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F. C. ATWOOD

2,370,765

SPINNERETTE

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Fig. 1

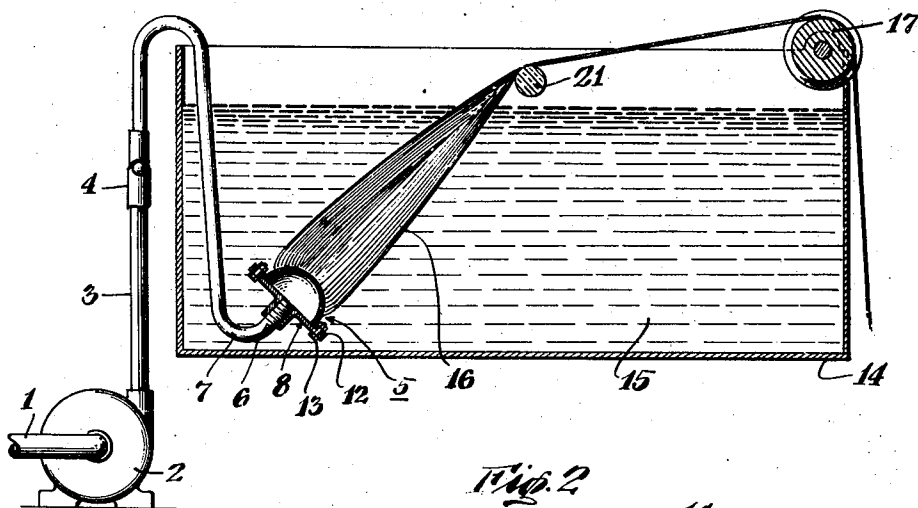


Fig. 2

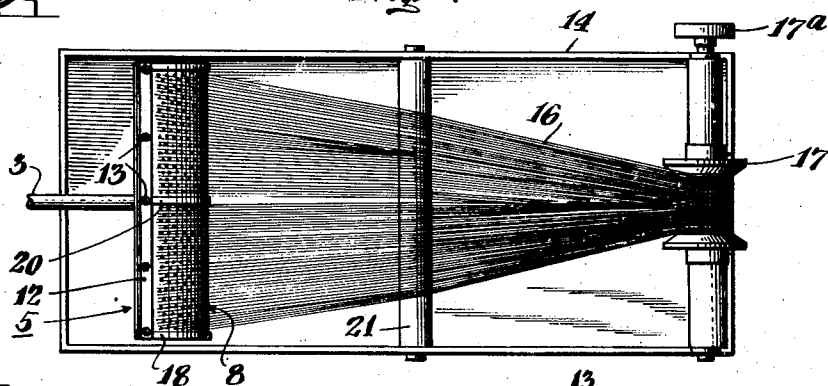


Fig. 4

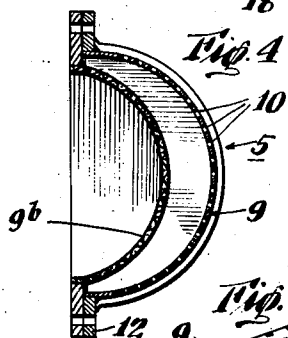


Fig. 3

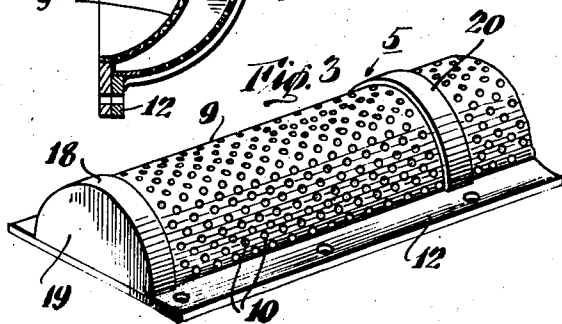
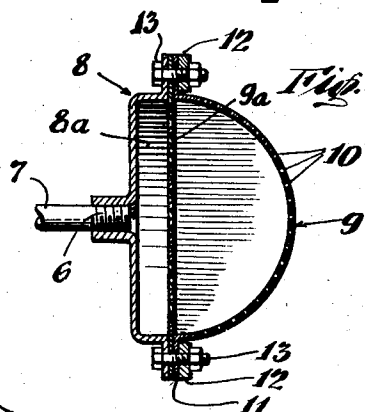


Fig. 5



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SPINNERETTE

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5 Claims. (Cl. 18-8)

This invention relates to spinnerettes and, more particularly, to an improved form of spinnerette to be used in the simultaneous production of a relatively large number of artificial fibers or filaments from protein, cellulosic or other solutions. The spinnerette is primarily adapted for use in a process in which the spinnerette is immersed in a coagulating bath and the fiber or filaments are extruded directly in and through said bath.

