Sept. 9, 1952 G. SLAYTER ET AL 2,609,566

METHOD AND APPARATUS FOR FORMING FIBERS

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FIG. 1

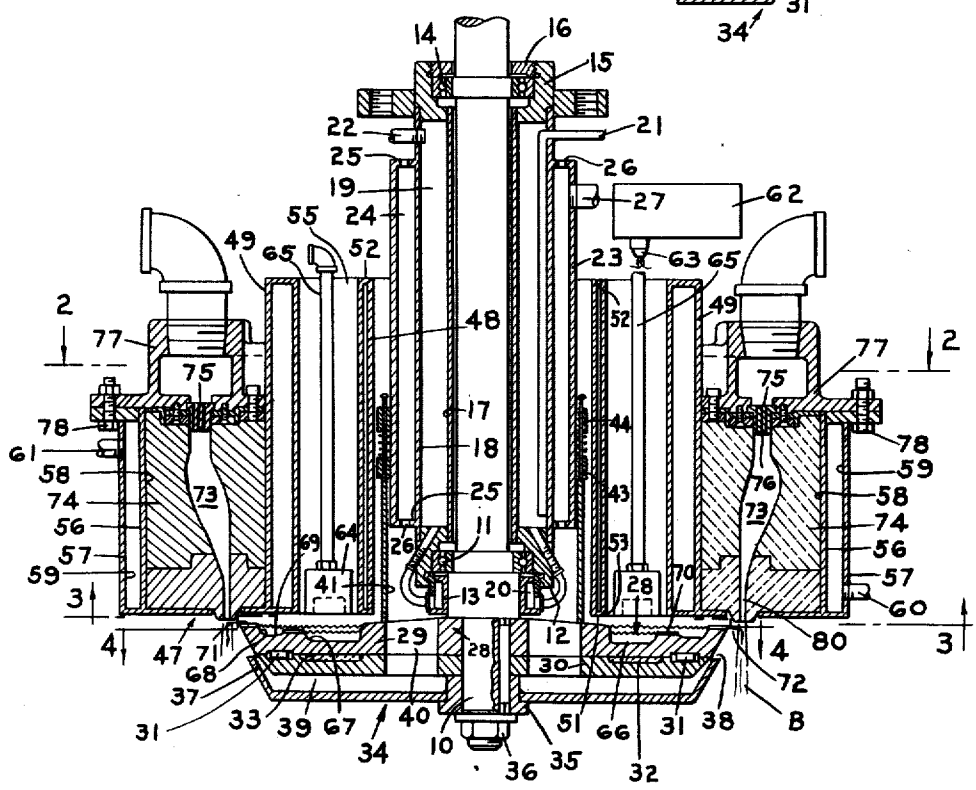


FIG. 11

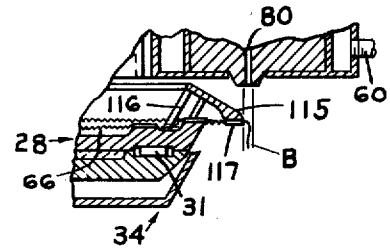
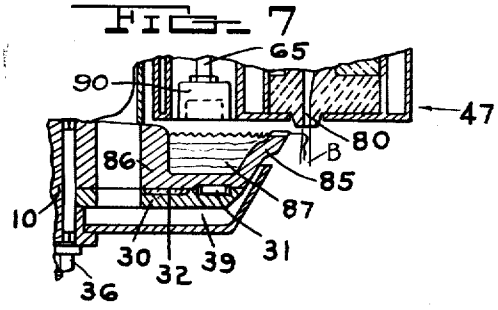


FIG. 7



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METHOD AND APPARATUS FOR FORMING FIBERS

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FIG. 2

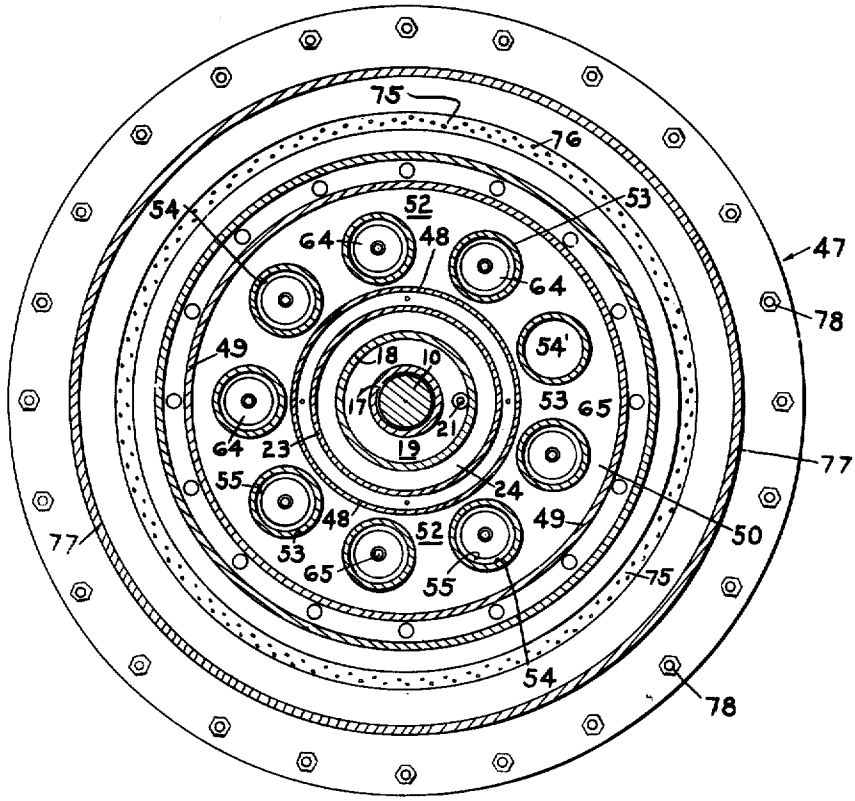


FIG. 6

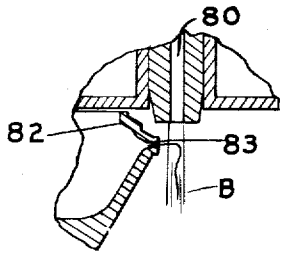
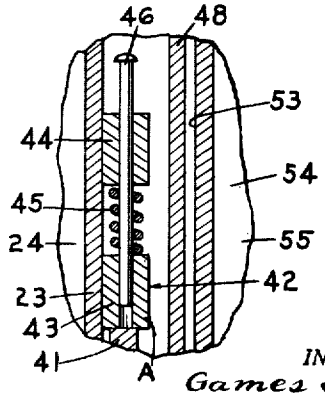


