Feb. 12, 1952 E. R. POWELL 2,585,496

METHOD AND APPARATUS FOR THE MANUFACTURE OF FINE FIBERS

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Fig. 3.

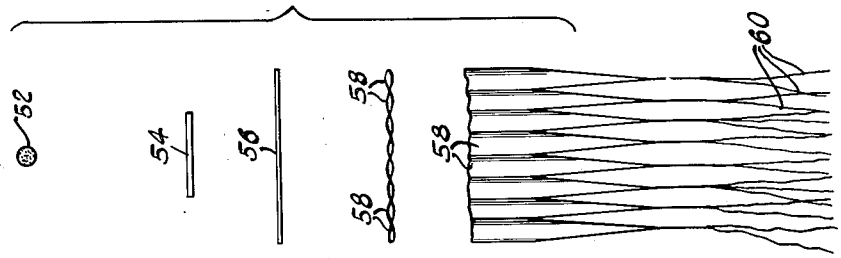


Fig. 2.

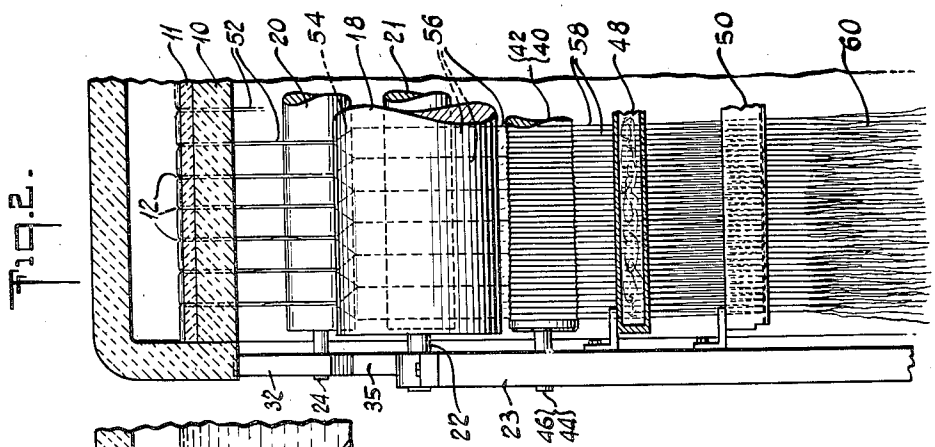
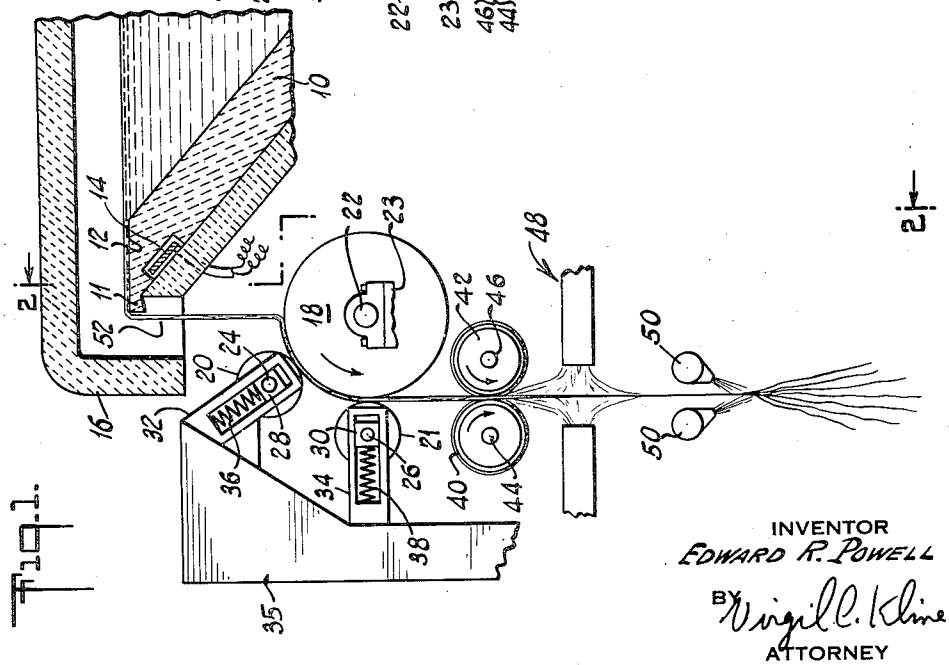


Fig. 1.