It has been found that the spinnerettes as heretofore made are unsatisfactory for the formation of a large number of fibers or filaments in a continuous operation. This is due primarily to the fact that the prior art spinnerettes, which for the most part have flat or spherical surfaces, are incapable of being increased in size without greatly decreasing their strength and efficiency in operation.

As indicative of the problem involved, the perforated portion of the nozzle must be formed out of a very thin material in order to facilitate the punching or boring of holes in said material. Thus, if the spinnerettes in the shapes previously known are made larger so as to be capable of producing simultaneously a larger number of fibers or filaments, it has been found that the material of the nozzle will not withstand the necessary extrusion pressure. In order then to adapt the previous form of spinnerette to fulfill the present demand of the trade, it is necessary to place the holes very much closer together, to increase the thickness of the material forming the nozzle, or to use a large number of small spinnerettes.

If the first mentioned expedient is resorted to, namely, placing the holes closer in a spinnerette of a shape heretofore used, it is found that great difficulty is encountered in properly coagulating the fibers. The bath does not come into contact sufficiently with the fibers with the result that they frequently run together and the final product is not uniform. This is particularly true in the art of spinning synthetic protein fibers from casein inasmuch as the extruded fibers coagulate at a relatively slow rate.

If the second mentioned expedient is followed, namely, increasing the thickness of the perforated portion of the nozzle, the cost of forming the holes is increased. I have found that the relationship between the thickness of the spinnerette head and the diameter of the orifices is preferably not greater than two to one, if the holes are to be formed expeditiously by punching. Thus, since the diameter of the orifices is one of the factors determining the size of the final product, which is preferably as small as possible, and since the

thickness of the spinnerette head is dependent on the diameter of the orifices, it is apparent that a thick material for the spinnerette head can not be employed when the desirable small diameter fibers are to be manufactured. This is another limitation which rendered the prior art spinnerettes unsuitable for producing a large number of fibers simultaneously, particularly when the product desired was of a relatively fine nature. It would be impossible to enlarge the prior art spinnerettes so that they would be capable of producing the large number of fibers without, at the same time, so increasing the thickness of the perforated portion of the nozzle that they would be unsuitable for extruding relatively fine fibers.

The adoption of the third expedient, namely, using a large number of spinnerettes, is expensive, space consuming, and is particularly disadvantageous in that it results in a lack of uniformity of the fibers.

Furthermore, it has been found that in spinnerettes of the shapes heretofore made, other than planar, the boring or punching of holes is a difficult and costly procedure, due to the fact that the holes have been bored or punched after the nozzle has been made into its spherical or other shape.

Accordingly, an object of my invention is to provide a spinnerette having very small holes for extruding simultaneously an unlimited number of filaments, for example, of the order of as high as 8,000 to 10,000 or more, and which is capable of withstanding the usual fluid pressure applied thereto.

An additional object of my invention is to provide a spinnerette of such form and shape as to permit a more close spacing of the holes without interfering with the proper manufacture of the fibers.

A further object of the invention is to provide a spinnerette having any desired large number of apertures, in which said apertures are sufficiently spaced so that substantially all the fibers or filaments extruded therefrom will come into sufficient and substantially equal contact with the coagulating bath, whereby blobbing or running together of the fibers will be reduced to a minimum.

Still a further object of the invention is to provide a spinnerette adapted to extrude synthetic filaments in such a manner that any broken or stray fibers will be carried along by the other fibers and thus not accumulate in the bath and interfere with or impede the withdrawal of the fibers.

More specifically, it is an object of my inven-

tion to provide a spinnerette substantially semi-cylindrical in shape in which the diameter is relatively small as compared with the length and which diameter is relatively the same for different sizes of spinnerettes, the increase in size being obtained by an increase in length.

Another object of the invention is to provide a spinnerette having the desirable characteristics described above and which is relatively inexpensive and easy to manufacture.

Additional objects of the invention will be apparent from the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a front view, partly in cross section, of the spinning apparatus in assembled position;

Figure 2 is a plan view of part of Figure 1;

Figure 3 is a view in perspective of one form of the spinnerette head;

Figure 4 is a sectional view of the spinnerette head shown in Figure 3; and

Figure 5 is an enlarged cross sectional view of the spinnerette shown in Figure 1.