FIG. 10



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METHOD AND APPARATUS FOR FORMING FIBERS

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FIG. 3

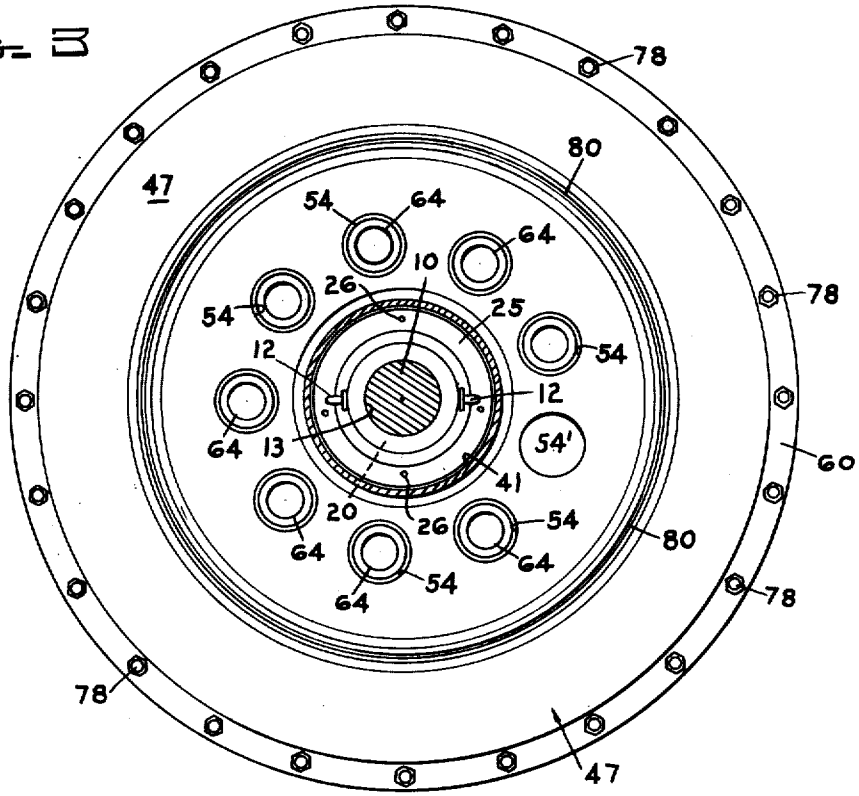
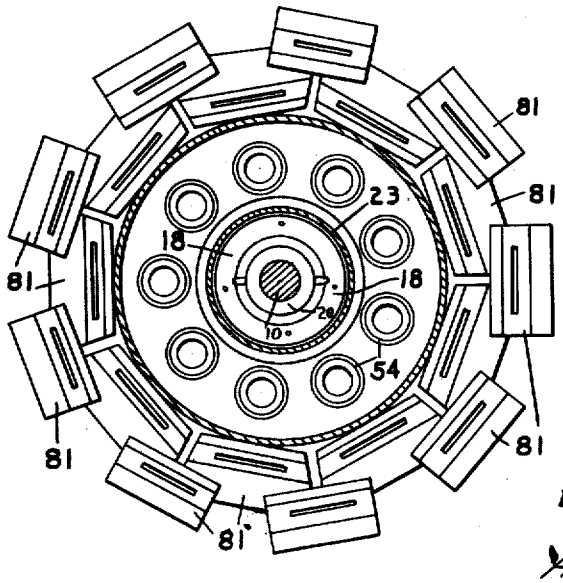


FIG. 5



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METHOD AND APPARATUS FOR FORMING FIBERS

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FIG. 8

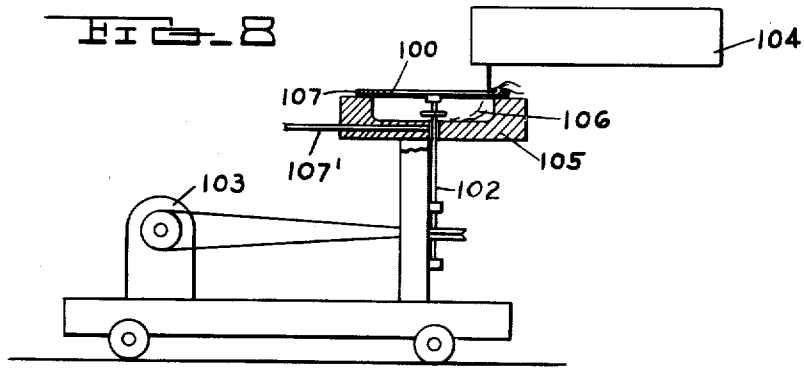


FIG. 3

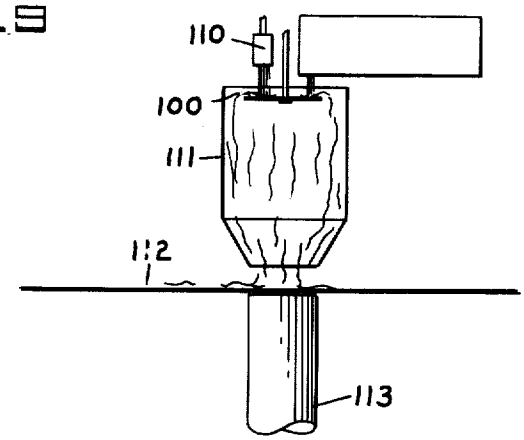
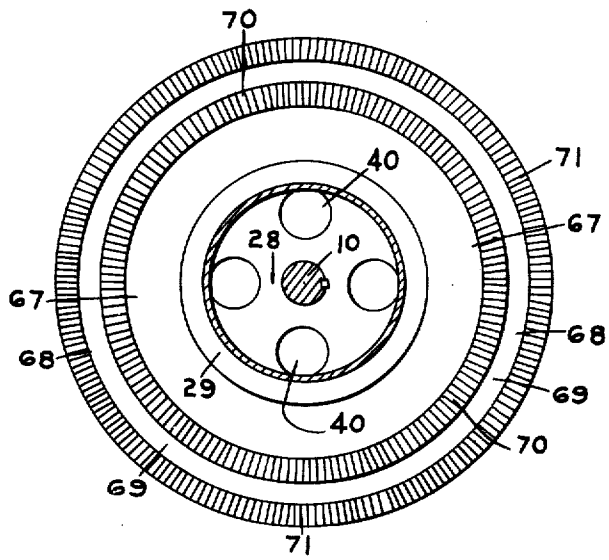