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METHOD AND APPARATUS FOR THE MANUFACTURE OF FINE FIBERS

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16 Claims. (Cl. 18—2.5)

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The instant invention relates to the manufacture of fine fibers, filaments and the like from thermoplastic materials, and particularly to a novel method and apparatus for the production of very fine glass fibers. The term "glass" is employed herein in a generic sense to include conventional glass compositions, synthetic low-alkali glass and natural glass, such as obsidian or melted rock of stable composition.

A principal object of the invention is the provision of an economical method and apparatus for the production of very fine fibers, the method promoting the simultaneous production of a great multiplicity of the fibers.

A further object of the invention is to provide a method which adapts itself to the production of various distinct types of fibers such as staple fiber or long fine filaments, by simple modification or adjustment of the apparatus.

Another object of the invention is the provision of a method which does not require the use of fine orifices, particularly the expensive platinum or alloy orifices employed in prior art methods. The clarification of the melt necessary for the proper functioning of the orifices is a major expense in these prior methods, such clarification being unnecessary in the instant method. Furthermore, the instant method and apparatus is adapted to utilize hotter melts than can be used satisfactorily with metal orifices.

Briefly stated, the present invention consists in the production of very fine glass wool or fibers by a method comprising flowing one or preferably a plurality of streams of material from a molten supply, flattening the streams into broad flat ribbons, mechanically subdividing the ribbons while still in a plastic condition into a plurality of substantially individual, uniform rods, melting and fluidifying said rods and simultaneously drawing said fluidified rods into fine filaments or staple fiber.

Exceedingly fine glass fiber has been produced by known processes which require the discharge of one or a plurality of fine streams of glass from small platinum or platinum alloy orifices. These fine streams, after partial or complete cooling, are refluidified and stretched into fine fibers by high velocity jets or mechanical pulling. Other processes employ a relatively large, highly fluidified stream which is flowed over a grooved surface and spread out on the surface into a thin layer which is divided into a plurality of rivulets in the grooves. The rivulets are attenuated by means similar to those above mentioned. The orifice methods require costly, time-consuming clarification and fining steps to eliminate undissolved grains and entrapped air bubbles so that the streams will satisfactorily run through fine orifices. Also, the melt temperature is limited when employing metal orifices, principally by the volatility of such metals. Furthermore, all of these methods demand rigorous temperature control to insure satisfactory production of fine fibers. A relatively small drop in the temperature of the streams flowing from the furnace is manifest in coarser drawn fibers and frequently causes breakage of the streams before stretching. The instant invention overcomes these disadvantages.

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My invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the more detailed description of a preferred embodiment thereof which is to follow and to the accompanying drawings in which:

Fig. 1 is a diagrammatic, side elevational view, with parts in section, of an apparatus in accordance with the invention.

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1; and,

Fig. 3 is a diagrammatic representation, on an enlarged scale and partly in plan and partly in elevation, of a glass stream in the various stages of processing.

Referring now to the drawings, the apparatus includes a glass melting furnace 10 of any suitable type, for example, a conventional gas-fired furnace. Furnace 10 has a substantially horizontal lip 11 having a plurality of spaced notches 12. The lip, which may be made of Monofrax, sillimanite or other heat-resistant materials, preferably includes heating means, such as electrical resistance unit 14 embedded in the material of the lip to maintain the proper viscosity of the glass as it exudes through the notches 12. The notches may be relatively closely spaced, say 1" to 3" apart. The upper wall of the furnace is extended to overlie the lip and the issuing streams to reduce heat loss to a minimum, and includes a depending flange 16 forwardly of the lip. It will be understood that the particular type of melting furnace employed and the means for discharging the initial streams of glass may take different forms without departing from the spirit of the invention.

