

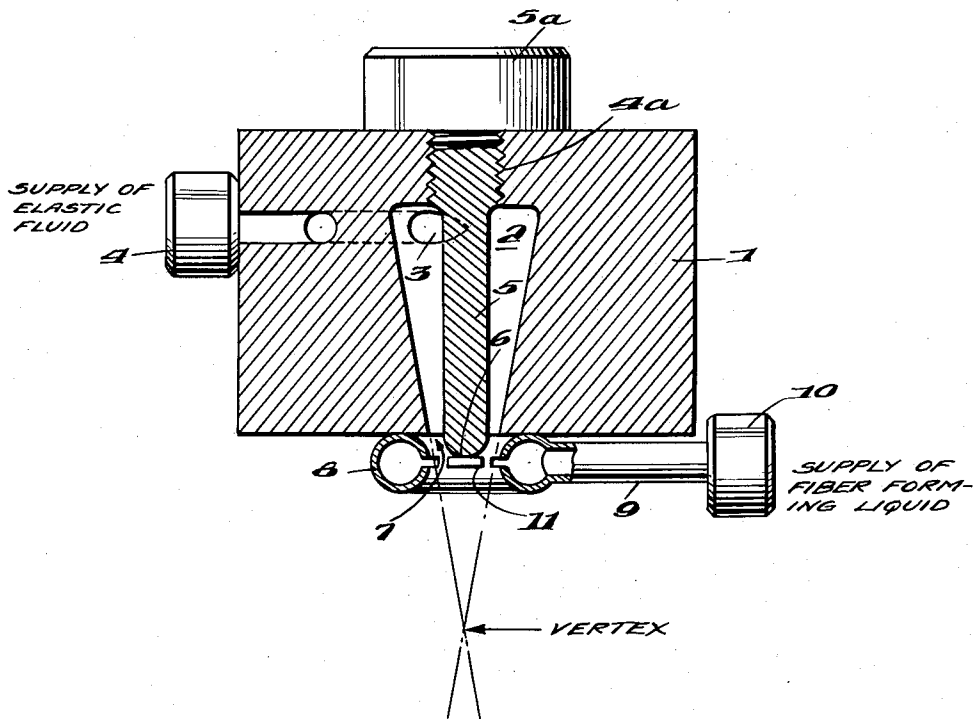
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METHOD AND APPARATUS FOR PRODUCING FIBERS

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METHOD AND APPARATUS FOR PRODUCING FIBERS

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7 Claims. (Cl. 18—2.5)

This invention relates to a fiber-forming nozzle and a method for the economical production of fine fibers from fiber-forming liquids, such as inorganic glass and organic plastics.

Fibers, particularly from inorganic glass, have heretofore been produced by several processes which include flowing a stream of fiber-forming liquid into a blast of steam or air. The stream is disrupted into a multiplicity of particles by the atomizing action of the blast. Most of these particles are then attenuated into fibers by the force of the blast. The production of fine fibers of a relatively uniform quality by these processes is difficult and expensive for several reasons. The stream of fiber-forming liquid must have a very low viscosity to minimize solidification before the fibers are formed. With materials solidifying at high temperatures, such as inorganic glass, intensely hot auxiliary gas is sometimes used to envelop the fiber-forming liquid and the blast of air or steam in order to maintain a sufficiently high temperature within the space in which the fibers are formed. This necessitates the use and the concomitant expense of large quantities of intensely hot auxiliary gas. With heat-softenable materials, such as synthetic organic resins, these processes are, in general, not suited for the production of fine fibers of a uniform quality. Such materials usually do not have a sufficient thermal stability to convert them into the required fiber-forming liquids having a low viscosity. From a more basic point of view, these processes do not lend themselves particularly to the production of any fine fibers of a very uniform quality. They operate on the principle that the fiber-forming liquid is initially shattered into particles by the force of the stream of air or steam, whereupon the individual particles are attenuated into fibers by the force of the blast in a haphazard manner. These processes lack, therefore, the element of a smooth drawing action on the body of fiber-forming liquid to form the fibers.

A primary object of the present invention is the production of fine fibers from fiber-forming liquids, such as inorganic glass and organic resins, by a process which is free of the above difficulties and limitations.

One of the principal objects of this invention is to provide a fiber-forming nozzle wherein the fiber-forming liquid is supplied peripherally to a stream of an elastic fluid which proceeds in a spiral path at a very high velocity. This arrangement greatly minimizes the shattering of the fiber-forming liquid into a multiplicity of particles inasmuch as the fibers are pulled and drawn directly from the body of the fiber-forming liquid into the rotating stream of elastic fluid.

Another object of this invention is to provide means whereby fibers are drawn out to fineness by traveling in a long spiral path of elastic fluid merely to a short distance away from the body supplying the fiber-forming liquid. This feature is particularly advantageous with materials solidifying at a high temperature, since the size of the space in which the fibers are drawn is kept at a minimum

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and, therefore, the loss of heat from this very small space is also kept at a minimum.