FIG. 4



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Patented Sept. 9, 1952 2,609,566

UNITED STATES PATENT OFFICE

2,609,566

METHOD AND APPARATUS FOR FORMING FIBERS

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Application December 31, 1948, Serial No. 68,664

12 Claims. (Cl. 18—2.5)

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This invention relates to the manufacture of fibers from a material which will soften in the presence of heat and which may be attenuated or drawn out into fine fibers when in a softened state.

More particularly the invention refers to a process and apparatus for manufacturing on a commercial basis and at a high rate glass fibers of one to five microns in diameter.

One satisfactory process for making fibers from glass or materials having similar characteristics is to melt a body of the material in a feeder having a multiplicity of small orifices in the bottom wall through which the molten material flows into the atmosphere in the form of streams. As the streams are introduced to the atmosphere they solidify and are attenuated to produce individual primary filaments by feed rolls which also serve to project the filaments into a blast of hot gas. The temperature of the blast exceeds the softening point of the material and the speed of the blast is sufficient to attenuate or draw out the softened material into fibers of the desired size.

While glass fibers of varying degrees of fineness ranging from one micron or less in diameter to two and one-half microns or more in diameter have been successfully produced commercially by the process briefly noted above, nevertheless, this general process has certain disadvantages. One objection is that the process is ordinarily initially started by manually pulling the individual streams and threading the primary filaments into a grooved guide which usually occupies a position directly below the feed rolls. This operation must be repeated following each intentional or accidental interruption of the process, and not only requires skill on the part of the attendant, but also increases the down time of the production equipment.

Also in order to facilitate handling of the streams or primary filaments, it has been the practice to provide a generous clearance between adjacent streams issuing from the feeder, and this clearance is ordinarily greater than required for efficient operation. In other words, the lateral spacing between adjacent primary filaments is ordinarily greater than would be required if it were not necessary to handle the filaments during starting and accordingly full advantage of the capacity of the equipment is not realized.

One of the objects of this invention is to provide an improved fiber forming apparatus of a design which is less likely to cause accidental interruption in the fiber forming phase, and is

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capable of substantially continuous operation. Thus production losses due to equipment "down time" are materially reduced with a corresponding reduction in manufacturing costs.

Another object of this invention is to provide fiber forming apparatus in which the actual operation of forming fibers need not be started manually after an interruption, but one in which attenuation of the material to fibers is resumed automatically without appreciable delay following an interruption from any cause whatsoever. Inasmuch as it is not necessary to handle the filaments the distance between adjacent filaments may be reduced, and a greater number of filaments may be fed into a fiber forming zone or blast of given width. As a result, the quantity of fibers produced with apparatus of a given size is increased, and the cost of manufacture is further reduced.

Still another object of this invention is to initially draw out a body of heat softened material such as glass into a multiplicity of primary filaments by the action of centrifugal force, and to finally attenuate the filaments to form fine fibers by introducing the filaments endwise into a blast of gas having a temperature which exceeds the softening temperature of the material and having a velocity sufficiently high to provide the force required to reduce the filaments to fibers of the desired size. In accordance with this invention the magnitude of the centrifugal force is not only sufficient to initially draw out the heat softened glass and form filaments, but is also sufficient to project the filaments endwise into the fiber forming blast.

A further object of this invention is to deposit heat softened or molten material on a rotor having provision adjacent the periphery for producing a multiplicity of generally radially outwardly extending primary filaments and also having means for mixing the material to increase its homogeneity prior to forming the primary filaments. This feature renders it possible to eliminate the pulling mechanism or feed rolls and associated guides previously referred to, and also enables the use of a single ring-type burner for producing the attenuating gaseous blast. Moreover, refining the material as stated above assists materially in reducing to a minimum the formation of slugs or beads during the fiber forming phase and improves the quality of the finished product.

A still further object of this invention is to provide an arrangement of the above type wherein the temperature of the primary filaments is

either at or closely approaches the attenuating temperature of the material before being introduced into the attenuating blast. Thus the major duty of the gaseous blast is to attenuate the material forming the primary filaments with the result that a narrower blast may be provided moving at greater velocities.

It is still another object of this invention to provide a process wherein the glass or similar material is first converted into primary filaments and then into fine fibers in a small space or zone by closely associated steps. This enables employing lower temperatures at the centrifugal rotor, and assists in obtaining the desired results with relatively low rotor speeds. In fact the temperature at the rotor is reduced to such an extent as to enable forming the rotor and associated parts of relatively inexpensive base metals instead of precious metals such for example as platinum.

It is still a further object to convert glass batch to molten glass and then to fine fibers at a single station and in a closely associated sequence of steps.

The foregoing, as well as other objects, will be made more apparent as this description proceeds, especially when considered in connection with the accompanying drawings, wherein:

Figure 1 is a vertical sectional view through one type of apparatus forming the subject matter of this invention and capable of carrying out the steps of the improved process;

Figure 2 is a cross-sectional view taken on the line 2—2 of Figure 1;

Figure 3 is a cross-sectional view taken on the line 3—3 of Figure 1;

Figure 4 is a plan view of the rotor;

Figure 5 is a plan view showing a modified arrangement of the burners;

Figure 6 is a fragmentary sectional view showing a modified form of rotor periphery;

Figure 7 is a diagrammatic sectional view showing another type of rotor construction;

Figure 8 is a diagrammatic view partly in section of a further modification of fiber forming apparatus;

Figure 9 is a diagrammatic elevational view of still another type of apparatus;

Figure 10 is a fragmentary sectional view of a part of the apparatus; and

Figure 11 is a fragmentary sectional view of a modified form of construction.