A stream flattening means is located below the lip of the furnace, this comprising a drum 18 and two or more cooperating cylinders 20 and 21. Both the drum and the cylinders are smooth-surfaced and are made of a heat-resistant metal. Drum 18 is positioned to receive the effluent streams from the supply on its upper surface and is carried for rotation by shaft 22 supported on suitable bearings from frame members 23. It will be understood that the frame members are provided at both ends of the apparatus although only one is shown. The drum is driven by a motor or other driving means (not shown) in the direction indicated by the arrow in Fig. 1. The cylinders 20 and 21 are carried by shafts 24 and 26 respectively which, in turn, are supported from the frame in a manner to exert a yieldable pressure on the streams passing between the cooperating drum and cylinders and to cause the

cylinders to be driven by the drum. To this end, the bearings for shafts 24 and 26 are mounted in movable blocks 28 and 30 respectively, slidably mounted in tracks in arms 32 and 34. The arms are carried by frame members 35 and extend radially with respect to the drum. Compression springs 36 and 38 are confined in the tracks behind the blocks to exert yieldable pressure which is transmitted to the shafts and thence to the cylinders. Cylinder 20 is preferably located to contact drum 18 adjacent the points of contact of the streams with the drum, while cylinder 21 is preferably supported in substantially the horizontal plane of the drum axis.

Located below the stream flattening means is a pair of juxtaposed, cooperating, grooved rolls 40 and 42 which continuously subdivide and mold the flat ribbons lengthwise into a plurality of substantially individualized, semi-plastic rods. To perform this operation each roll has disposed on its surface a multiplicity of closely spaced, alternate, annular ridges and grooves. The rolls are mounted for rotation on parallel horizontal shafts 44 and 46, respectively, supported, for example, by bearings carried by the frame members. The rolls are driven by any suitable means in opposite directions and at the same speed. Rolls 40 and 42 are mounted with their ridges in contact so that the grooves on one roll face the corresponding grooves on the other roll to define channels therebetween. These rolls may be subject to considerable modification and remain within the scope of the invention; for example, one roller may be smooth-surfaced and only the cooperating roller may have the annular ridges and grooves.

Spaced directly below the grooved rolls is a heater 48, suitably consisting of gas burners directing their flames on opposite sides of the rods passing therebetween. Other means, such as radiant heating devices, dielectric heating elements, or the like may be used in lieu of gas burners if desired. Nozzles 50 are positioned beneath the heater 48 on opposite sides of the rods, the nozzles having orifices positioned to direct downwardly converging, gaseous jets against the rods. The nozzles are connected to any suitable source of fluid under pressure, such as compressed air or steam, preferably the latter.

In carrying out the method of the instant invention molten glass streams 52 continuously flow from the spaced notches in the lip 11 at the outlet of the melting furnace. The streams fall onto the surface of the large, smooth-surfaced rotating drum 18 and are carried thereby into the bight between the drum and the first cylinder 20, and then into the bight between the drum 18 and the second cylinder 21, whereby each stream is flattened through the intermediate stage illustrated at 54 into a relatively thin ribbon 56 (see Fig. 3). For example, an originally round stream of the proper size may be suitably flattened to a ribbon of a cross-section of $\frac{1}{32}$" by 2". At this stage the ribbons have cooled substantially but are still plastic.