A further object of this invention is to produce inherently curled fine fibers by drawing them out in a spiraling elastic fluid. This increases the usefulness of such fibers for many purposes over fibers being substantially straight, as is well known in the art.

A still further object of this invention is to supply fiber-forming liquid to be drawn out to fibers at any desired practical viscosity to a spiraling stream of elastic fluid, which latter may be heated substantially above the temperature of the fiber-forming liquid. This feature is particularly useful in producing fibers from organic fiber-forming liquids which may be supplied at a low enough temperature to preclude substantial thermal decomposition of the material.

The foregoing as well as other objects will become more apparent as this description proceeds, especially when considered in connection with the accompanying drawing forming a part of this specification.

The figure of the accompanying drawing is a longitudinal section through a fiber-forming nozzle for practicing the method of the invention. The preferred nozzle comprises a body 1 having a hollow frusto-conical chamber 2 on the inside and having an inlet 3 for an elastic fluid opening tangentially at the larger end of said chamber with a coupling 4 to couple a supply pipe of elastic fluid (not shown) to the nozzle. The elastic fluid supplied may be compressed air, steam, nitrogen or other gas or vapor, which does not chemically interfere with fiber and/or filament formation from fiber-forming liquids under the conditions obtaining. Generally, the elastic fluid will be heated. The nozzle body 1 may be insulated by a layer of insulation (not shown) against heat loss. For higher operating temperatures of the nozzle, a heating element (not shown) is preferred to and is used in place of the insulation. Arranged coaxially of the nozzle and screwed into the nozzle body 1 as at 4a is a straight rod 5 having its free end 6 rounded off and projecting slightly beyond the discharge opening 7 in the nozzle. Rod 5 has an enlarged head or cap 5a by means of which it may be screwed tight or removed for inspection when desired. Discharge opening 7 is a narrow annular opening defined by the inside walls of body 1 at its smaller end and the outer wall of rod 5. It will be noted that this discharge opening is directed toward a point outside the nozzle marked "Vertex" which is the vertex of the cone that coincides with the inner frusto-conical walls of chamber 2. Concentrically with and near discharge opening 7 is a feed tube 8 bent to a full circle and having a slightly greater inside diameter than the outside diameter of discharge opening 7. Feed tube 8 has a supply tube 9 and a coupling 10 connecting the feed tube to a supply pipe of fiber-forming liquid (not shown). Small discharge openings 11 in the inside wall of feed tube 8 facilitate the feeding of fiber-forming liquid to the elastic fluid to be drawn out to fibers.

Referring now to the operation of the nozzle as shown, it will be noted that the nozzle delivers a rotating flow of elastic fluid which travels at a high velocity and may attain supersonic velocity, toward a point outside the nozzle termed the "vertex," and near this "vertex," fiber-forming liquids are readily drawn out to form fibers and/or filaments of varying lengths and degrees of fineness. It will be understood that this phrase "near the vertex" includes any and all points along the cone having its tip at the "vertex" and its base at the discharge opening 7. The aspirating force of the spiraling elastic fluid, which latter is discharged from the nozzle through discharge opening 7, draws fibers into the spiraling elastic fluid from the supply of fiber-forming liquid at discharge openings 11 in feed tube 8. For feeding an

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organic fiber-forming liquid, such as, for instance, polystyrene, polyethylene or the like, coupling 10 may be connected to a plastic extruder delivering a viscous melt of the thermoplastic to be drawn out to fibers, in the manner well known in the art. Feeding of organic thermoplastics by gravity may be employed in those instances in which the plastics may be heated to a liquid of low viscosity without substantial thermal decomposition. For this purpose, the nozzle assembly shown in the accompanying figure in a vertical position may be arranged horizontally, and the coupling 10 may be coupled to a pipe connecting it with a supply of liquefied thermoplastic.

To produce fibers from inorganic glass, the nozzle body 1 and the rod 5 are preferably made of a heat resistant material, such as silicon carbide, while the feed tube 8 and supply tube 9 are preferably made of platinum-rhodium alloy. In this case, it is advantageous to install the nozzle assembly in a chamber which may be heated by any suitable means, such as gases of combustion, to eliminate or minimize heat loss from the assembly. The chamber (not shown) has in its bottom an aperture through which the fibers issuing from the nozzle assembly and waste gases may escape. For producing fibers from inorganic glass, the nozzle is coupled, at coupling 4, to a supply of intensely hot elastic fluid, such as gases of combustion.