In general the present invention provides a process and apparatus for forming fibers of varying sizes from glass or materials having characteristics similar to glass. Such materials are of a nature which enables softening the same in the presence of heat and are capable of being attenuated or drawn out into fine rods or fibers when in a softened condition. These properties are present in many types of thermoplastic materials, and are also found in some synthetic resins. While the invention contemplates the formation of fibers from various different types of materials, nevertheless, it has been primarily developed in connection with the manufacture of glass fibers and accordingly this material is stressed in the following description of the invention.

Briefly glass cullet such for example as glass marbles, or in keeping with one aspect of the invention, glass batch is reduced to a softened state ranging from a stiff putty-like consistency to a highly fluid condition, depending upon the nature of the product and particular mode of operation desired. In any case the softened material is subjected to the action of centrifugal force of a magnitude sufficient to cause the material to flow along a predetermined path and to draw out the material into a relatively thin sheet or into primary filaments or streams, depending upon the nature of the final product required. In the manufacture of fine fibers for use in certain types of insulating mats, it is preferred to separate the softened material into individual elongated bodies or streams as the material flows along its path of travel under the influence of the centrifugal force. These elongated bodies or streams are drawn out into what may be termed primary filaments by the action of the centrifugal force.

The drawn out material, whether in the form of a relatively thin sheet or in the form of filaments or streams, is projected by the action of the centrifugal force into a blast of gas, which moves in a direction extending transversely to the direction of the path of flow of the softened material under the influence of the centrifugal force. As will be more fully hereinafter described, the blast of gas not only has a temperature which exceeds the softening temperature of the material, but in addition, moves at a velocity sufficiently high to attenuate or draw out the softened material into fibers of the required size. The fiber size may vary over a wide range and depends on the size of the primary filament, temperature or viscosity of the material making up the primary filament, rate of feed of the primary filament by the centrifugal force and the velocity as well as the temperature of the blast of gas employed to attenuate the primary filament.

It follows from the foregoing that the softened material may be considered as being reduced to fine fibers in two stages of operation. One stage may be considered as the initial drawing out of the softened material by centrifugal force, and the second stage is the final attenuation of the previously drawn out material into fibers by the heat and force of the gaseous blast. These two steps in the process are performed in immediate succession, so that the initially drawn out material is actually introduced into the blast of gas before it has an opportunity to cool appreciably. As a result the blast of gas need not be relied upon entirely to heat the material to the attenuating temperature, and accordingly, the velocity of the blast may be increased to attenuate the softened material into fibers. Also the thickness of the blast may be reduced without the danger of projecting the filaments or material through the blast. The above feature provides for substantially increasing the production of fibers with a thinner blast of gas, and will be more fully understood as this description proceeds.

Also according to the present invention the softened material is refined as it flows along its path of travel under the influence of the centrifugal force. In this connection it will be noted that any cords that may be present in the material are actually drawn out in the direction of flow of the material by the centrifugal force. In one embodiment of the invention to be presently described in detail the softened material is actually separated into individual streams and recombined prior to being subject to the final drawing out operation by the centrifugal force. As a result the material is mixed, and any cords that may be present are reduced in length, so

that when the material is recombined, it provides a homogeneous body substantially free from cords of a size which would detrimentally affect the resulting product.

Referring now more in detail to the drawings, reference will first be made to the embodiment of the invention shown in Figures 1, 2, 3 and 4. The numeral 10 designates a vertical drive shaft suitably connected at the upper end to power mechanism (not shown) but adapted to rotate the shaft 10 at the desired speed. The lower end portion of the shaft 10 is journalled in a bearing 11, and this bearing is secured within a collar 12 by a ring 13 threaded in the lower end of the collar. The upper end of the shaft 10 is journalled in a bearing 14, and the latter is secured in a collar 15 by a ring 16 which is threaded in the upper end of the collar.

The two collars are connected by concentrically arranged tubes 17 and 18. The inner tube 17 surrounds the shaft 10 in close proximity to the latter, and the outer tube 18 cooperates with the inner tube to form an annular jacket 19 for a cooling medium such for example as water. It may be pointed out at this time that the ring 13 has an annular jacket 20 surrounding the portion of the shaft 10 immediately below the bearing 11 and connected to the annular jacket 19 to enable the circulation of cooling medium through the jacket 20. The desired coolant, such for example, as water is supplied to the jacket 19 by an inlet conduit 21 which enters the jacket 19 through an opening formed at the upper end of the tube 18 and extends downwardly within the jacket 19 to a position adjacent the lower collar 12. Thus the coolant is discharged into the jacket 19 adjacent the lower end thereof. The outlet for the coolant within the jacket 19 comprises an opening 22 formed in the tube 18 adjacent the upper end of the latter. The arrangement is such that the coolant actively circulates through the jacket 19 and jacket 20 in heat conducting relationship to the vertical shaft 10. The purpose of such an arrangement is to maintain the shaft 10 well below critical temperatures during heating of the glass which will be presently described. Due to this cooling arrangement, the shaft 10 and associated parts previously described may be produced from ordinary steels instead of high temperature resistant materials, and this is of course desirable, because it greatly reduces the cost of the construction.

Surrounding the outer tube 18 in concentric relation to the latter is a third tube 23 having a diameter greater than the diameter of the tube 18 to form with the latter an annular air passage 24. The opposite ends of the tube 23 are respectively connected to the tube 18 by rings 25, and the latter are formed with openings 26 therethrough. It will also be noted from Figure 1 of the drawings that the upper end of the tube 23 has an air inlet opening 27, and this opening is connected to a blower or a source of air under pressure not shown herein. The air under pressure flows downwardly in the passage 24 through the openings 26, and the purpose of the air under pressure will become apparent as this description proceeds.

Keyed or otherwise secured to the shaft 10 immediately below the ring 13 is a rotor 28 comprising a top section 29, and a bottom section 30. The bottom section 30 forms a support for the top sections, and is keyed at the periphery to the adjacent portion of the top section by pins

31. Each pin 31 is accommodated in registering recesses formed in the adjacent surfaces of the two rotor sections, and these recesses are of a size to permit limited radial movement of one section relative to the other. As will be apparent from the following description, the top section 29 is exposed to greater heat than the bottom section, and it is possible that this differential in temperature may cause the top rotor section to expand slightly relative to the lower rotor section. Such a condition is compensated for without causing undue warpage of the parts by the key connection 31. In order to minimize the transfer of heat from the top rotor section 29 to the bottom rotor section 30, a suitable high temperature insulation such for example as glass wool 32, is interposed between the two sections. As shown in Figure 1 of the drawings, the top surface of the bottom rotor section 30 is formed with an annular recess 33 which is closed by the bottom surface of the top rotor section and accommodates the high temperature insulation 32.