Referring to the drawing, the spinnerette is adapted to be used in a process and apparatus in which the spinning solution or vehicle is conveyed through a pipe 1 from any suitable supply source (not shown in the drawing) and forced under pressure by means of any suitable pumping device 2 through a pipe 3 to the spinnerette 5. The pipe 3 is formed with a variable joint 4 whereby the position and angle of the spinnerette 5 may be regulated within the tub 14. The neck 7 of the pipe 3 is attached to the distributor head 8 of the spinnerette by any suitable means such as by a screw thread as indicated at 6. The extruded filaments 16 are drawn by the withdrawing roller 17 through the coagulating bath 15 over the rod 21. The roller 17 may be power driven at a desired speed by means of pulley 17a. The roller 17 may be of the type shown in Figure 2 whereby the filaments are gathered together in a large strand.

In Figure 5, which is an enlarged view of a spinnerette similar to that shown in Figure 1, the spinnerette head 9, with radial holes 10 therein, is secured to the distributor head 8 by means of frame 12 and bolts 13. This may be accomplished, for example, by welding the longitudinal edges of spinnerette head 9 to form flanges 11, which are securely engaged between frame 12 and distributor head 8. In the drawing the size of holes is greatly enlarged for illustration, and in practice they are about 100 to 125 microns in diameter.

The distributor head 8 as illustrated in Figure 5 is formed with a recessed portion 8a. This construction has the advantage of providing a larger volume within the spinnerette and facilitates the equalization of the pressure in the fluid being extruded, a factor which is significant as will be seen from subsequent discussions. The recessed portion also makes it possible to employ a screen 9a which is secured between the distributor head 8 and the flanges 11 of the spinnerette head. This screen is effective for filtering out any foreign material or solid objects that may possibly be present in the spinning solution and obstruct the holes in the spinnerette or causes weak points in the fiber. In general a screen having a mesh size less than the size of the opening in the spinnerette head is employed. For example, an opening in the spinnerette having a diameter of 100 microns would correspond to a screen having 140 meshes to the inch. Since these meshes are more

or less rectangular, it is desirable to use a screen in which the diagonal of the screen opening is less than 100 microns. It is desirable, therefore to employ a screen having about a 200 mesh for use with a spinnerette having openings of 100 microns in diameter. Such a screen would remove from the solution any material that is likely to clog the holes of the spinnerette. The screen also assists in the equalization of the pressure of the spinning solution. Such screens have the advantage of eliminating the so-called "candle" filter which is normally employed in the rayon industry and located in the pipe line leading from the pump of the spinnerette.

In Figure 4, a modification of the screen is illustrated in which the screen surface 9b is curved so as to have a shape conforming to the contour of the spinnerette head 9. A screen of this type is advantageous in that it may be employed with a distributor head not containing a recess such as illustrated in Figure 1, but may also be employed with the distributor head of the type illustrated in Figure 5.

In the construction shown in Figure 3 the ends of the spinnerette head 9 are welded or soldered to the inner surface of the end bands 18 which bands in conjunction with the end piece 19 of the frame 12 hold the ends of the spinnerette head in place and seal the end portions of the spinnerette.

An optional construction is also illustrated in Figure 3 and comprises the reinforcing bands 20 positioned at suitable distances along the length of the spinnerette head to impart rigidity to the structure. Since the extrusion pressure on the perforated portion is transmitted primarily to the longitudinal portion 12 of the frame, the pressure at any point is the same irrespective of the length of the spinnerette, and the bands are not essential. They do, however, assist in imparting ruggedness to the spinnerette.

If the reinforcing bands 20 are employed, their position is governed in part by the thickness of the perforated portion of the spinnerette. Thus, since a fine fiber requires a relatively thinner head, the bands 20 would preferably be somewhat closer together in a spinnerette constructed to produce a fine fiber. In general, it has been found that the bands 20 may be spaced to advantage at not closer than twice the diameter of the head. Spinnerettes having a length of four or five times the diameter have been constructed without reinforcing bands, and the spacing of the bands, therefore, may be at least this great and is not critical. These bands have also been found very advantageous in breaking up the extruded fibers into blocks and leaving channels into which the coagulating liquid can freely flow between said blocks and thus come into more efficient contact with the extruded fibers.

It has been found that the substantially semi-cylindrical shaped head, aside from allowing an indefinite extension in size of the spinnerette through extension of length, with the resulting capability of forming any predetermined number of fibers simultaneously, also provides a much more uniform and thorough coagulation of the extruded fibers. This is due in part to the extended length of the spinnerette head which enables a large number of fibers to be extruded in a relatively thin sheet. Thus the coagulating bath may come into contact with all of the fibers in a very uniform manner and is not impeded in its contact with the innermost fibers as was the case with the prior art spinnerettes.