The ribbons then pass through the bight between the grooved, juxtaposed rolls 44 and 46 which are rotated at peripheral velocities approximately equal to the normal speed of flow of the ribbons, suitably 150–400 ft. per minute. The upper speed is limited by the tendency of the material to be drawn off the rolls by centrifugal force when the rolls operate at higher speeds. The plastic material is forced into the channels defined by the opposed ridges to divide each of the ribbons into substantially individualized, narrow ribbons 58. By the time the material leaves the grooved rolls it is substantially solidified into glass rods which are still integral with the molten supply in the furnace.

The rods are remelted or fluidified as they pass between the gas burners 48 and are drawn out into fibers or filaments 60 by the gaseous jets issuing from nozzles 50. The speed of attenuation of the fibers by the jets is of a much higher order than the speed of the surfaces of rolls 40 and 42 and may reach 60,000 ft. per minute for the production of extremely fine fibers. Low speeds produce coarse fibers which are limited in their applicability because of their lack of pliability.

The fibers produced may be either continuous or staple fibers. Where the flame issuing from gas burners 48 is adjusted so that the rods are not in a highly molten state when subjected to action of the gaseous jets, a substantially continuous filament will be drawn from each of the rods, the stretching or drawing taking place at or adjacent the location of the flame. On the other hand, if the flame is adjusted to maintain the rods in a highly molten state until impacted by the jets, they will mostly be subdivided into a plurality of extremely fine staple fibers, as illustrated. The formed filaments are carried a distance by the blast and accumulated in any suitable way.

As pointed out above, the method and apparatus in accordance with the instant invention promote the simultaneous production of a great multiplicity of the fibers by an economical means which obviates the use of expensive orifices and the difficulties of temperature control and melt purification attendant their use.

It will be appreciated that many of the vitreous materials employed in the instant invention have no sharply defined melting points, hence, the term "melting" is used herein to represent the act of raising the material to that temperature range at which the material can be attenuated in response to relatively small stretching forces.

Having thus described my invention in rather full detail, it will be understood that these details need not be strictly adhered to and that various changes and modifications may suggest themselves to one skilled in the art, all falling within the scope of the invention as defined by the subjoined claims.

What I claim is:

1. The method which comprises continuously flowing a stream of thermoplastic material from a molten supply, allowing said material to partially cool and flattening said stream into a plastic ribbon, subdividing and molding said ribbon while plastic into a plurality of substantially individual rods, remelting said rods and simultaneously applying a drawing force to said rods to draw them out into fine fibers.

2. The method which comprises continuously flowing a plurality of streams of glass from a molten supply, allowing said glass to partially cool and flattening said streams into plastic ribbons, subdividing and molding said ribbons longitudinally while plastic into a plurality of substantially individual rods, said rods being integrally connected with said molten supply, remelting said rods and simultaneously applying a drawing force to said rods to draw them out into fine fibers.

3. The method which comprises continuously flowing a stream of thermoplastic material from

a molten supply, allowing said material to partially cool and mechanically pressing said stream into a broad plastic ribbon, subdividing said ribbon longitudinally while plastic by molding it into a plurality of substantially individual rods, melting said rods and simultaneously applying a drawing force to said rods to draw them out into fine fibers.

4. The method which comprises continuously flowing a multiplicity of streams of glass from a molten supply, allowing said glass to partially cool and compressing and flattening said streams into contacting broad, thin, plastic ribbons, subdividing said ribbons longitudinally while plastic, along lines different from the divisions of the original ribbons, into a plurality of substantially individual rods, melting said rods and simultaneously applying a drawing force to the ends of said rods to draw them out into fine fibers.

5. The method which comprises continuously flowing a stream of glass from a molten supply, allowing said glass to partially cool, flattening said stream into a broad, plastic ribbon, subdividing said ribbon longitudinally into a plurality of substantially individual rods of predetermined size, said rods being substantially solidified and integral with the molten supply, melting said rods and applying a drawing force to said rods to draw them out into fine fibers.