Positioned directly below the rotor 28 is a fan 34 having a hub 35 keyed on the shaft 10 and secured in place by a nut 36 which is threaded on the lower end of the shaft 10. The fan 34 is substantially cup-shaped in cross section having an upwardly extending radially outwardly flared flange 37 at the periphery thereof. The flange 37 encircles the lower section of the rotor 28, and is spaced a slight distance outwardly from the periphery of the rotor to form with the periphery of the rotor a restricted upwardly directed annular discharge passage 38 for the air.

Projecting radially outwardly from the hub 35 of the fan to the peripheral flange 37 is a series of vanes 39 arranged to move air radially outwardly from the hub 35 through the restricted discharge passage 38. Referring again to Figure 1 of the drawings, it will be noted that the rotor 28 is formed with a series of openings 40 spaced from each other around the axis of the shaft 10 and registering with the openings 26 at the lower end of the annular air passage 24. The openings 40 extend entirely through both sections of the rotor 28 so that the air under pressure issuing from the openings 26 enters the fan 34 adjacent the hub 35. As stated above this air is conveyed to the annular discharge opening 38 by the vanes 39, and is discharged at substantial velocity in an upward direction from the opening 38. The air serves to cool the parts of the equipment during its flow from the inlet opening 27 to the annular outlet passage 38, and also has an additional important function which will be more fully hereinafter described.

The air flowing from the annular passage 24 to the fan 34 is prevented from escaping laterally outwardly over the top surface of the rotor 28 by a tubular shield 41 having the lower end secured to the top section 29 of the rotor 28 in concentric relation to the axis of the shaft 10. The upper end of the shield 41 surrounds the lower end of the tube 23 in close proximity thereto, and a suitable seal may be provided for sealing the space between the upper end of the tube 41 and the adjacent surface of the tube 23. The seal 42 comprises a pair of axially spaced rings 43 and 44. The ring 44 is welded or otherwise permanently secured to the outer tube 23 and the ring 42 is positioned to have a bearing engagement with the top edge of the tubular shield 41. The ring 43 also has a sliding fit with the outer surface of the tube 23 and is urged

into frictional contact with the upper end of the tube 41 by coil springs 45. The coil springs 45 are spaced equal distances around the tube 23 and are located between the rings 43 and 44. The springs are respectively held in position by suitable pins 46 which extend through registering openings formed in the rings 43 and 44. With the above arrangement the shield 41 cooperates with the outer tube 23 to form a sealed passage for the air from the fan 34 to the passage 24.

Referring now more particularly to Figure 2 of the drawings, it will be noted that an annular support 47 is positioned directly above the rotor 28. The support 47 has an inner tube 48 which encircles the air shield 41 in concentric relation to the axis of the shaft 10, and also embodies a tube 49 positioned in concentric relation to the tube 48. The tube 49 has a diameter substantially greater than the tube 48 to form with the latter an annular space 50 having the lower end closed by an annular plate 51. The upper end of the annular space 50 is closed by a similar annular plate 52, and the two plates are formed with circumferentially spaced aligned openings 53. The aligned openings 53 are respectively connected by a tube 54, and these tubes form vertical chambers 55.

Surrounding the lower end portion of the tube 49 and concentrically arranged with respect to the latter is a pair of tubes 56 and 57. The diameter of the tube 56 is substantially greater than the diameter of the tube 49, and cooperates with the latter to form an annular casing 58. The tube 57, on the other hand, is of greater diameter than the tube 56, and provides an annular jacket 59 for coolant. The cooling medium is introduced into the jacket 59 adjacent the lower end thereof through a supply conduit 60, and is discharged from the jacket through the conduit 61 adjacent the upper end of the jacket. Thus the cooling medium flows in heat conducting relation to the casing 58 and prevents excessive heat transfer from the annular casing to the outer wall or tube 57 of the support.

Upon reference to Figure 1 of the drawings it will be noted that the lower ends of the tubes 54 assume positions directly above the rotor 28 and one or more of the tubes communicate at the upper ends thereof with a supply of molten glass. For the purpose of illustration the source of supply of molten glass comprises an orthodox forehearth diagrammatically indicated by the numeral 62 and having an outlet 63 communicating with the upper end of only one of the tubes designated by the numeral 54'. The molten glass flows by gravity downwardly through this tube and is deposited on the top surface of the rotor 28. The remaining tubes serve as housings for gas combustion burners 64 of the radiant type. One burner 64 is suitably supported in each tube 54 at the bottom of the latter in such a position that the flame is directed against the rotor and the desired combustible mixture of gases is supplied to the burners by conduits 65 extending upwardly through the respective tubes 54 to a source of supply. The purpose of these burners is to maintain or heat the glass deposited on the rotor 28 to the proper temperature.

The top surface of the rotor 28 registering with the lower ends of the vertical tubes 54 is formed with an annular recess 66, and the molten glass discharged from the tube 54' collects in this recess. The radially outer wall of the recess 66 is formed by an annular rib 67 projecting upwardly from the top surface of the rotor and cooperating with an upstanding annular flange 68 at the periphery of the rotor to form a second annular recess 69. The annular recess 69 is spaced radially outwardly from the annular recess 66 in a position where it does not receive glass directly from the tube 54' and the flange 68 extends upwardly beyond the elevation of the rib 67. The top edge of the rib 67 and the corresponding surface of the flange 68 are serrated to provide a multiplicity of closely spaced radially extending grooves 70 and 71. Although the spacing between adjacent grooves may vary considerably, nevertheless, it is preferred to provide as many grooves as possible without disrupting the operation. In practice the center distances between adjacent grooves may be as small as one-sixteenth of an inch.