The uniformity of coagulation of the fibers may be further simplified by a radial positioning of the orifices. In this way, the fibers are naturally separated a sufficient distance from each other when they first come in contact with the bath to allow easy access of the bath to every fiber, and also to allow each fiber to become sufficiently fixed by the bath before coming in contact with other fibers so that blobbing or running together is reduced to a minimum. Particularly with reference to the spinning of synthetic protein fibers from casein, it has been found that because of the improved shape of the head and the radial positioning of the orifices it is possible to effect perfect coagulation with practically no blobbing or running together, even though the holes are formed as closely together as six to eight hundred to the square inch.

The fabrication of a spinnerette formed in accordance with my invention is easier and more economical than the manufacture of those of the prior art. The material forming the head may be drilled or punched while in sheet form, with the holes perpendicular to the plane surface of the sheet. Thus, the holes automatically become radial to the axis of the head when the sheet is bent into the desired semi-cylindrical form. The sheet thus prepared may then be secured to the supporting frame 12 at end bands 18 and at the reinforcing bands 20 as already described. The longitudinal edges are either welded or soldered to the side pieces of frame 12 or clamped by means of flange 11 to the distributor head 8, as shown in Figure 5.

It is thus seen that my improved spinnerette, in addition to permitting a large number of orifices so spaced as to make coagulation effective, presents a well sealed, strong construction which is not susceptible to distortion or bulging. The shape of the head is normally the most extended shape that the head can assume, and as the material of the head is well secured along its edges, no distortion or bulging is possible, and the spinnerette retains its shape throughout its life.

Furthermore, the head furnishes a large enough reservoir within the spinnerette to insure an equal extrusion pressure throughout the spinnerette and thus provides for a uniform extrusion speed at all parts of the head. This is not possible with a number of small spinnerettes in which the pressure may vary. In the event that a relatively elongated head is used, it is a mere mechanical detail to provide a larger reservoir behind the perforated surface to equalize the pressure. This may be done in the manner shown in Figure 5 or by making the head 8 concave in shape. Alternatively, a plurality of supply pipes 3 may be spaced at sufficient distances along the back of distributor head 8 to insure an equal extrusion pressure throughout the head from a common source under pressure. Alternatively a header or feeder pipe may be provided within the head of the spinnerette with outlets so regulated and positioned that the volume of the spinning solution will be delivered uniformly throughout the head of the spinnerette. The distributor pipe within the spinnerette head can be connected to a single supply pipe.

It has been found that with the spinnerette of my invention, the tendency of broken fibers to separate from the main body or mass of fibers and eventually build up and impede the operation of the process, is greatly lessened. The fibers which are most prone to wander are those that lie in a relatively straight position between the

spinnerette and the withdrawing roller, namely, the fibers extruded from the centrally located holes of the spinnerette. This may be due in part to the fact that these fibers are farther from the bulk of the coagulating bath, and the coagulating liquid reaching the center fibers may be partially depleted in passing through the outer fibers. However, this action is reduced to a minimum in accordance with my invention because of the narrow lateral dimension. The fibers extruded from the outer holes, due to their curved path in the bath, exert a policing action whereby broken fibers are caught up and carried along by the main body or mass of fibers, and thus are kept from accumulating and necessitating the periodical cessation of operation to remove them.

A further advantage of a spinnerette formed in accordance with my invention is that a major proportion of the extruded filaments, particularly those at the sides, are withdrawn from the spinnerette at an angle to the orifices therein. The extrusion pressure upon the solution is generally sufficient to force the solution a little distance away from the spinnerette before it is turned in the direction of pull on the fibers. The curving in of the filaments as they are spun tends to draw fluid into the center of the mass of fibers, thus setting up a circulation which brings a supply of fresh coagulating liquid to the inner fibers. This effect is particularly desirable in the art of spinning synthetic fibers in which the coagulating liquid exerts a chemical action, that is to say, is used up as coagulation takes place. It is desirable that each fiber be subjected to a volume of coagulating liquid of uniform density and composition to insure uniformity of the fibers being produced.

In accordance with my invention, the spinnerette may be formed of any of the metals commonly used in apparatus of this type. The inert metals such as gold, platinum, and tantalum may be used effectively, except that the same are easily abraded and are difficult to fabricate, particularly where soldering is required. Satisfactory results may be obtained with heavy metals, such as brass, particularly if they are given a plating of metal such as nickel, which because of its passivity will not be affected by the coagulating bath.