6. The method comprising continuously flowing a stream of glass from a molten supply, allowing said glass to partially cool and flattening said stream between pressure rolls, subjecting the flattened stream to the action of cooperating grooved rolls to divide the same into parallel, substantially individual rods, heating said rods to fluidify the same and stretching said fluidified rods to convert them into fibers.

7. The method comprising continuously flowing a stream of glass from a molten supply, allowing said glass to partially cool and flattening said stream between pressure rolls, subjecting the flattened stream to the action of cooperating grooved rolls rotating in opposite directions at the same peripheral velocities to divide the stream into parallel, substantially individual rods, heating said rods to fluidify the same and subjecting the rods to the action of gaseous jets to stretch the same and convert them into fibers, the speed of stretching exceeding the peripheral velocities of the grooved rolls.

8. The method which comprises subjecting a flattened glass stream in a plastic state to the action of cooperating rotating members to divide the stream into substantially individual glass rods, heating said rods to fluidify them and drawing said fluidified rods at a speed greatly in excess of that of said rotating members to stretch them into fine fibers.

9. In an apparatus for the manufacture of fine fibers from thermoplastic melts, the improvement comprising, means for supplying a stream of molten thermoplastic material, means for pressing the stream into a relatively broad ribbon, means for mechanically subdividing the ribbon into a plurality of substantially individual rods, means for heating said rods to fluidify the same, and means for stretching the fluidified rods into fine fibers.

10. In an apparatus for the manufacture of fine fibers from thermoplastic melts, the improvement comprising, means for supplying a stream of molten thermoplastic material, coacting rolls for flattening said stream into a relatively broad ribbon, coacting roll means including a grooved surface for subdividing said ribbon into a plurality of substantially individual rods, means for heating said rods to fluidify the same, and means for stretching the fluidified rods into fine fibers.

11. In an apparatus for the manufacture of fine fibers from thermoplastic melts, the improvement comprising, means for supplying a stream of molten thermoplastic material, coacting rolls for flattening the stream into a relatively broad ribbon, coacting roll means including a grooved surface for subdividing said ribbon into a plurality of substantially individual rods, means for heating said rods to fluidify the same, and nozzles supported to direct gaseous jets against said rods to draw them into fine fibers.

12. In an apparatus for the manufacture of fine fibers from thermoplastic melts, the improvement comprising, means for supplying a stream of molten thermoplastic material, coacting rolls for flattening the stream into a relatively broad ribbon, coacting roll means including a grooved surface for subdividing said ribbon into a plurality of substantially individual rods, means for heating said rods to fluidify the same, and opposed nozzles supported to direct converging gaseous jets against said rods to draw them into fine fibers.

13. In an apparatus for the manufacture of fine fibers from thermoplastic melts, a melting furnace including a lip, notches in said lip for flowing a plurality of streams of molten material from the furnace, and means for heating said lip, coacting rolls for flattening said streams into relatively broad ribbons, coacting roll means including a grooved surface for longitudinally subdividing said ribbons into a plurality of substantially individual rods, means for heating said rods to fluidify the same, and means for stretching the fluidified rods into fine fibers.

14. The method of forming glass fibers which comprises forming a flat, thin layer of glass in a plastic condition of substantially uniform thickness, subdividing and molding said layer of glass into a plurality of rods of predetermined size, heating said rods to fluidify them, and drawing them into fibers.

15. In an apparatus for the manufacture of fibers from thermoplastic materials, means for compressing said thermoplastic materials into a flat ribbon of substantially uniform thickness in a plastic condition, coacting means for subdividing the ribbon into a plurality of substantially individual glass rods, means for heating the rods to fluidify the same, and means for drawing the fluidified rods into fine fibers.

16. In an apparatus for the manufacture of fibers from thermoplastic materials in the form of a flat ribbon in a plastic condition, coacting grooved rolls for subdividing the ribbon into a plurality of substantially individual glass rods, means for heating the rods to fluidify the same, and nozzles supported to direct gaseous jets against the rods to draw them into fibers.

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