Operation of rotor assembly

The glass deposited in the annular recess 66 in the rotor 28 is more or less uniformly distributed throughout the recess as the rotor revolves about the axis of the shaft 10 and is heated by the radiant burners 64. The temperature to which the glass is heated may vary considerably depending upon the nature of the final fibers required, but in any case, this temperature exceeds the softening point of the glass. The molten or heat softened glass contained within the recess 66 in the rotor 28 is subjected to the action of centrifugal force resulting from rotation of the rotor, and flows radially outwardly along the rotor under the influence of this force. Any cords that may be present in the body of glass tend to orient themselves in the general direction of glass flow and are drawn out to some extent.

The heat softened body of glass is divided into a multiplicity of small streams as it flows across the serrated rib 67 on the rotor 28 and the serrations formed by the grooves 70 tend to cut the cords into shorter lengths. After the body of glass passes over the annular serrated rib 67 the individual streams are combined in the annular recess 69 in the rotor and the resulting body of glass passes outwardly over the serrated edge of the annular flange 68 at the periphery of the rotor 28. It follows from the above that the body of heat softened glass is refined and rather vigorously mixed as it flows radially outwardly over the rotor 28 under the influence of the centrifugal force. The arrangement is such as to substantially improve the homogeneity of the glass and eliminate cords of a size which would have any appreciable detrimental effect on the product or on the final fiber forming steps of the process.

As the heat softened glass passes over the annular serrated edge of the peripheral flange 68, it is again separated into a multiplicity of individual streams which are drawn out by the action of centrifugal force to provide primary filaments or streams indicated in Figure 1 of the drawings by the numeral 72. The diameter of the primaries 72, or in other words, the extent to which the streams are drawn out by centrifugal force depends largely upon the peripheral speed of the rotor and the viscosity of the heat softened body of glass flowing outwardly along the rotor. As will be presently described the primaries 72 are projected by the action of centrifugal force into an intensely hot high velocity blast B and are further drawn out or attenuated into fine fibers by the heat and force of the blast B. Primaries of a diameter rendering it possible to produce extremely fine fibers of two microns or

less in diameter may be obtained by rotating a twelve-inch diameter rotor 28 at a speed in the neighborhood of between 500 and 1000 R. P. M. and with glass heated to temperatures as low as 1500 or 1600° F. Such speeds and temperatures are well within a range which renders it practical to form the rotor and associated parts of inexpensive base metals such as nickel, chrome or tungsten alloy steels.

It is also important to note that the formation of primary filaments or streams 72 is effected continuously as long as glass is supplied to the rotor 28 and accidental interruptions in the primary forming phase are practically entirely eliminated. Moreover, initial starting of the primary forming phase following an interruption from any cause is automatic in that manual handling of the primaries is not required. This feature not only greatly facilitates starting and reduces "down time" of the apparatus, but in addition makes it unnecessary to employ skilled attendants. Furthermore, since the apparatus does not require manual manipulation of the primaries to effect starting of the forming operation the primaries may be positioned in much closer relationship, and accordingly a greater number of primaries may be introduced into a blast B of given width. This contributes materially to increasing the fiber forming production without increasing the size of the equipment.

It has been stated above that the primaries 72 are projected radially outwardly by centrifugal force into a blast B of gas. The blast surrounds the periphery of the rotor 28 in substantial concentric relation to the axis of the rotor and the location of the source of the blast is so determined that the blast passes the peripheral flange 68 on the rotor in such close relationship thereto that the primaries 72 are fed into the blast before they have an opportunity to cool appreciably. Thus the temperature of the primaries entering the blast B may approximate the attenuating temperature of the glass so that the blast need not be relied upon to actually heat the primaries to the attenuating temperature. For reasons which will become more apparent as this description proceeds, the above feature simplifies obtaining a blast having the velocity required to attenuate the heat softened primaries 72 to fine fibers.

In the present instance the blast B flows in a downward direction and the fibers formed from the primaries are blown in a corresponding direction. These fibers may be collected in the form of a mat, if desired, on a conveyor (not shown) supported below the apparatus. As the ring-like blast B flows downwardly around the periphery of the rotor 28, there is a tendency for the blast to "neck-in" around the rotor, and this is avoided by the air under pressure discharged from the restricted annular passage 38. Upon reference to Figure 1 of the drawings, it will be noted that the air issuing from the annular passage 38 flows upwardly and outwardly along the peripheral flange 68. Thus the air has the additional function of acting in effect as a support to hold the primaries 72 leaving the rotor 28 in a plane substantially normal to the blast B. In other words, the air under pressure in conjunction with the centrifugal force acting in a radially outward direction on the primaries 72 insures feeding the primaries endwise into the blast, even though the primaries are in a relatively soft condition.

In accordance with this invention the blast B is composed substantially entirely of products of combustion obtained by burning a combustible mixture of gases within a chamber 73 and discharging the burned gases from the chamber through a restricted outlet opening in one wall of the chamber. The chamber 73 shown in Figure 1 of the drawings is annular in configuration and is formed in an annular refractory block 74 suitably supported in the annular casing 58. The upper end of the chamber 73 is closed by an annular ring 75 having a series of passages 76 therethrough for a combustible mixture of gases. These gases are conducted to the passages 76 by an annular manifold 77 suitably secured to the support 47 by fastener elements 78 and communicating with a gas mixing device (not shown) through conduits 79.

The bottom wall of the chamber 73 is formed with an annular outlet opening 80 concentrically arranged with respect to the axis of rotation of the rotor 28 and having a diameter such that the gases issuing therefrom flow downwardly in the form of a ring past the periphery of the rotor. It is also pointed out at this time that the plane occupied by the delivery end of the outlet opening 80 lies in such close relationship to the plane including the top edge of the annular peripheral flange 68 on the rotor 28 that the primaries 72 enter the blast before the latter has an opportunity to expand appreciably. In other words the primaries are projected into the portion of the blast which is at substantially the maximum available temperature and which is traveling at practically the maximum velocity. Thus full advantage is taken of the heat and velocity characteristics of the blast B in reducing the primaries to fine fibers.

Operation of burner

The combustible mixture of gases enters the annular combustion chamber 73 through the passages 76 in the top wall or ring 75, and are ignited. As the gas mixture burns within the chamber 73 the walls of the latter become extremely hot and the rate at which the incoming gas mixture burns is substantially increased. The resulting high rate of combustion causes a great expansion of the burned gases within the chamber 73, and since the outlet opening is substantially restricted, it follows that these gases are discharged from the chamber in the form of an intensely hot high velocity blast.

