal process an access to the precipitation bath is only required if and when a spinnerette must be renewed. The parts of the machine where gases, bad odors, vapors or the like are generated, are entirely enclosed by housing 2 and efficiently ventilated, access to each enclosed part being provided by openings like 110. The bobbins or reels when filled with yarns are exchanged for empty ones at the far end of the machine when the fibers are finished and dried.

The same advantages are achieved when fibers are produced from masses which are solidified by air or other gases.

It is admitted that in the latter case the manufacture may be carried out at a higher speed than by the wet spinning process on the standard vertical machines; however, all of the above cited drawbacks adherent to the vertical system requiring drawing, stretching etc., of each individual thread by many separately driven devices and the high costs of such machines remain at a considerably increased rate. On the other hand, the above referred to advantages of my process and the possibility to improve the quality of the threads during their production by the easy variation of the positive stretching and/or shrinking action, by the impregnating, sizing or other treating action performable as one continuous operation with the cutting of the fibers and their conversion into yarn of spun fibers are not obtainable in the hitherto customary system of vertical spinning.

In addition to the advantages and the advance in the art derived from the use of my invention in connection with the wet spinning processes the important advantage of improved sanitary conditions must be considered.

When in the performance of the present vertical methods a bobbin or a pot is filled with threads, each of the many thousands of the still acid threads must be cut and the completed bobbins or pots must be replaced by empty ones. Depending on the size of the yarn and the production speed such operations must be performed very often, sometimes every thirty minutes. The working personnel is at each exchange manipulation exposed to the injurious action of the fumes, bad odors and gases developed from carbon disulphide and other agents given up by the viscose and/or cuprammonia, protein and the like spinning solutions, when the same enter in the coagulation bath. Everybody who is familiar with this industry is well aware of the great number of workmen in the rayon industry suffering especially from eye and similar illnesses.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is understood that I do not limit myself to the specific embodiment thereof shown and described in the specification.

It is also understood that my invention is equally applicable to all methods and apparatus where spinning masses are extruded into a solidifying medium to produce synthetic fibers.

I claim:

1. A method for the continuous production of synthetic filaments comprising extruding a spinning solution through adjacent spinnerettes into a coagulating bath, producing by adjustment of the concentration of the bath ingredients partially coagulated filaments while maintaining the same in the bath in a separated horizontal and unsupported position, drawing the partially coagulated filaments by a multi-roller unit through at least one additional coagulating bath to complete the coagulation, hereupon drawing the completely coagulated filaments by a multi-roller unit through at least one after-treating bath to produce the finished filaments, maintaining the filaments in the said additional coagulating bath and in the after-treating baths in the separated unsupported horizontal position and under tension and subjecting the filaments during their passage through the multi-roller units to a successive stretching and shrinking action by said rollers.

2. A method for the continuous production of synthetic filaments comprising extruding a spinning solution through adjacent spinnerettes into a coagulating bath, producing by adjustment of the concentration of the bath ingredients partially coagulated filaments while maintaining the same in the bath in a separated horizontal and unsupported position, drawing the partially coagulated filaments by a multi-roller unit through at least one additional coagulating bath to complete the coagulation, hereupon drawing the completely coagulated filaments by a multi-roller unit through at least one after-treating bath to produce the finished filaments, maintaining the filaments in the said additional coagulating bath and in the after-treating baths in the separated unsupported horizontal position and under tension and subjecting the filaments during their passage through the multi-roller units to a stretching action by said rollers and to a shrinking action.

3. A method for the continuous production of synthetic filaments comprising extruding a spin-

ning solution through adjacent spinnerettes into a coagulating bath, producing by adjustment of the concentration of the bath ingredients partially coagulated filaments while maintaining the same in the bath in a separated horizontal and unsupported position, drawing the partially coagulated filaments by a multi-roller unit through at least one additional coagulating bath to complete the coagulation, hereupon drawing the completely coagulated filaments by a multi-roller unit through at least one after-treating bath to produce the finished filaments, maintaining the filaments in the said additional coagulating bath and in the after-treating baths in the separated unsupported horizontal position and under tension and subjecting the filaments during their passage through the multi-roller units while still containing the coagulating liquids to a successive stretching and shrinking action by said rollers.

4. A method for the continuous production of synthetic filaments comprising extruding a spinning solution through adjacent spinnerettes into a coagulating bath, producing by adjustment of the concentration of the bath ingredients partially coagulated filaments while maintaining the same in the bath in a separated horizontal and unsupported position, drawing the partially coagulated filaments by a multi-roller unit through at least one additional coagulating bath to complete the coagulation, hereupon drawing the completely coagulated filaments by a multi-roller unit through at least one after-treating bath to produce the finished filaments, maintaining the filaments in the said additional coagulating bath and in the after-treating baths in the separated unsupported horizontal position and under tension and subjecting the filaments during their passage through the multi-roller units to a multiple stretching and shrinking action by said rollers.

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