Turning now to the term "fiber-forming liquids," useful for practicing this invention, it will be understood that this category includes inorganic glasses, organic thermoplastics, and in general those materials which are heat-softenable and which are capable of forming fibers and/or filaments when introduced as a melt into a blast of elastic fluid. Lowering the viscosity of the fiber-forming liquid to a value approximately between 10 and 100 poises renders it possible to produce large quantities of micro-fibers from a single fiber-forming nozzle of this invention. Thus, a nozzle with a discharge opening 7 of one quarter of an inch in outside diameter and a width of approximately 500 microns will deliver fibers with average fiber diameters from about 5 to 10 microns at a rate of approximately 20 pounds of inorganic glass and 7 pounds per hour of low or medium molecular organic thermoplastic, respectively. It has been found that apertures 11 in feed tube 8 are preferably made as small as is consistent with the feeding of the fiber-forming liquid at an uninterrupted, sufficiently high rate. Apertures 11 in feed tube 8 are preferably slits having widths between 250 and 500 microns. However, wider and narrower slits, respectively, may be used depending primarily on the degree of viscosity of the fiber-forming liquid and the desired average fiber diameter. Narrow slits produce, in general, finer fibers at a reduced rate. It is entirely feasible to feed the fiber-forming liquid to the spiraling elastic fluid in various other ways than shown in the accompanying drawing of this specification, provided the feeding is done close to the periphery of the elastic fluid where the aspirating force of the elastic fluid is sufficiently high to pick up and draw the fibers from the supply of fiber-forming liquid. Good results have been obtained, for example, with organic fiber-forming liquids and with nozzles having an annular feed opening of 250 microns width, the feed opening being positioned concentrically with and very close to annular discharge opening 7.

The angle of the vertex of the imaginary cone defined above is of some importance with respect to the length of the fibers which may be produced. An angle of 20° at this point has proved to be entirely satisfactory for forming fibers having an average length between ½ and 8 inches depending on the other variables of the described process. Increasing the angle tends to decrease the average length of the fibers, and vice versa. With an angle approaching zero, e.g. when the spiraling stream of elastic fluid is discharged from the nozzle in a sub-

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stantially straight forward direction, longer fibers are produced than, for instance, with an angle of 10° or 20° under otherwise identical conditions of the "run." It is noted in this connection that the spiraling elastic fluid being discharged from discharge opening 7 at a very high velocity invariably tends to assume a conical shape. This is probably due to the formation of a partial vacuum within the confines of the spiraling elastic fluid, with the atmospheric pressure pushing the rotating masses of the elastic fluid into said vacuum to form the cone.

I claim:

1. A method of forming fibers characterized by causing an elastic fluid to flow in a spiral path with a very high and ever increasing velocity towards a point in mid-air, said spiral path defining a hollow cone whose vertex is said point; and causing a fiber-forming liquid to flow into contact with the elastic fluid in said hollow cone at a plurality of points around the outer periphery of said cone to form fibers by a smooth drawing and pulling action on the fiber-forming liquid.

2. The invention defined in claim 1, wherein the fiber-forming liquid is caused to contact the elastic fluid at a plurality of spaced points substantially lying in a plane that intersects said cone at right angles.

3. Fiber-forming nozzle for producing fibers from fiber-forming liquids comprising an annular feed tube having apertures which face toward the central axis of said annular tube, means for coupling said tube to a supply of fiber-forming liquid, a nozzle body having a chamber, open at its lower end, for discharging a stream of spiraling elastic fluid into and through the space bounded by the inner walls of said annular feed tube, the discharge opening of said chamber being positioned near the feed tube, and means for coupling the upper end of the chamber tangentially to a supply of compressed elastic fluid.

4. The invention defined in claim 3, wherein the chamber is frusto-conical and said discharge opening is at the smaller end of the chamber, and wherein a substantially cylindrical body is fixed co-axially within the chamber so that an annular discharge opening is formed at the smaller end of the chamber between the outside wall of the cylindrical body and the inside wall of the chamber.

5. Fiber-forming nozzle for producing fibers from fiber-forming liquids comprising a nozzle body having a frusto-conical chamber closed at its larger end and open at its smaller end, a substantially cylindrical body within and having its axis substantially coincident with the axis of the chamber so that an annular discharge opening is formed between the outside wall of said cylindrical body and the inside wall of the chamber, means for coupling the larger end of the chamber tangentially to a supply of compressed elastic fluid, a member for delivering the fiber-forming liquid, said member being positioned near said annular discharge opening, said member having an annular feed opening surrounding the cone of elastic fluid formed from said discharge opening, and means for coupling said member to a supply of fiber-forming liquid.

6. A nozzle for producing fibers from fiber-forming liquids comprising a body having a frusto-conical chamber closed at its top, which is the larger end, and open at its bottom, which is the smaller end; means for delivering a supply of elastic fluid tangentially into said chamber near its closed upper end; a member fixed within said chamber and constructed and arranged so that an annular discharge opening for said elastic fluid is formed between the outside walls of said member and the bottom opening of said chamber; an annular liquid feeding tube located wholly outside of said chamber adjacent said annular discharge opening, said feeding tube having a plurality of liquid discharge openings on

the inner periphery thereof, said liquid discharge openings being closely adjacent to and surrounding the cone which is an extension of said frustro-conical chamber; and means for coupling said feeding tube to a supply of fiber-forming liquid.

7. The invention defined in claim 6, wherein said fixed member is cylindrical, has its axis coinciding with the axis of said frustro-conical chamber, and has a free end which projects outside of said annular discharge opening and is rounded, said free end being closer to said body than said liquid discharge openings.

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