The type of combustible gas used may be of any suitable kind, but for reasons of economy, it is preferably an ordinary fuel gas, such as natural or manufactured fuel gas. This gas is mixed with the proper amount of air by means of the orthodox air and fuel mixers. The gas and air mixture is taken from the mixer at moderate pressures of approximately one to five pounds per square inch, but may be considerably higher if desired. The aim is to feed as much of the mixture as possible into the chamber 73 without causing the combustion to become unstable or to take place at the outside of the chamber, or to cease altogether. This mixture is fed into the chamber 73 at velocities below the rate of flame propagation of the particular mixture in the atmosphere. However, after the refractory walls of the chamber become heated, it is possible to increase the rate of feed of the mixture into the chamber 73 above the rate of flame propagation.

The cross sectional area of the annular outlet

opening 80 is so proportioned with respect to the size of the chamber 73 or with respect to the quantities of gas burned that the products of combustion are discharged from the opening 80 in the form of a blast having a temperature in excess of the softening temperature of the glass and having a velocity sufficiently high to draw out or attenuate the softened glass into fibers of the required size. The combustible mixture of gases may be burned in such quantities with respect to the volume of the chamber 73 as to produce a rate of combustion of the gases within the chamber 73 sufficiently high to force the burned gases from the chamber in the form of a blast having a temperature as high or higher than 3000° F. and a velocity as high or higher than 1200 feet per second.

It will, of course, be understood that the cross sectional area of the outlet opening 80 may be varied with respect to the size of the combustion chamber 73 to obtain blasts having different temperature and velocity characteristics. Outlet openings of greater cross sectional area permit burning a greater amount of gas and result in generating great heat in the blast. However, as the size of the outlet opening 80 is increased the velocity of the blast issuing from the outlet opening is decreased, and therefore, it is preferred to form the outlet opening with a cross sectional area no greater than necessary to obtain in the blast the heat required to maintain the glass at the desired attenuating temperature. As stated above, the blast need not be relied upon to actually heat the glass, and as a consequence, the size of the outlet opening 80 may be reduced to a somewhat greater extent than would be practical where the primaries are actually melted or softened by the temperature of the blast.

Reference has also been made above to the fact that the primaries 72 are initially drawn out by the action of centrifugal force resulting from rotation of the rotor, and are immediately thereafter attenuated into fine fibers by the force of the blast B. The magnitude of the centrifugal force depends upon the peripheral speed of the rotor 28, and is sufficient to perform the additional function of projecting the primaries endwise into the blast B in close proximity to the outlet opening 80 where the temperature and speed of the blast is at a maximum. The centrifugal force, however, is substantially less than the force of the gas in the blast B, so that this force actually turns the ends of the primaries 72 downwardly in the blast B and attenuates the primaries into fine fibers.

The size of the fibers depends on the size of the primaries 72, temperature of the primaries, rate of feed of the primaries, velocity and temperature of the blast B. Either or all of these may be varied within limits to obtain fibers of one micron or less in diameter to two and one-half microns or more in diameter.

The embodiment of the invention shown in Figure 5 of the drawings differs from the above construction in that the ring-like blast B instead of being produced by an annular burner is obtained by a multiplicity of separate burners 81 arranged in rows concentric with the axis of the rotor 28. The burners 81 in each row are spaced apart, but are staggered wtih respect to the burners in adjacent rows, so that the blast issuing from one burner effectively bridges the gap between adjacent burners in the next row. The individual burners 81 operate on the same principle as the burner shown in Figure 1 and need not be described in detail.

In the first described form of the invention the body of glass or heat softened material is separated into individual streams or primaries 72 by a multiplicity of grooves 71 formed by serrating the top edge of the peripheral flange 68. If desired, the primaries 72 may also be successfully produced in the manner shown in Figure 6 of the drawings by extending the peripheral rotor flange 82 upwardly and forming a multiplicity of small holes 83 in the flange. The holes 83 are spaced in close proximity to each other circumferentially of the flange 82, and coact with the centrifugal force to produce well defined primary filaments or streams.

Figure 7 of the drawings is a diagrammatic illustration of apparatus rendering it possible to actually melt the body of glass in the rotor and thereafter to discharge the glass in the form of a multiplicity of separate primaries by the action of centrifugal force. The rotor is designated by the numeral 85 and is supported for rotation on a vertical shaft 10 in much the same manner as described in connection with the first embodiment of this invention. However, in the present instance the rotor 85 is formed of a high heat resistant material, such for example, as platinum, molybdenum, tantalum, ceramic materials or any combination of these and other materials.

The rotor 85 is shaped to provide an annular receptacle 87 into which glass batch in the form of fine powdered material or in the form of briquettes of intermixed glass ingredients may be fed. Alternatively, glass cullet such as granulated glass or glass marbles may also be fed directly into the annular receptacle 87. Any suitable means may be employed to feed the selected material into the receptacle, such for example, as a hopper and a chute leading from the hopper to a position directly above the receptacle.

In the present instance the glass in one form or another is heated by radiant burners 90 supported above the rotor 85 on a suitable fixed support in a position to direct the flames against the material or glass in the receptacle 87. However, it will be understood that the receptacle 87 may be heated in other ways such, for instance, through means of electric current. This current may be passed through the walls of the receptacle by making the rotor the secondary of a transformer having its primary in the form of a coil (not shown) connected to a source of alternating current. With such an arrangement current is induced in the walls of the receptacle 87 and heats the contents of the latter to the melting temperature.

Regardless of the specific form of heating selected, the contents of the receptacle are melted or softened to such an extent that they flow generally radially outwardly under the influence of the centrifugal force obtained as a result of rotating the receptacle about the axis of the shaft 10. The peripheral edge of the rceeptacle at the top of the latter may be formed with a multiplicity of closely spaced openings similar to the openings 83 of Figure 6, and the heat softened material flows through the openings under the influence of centrifugal force to form individual primaries. These primaries are projected into a blast of gas, and are attenuated into fibers by the heat and force of the blast in the same manner noted in connection with the modification shown in Figures 1 to 4 inclusive.