In a process for the manufacture of staple fibers, in which process the fibers are cut into staple lengths at some stage in their manufacture, the production of fibers that are uniform as to diameter and other properties is exceedingly important, and the ability to spin fibers having such uniformity is aided in a large measure by the use of a spinnerette capable of spinning from 5,000 to 10,000 fibers simultaneously, accompanied by more effective and uniform coagulation.

In producing fibers of very small diameter, a spinnerette producing simultaneously a large number of fibers simultaneously is also an important element. One of the most advantageous ways of obtaining fiber of a smaller diameter is to split or subdivide a definite amount of the fiber forming solution into a greater number of fibers. Assuming that the amount of spinning solution applied to a spinnerette is constant, then a spinnerette with a larger number of holes must produce fibers with a smaller diameter regardless of the size of the opening. While it is true that other factors will affect the diameter of the fiber such as the pressure applied to the spinning solution, the rate of withdrawal of the formed fibers,

etc., it has been found that by keeping all these other factors constant and by increasing the number of openings in the spinnerette, the desired smaller fibers having greater strength and other desirable properties are more easily obtained.

It is obvious that semi-elliptical, parabolic and other contours may similarly be advantageous in forming the spinnerette, and I intend these to be included in the expression "substantially semi-cylindrical."

It will also be apparent that the above described spinnerette may be subjected to variations within the scope of my invention and it is to be understood that all the equivalent changes to which the form and method are susceptible are included in my invention as defined and set forth in the appended claims.

I claim:

1. A spinnerette comprising a base, a head substantially semi-cylindrical in shape the diameter of which is relatively small as compared with its length, and along the length whereof there are positioned reinforcing bands, at a distance of at least twice said diameter, said head being formed of a thin sheet of metal with holes therein radial to the axis of said semi-cylindrical head and spaced substantially of the order of at least four hundred to the square inch, the thickness of said thin sheet metal being about twice the diameter of said holes, means for securing the base to the head with the head protruding outwardly from the base and forming a reservoir therebetween, at least one supply pipe connected with said base and of sufficient size to maintain an equal extrusion pressure throughout the reservoir in said spinnerette.

2. A spinnerette comprising a base, a substantially semi-cylindrical head composed of a sheet of metal sufficiently thin to be provided with orifices having a diameter of the order of about 100 to 125 microns positioned radially with respect to the axis of said head and spaced substantially of the order of at least four hundred to the square inch, the thickness of said sheet of metal being approximately twice the diameter of said orifices, means comprising an orifice for admitting the fiber forming material to the spinnerette, and means for firmly securing said head to the base of the spinnerette with the head protruding outwardly from said base.

3. A spinnerette comprising a base, a substantially semi-cylindrical head composed of a thin sheet of metal with a plurality of minute orifices

therein through which the fibers are extruded, said orifices being radial with respect to the axis of said head, substantially semi-cylindrical bands positioned along the length of said head, the inner surface of said bands engaging the outer surface of said head to reenforce the same, a frame to which the bands and the head are affixed to support the same and by means of which the head is attached to the base, end pieces engaged with said frame, and at least one supply pipe connected with said base through which the spinning solution is supplied and maintained at an equal pressure throughout the interior of said spinnerette.

4. A spinnerette comprising a base, a head substantially semi-cylindrical in shape the diameter of which is relatively small as compared with its length, said head being formed of a thin sheet of metal with not less than 5,000 holes therein radial to the axis of said semi-cylindrical head, the metal composing the substantially semi-cylindrical head being sufficiently thin to be provided with holes spaced substantially of the order of not less than four hundred to the square inch and less in thickness than twice the diameter of said holes, a supporting frame to which said head is adapted to be fastened and by which said head is secured to the base of the spinnerette with said head protruding outwardly from said base and forming a reservoir therebetween, at least one supply pipe connected with said base and of sufficient size to maintain an equal extrusion pressure throughout the reservoir in said spinnerette, and means for fastening said head to said base.

5. A spinnerette for forming fibers, comprising a base, a substantially semi-cylindrical head piece composed of a thin sheet of metal with radially extending flanges along the opposite edges thereof and having the portion thereof between said flanges provided with a plurality of rows of minute orifices therein through which the fiber forming material is extruded, said orifices being radial with respect to the axis of said head piece, a frame to which the flanges on said head piece are adapted to be affixed and by means of which the head piece is attached to and supported by the base with said head protruding outwardly from said base, end pieces engaged with said frame and head piece, and means including at least one supply pipe connected with said base through which the fiber forming material is supplied and maintained at an equal pressure throughout the interior of said spinnerette.

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