In practicing the process with the apparatus features in Figures 6 and 7, it is possible to heat glass batch material in the receptacle 87 just enough to fuse or soften the material so that it will compact against the outer wall of the receptacle and pass through the openings 83 in the form of batch rods. The rods are then projected into a blast of gas similar to the blast B and having sufficient temperature to melt the batch rod to form glass which is attenuated by the force of the blast into fibers.

In Figure 8 of the drawings another apparatus for producing fine glass fibers is shown. In detail, the numeral 100 indicates a disk supported for rotation about a vertical axis and having a serrated peripheral edge 101 simulating saw teeth. The shaft 102 on which the disk is secured is journalled in suitable bearings and is connected to a prime mover such for example as an electric motor 103. Suitably supported directly above the disk 100 is a receptacle 104 containing a supply of molten glass and having a discharge opening in the bottom wall through which molten glass flows as a stream under the influence of gravity. The opening is so located with respect to the disk 100 that the molten glass is deposited on the disk adjacent the serrated peripheral edge of the latter. Since the disk 100 is rotating about the axis of the shaft 102, the molten glass is directed radially outwardly under the influence of centrifugal force, and is separated by the teeth at the periphery of the disk into individual streams.

Supported directly below the disk 100 is a block of refractory material 105 having a recess 106 in the top surface and having an intake 107' through which a combustible mixture of gases is introduced into the recess. These gases are ignited in the recess 106 and the products of combustion serve to heat the disk which forms the top wall of the recess 106. The disk 100 is spaced above the top of the block 105 to form a restricted annular outlet opening 107 between the top of the block and the underside of the peripheral edge of the disk. The products of combustion which takes place in the recess 106 escape through the annular restricted outlet opening 107 and form a ring-like blast of intensely hot gas moving at substantial velocity. The primaries or streams discharged from the periphery of the disk 100 under the influence of centrifugal force are projected into this blast, and are further attenuated into fine fibers.

Figure 9 of the drawings features an arrangement somewhat similar to the above, except that the disk 100 is heated from above by one or more radiant types of gas combustion burners 110. The molten glass primaries flowing radially outwardly from the periphery of the disk 100 under the influence of the centrifugal force are interrupted by an annular shield 111 and are directed by this shield in a downward direction toward a conveyor or belt 112. The fibers are conveyed toward the belt by the action of suction produced by drawing air through a casing 113 suitably supported below the conveyor.

In Figure 11 of the drawings a construction is shown which may be identical to the embodiment shown in Figure 1, except that a ring 115 is positioned between the rotor 28 and the ring-like blast B. The ring 115 is attached to the rotor 28 at points spaced circumferentially of the rotor by spokes 116 and the outer edge 117 extends to a position immediately adjacent the blast B. It will also be noted from Figure 11 that the outer annular edge 117 of the ring is located in a position to intercept the streams of glass issuing from the peripheral edge 71 of the rotor 28, and since the ring 115 rotates as a unit with the rotor, the streams are fed into the blast B by centrifugal force.

Owing to the proximity of the ring 115 to the blast B, it is heated by the latter, and this heat assists in maintaining the glass in a softened condition during its travel from the rotor to the blast. Also by transferring the glass from the ring to the blast any tendency for molten glass to accumulate on the peripheral edge of the rotor is avoided, and in addition, the outer annular edge 117 of the ring assists the stream of air supplied by the blower 34 to prevent the blast from curving inwardly toward the rotor.

We claim:

1. The process of making glass fibers which comprises flowing a body of heat softened glass in a generally radially outward direction by the action of centrifugal force, mixing the glass as it flows outwardly under the influence of the centrifugal force to increase the homogeneity of the glass by separating the softened body of glass into streams, recombining the streams of glass upon continued flow of the glass body under the action of said centrifugal force to aid in mixing the glass, again separating the glass into a multiplicity of individual glass streams as the glass continues to flow under the influence of the centrifugal force, projecting the last-named streams into a blast of hot gas moving at substantial velocity in a direction extending transversely to the direction of flow of the glass, and attenuating the streams of glass into fibers by the heat and force of the blast.

2. The process of making glass fibers which comprises burning a combustible mixture of gases and discharging the burned gases in the form of a single ring-like blast of gas moving downwardly at a rate sufficient to attenuate softened glass into fine fibers, flowing a body of heat softened glass by centrifugal force in a generally radial direction normal to the movement of the blast, separating the body of glass as it flows under the influence of centrifugal force into a multiplicity of individual streams of glass, projecting the streams with sufficient force to enter but not go through the ring-like blast, and reheating and drawing out the streams into fine fibers by the heat and force of the blast.

3. The process of making glass fibers which comprises burning a combustible mixture within an annular chamber and discharging the products of combustion from the chamber in the form of an annular blast moving in one direction at a velocity sufficient to draw out heat softened glass into fibers, flowing a body of heat softened glass in directions extending generally radially outwardly from the axis of the annular blast by the action of centrifugal force, mixing the glass as it flows outwardly under the influence of centrifugal force to increase the homogeneity of the glass by separating the softened body of glass into individual streams and by stretching out any cords in the glass in a direction extending transversely to the direction of flow of the blast, recombining the glass streams during continued outward flow of the glass and again separating the recombined glass into individual streams, projecting the inidividual streams of glass endwise into the annular blast by the action of the centrifugal force, and drawing out the streams to form fibers by the heat and force of the blast.

4. The process of making glass fibers which

comprises flowing a body of heat softened glass along a predetermined path by the action of centrifugal force, successively separating the body of glass into individual streams and recombining the streams of glass while the body of glass moves along said path of travel under the influence of centrifugal force and finally forming the glass into streams, projecting the streams of glass endwise into a blast of extremely hot gas moving at a high velocity in a direction extending transversely to the path of movement of the glass body, and further attenuating the streams of glass into fine fibers by the heat and force of the blast.

5. The process of making glass fibers which comprises burning a combustible mixture of gases and discharging the products of combustion in the form of a ring-like blast of gas moving at a rate sufficient to attenuate softened glass into fine fibers, flowing a body of heat softened glass in a generally radially outward direction from the approximate center of the blast by the action of centrifugal force, separating the body of glass into a multiplicity of individual streams of glass and recombining them while said body flows under the influence of the centrifugal force and then forming the glass into individual streams projecting the streams of glass endwise into the annular blast by the action of centrifugal force, and attenuating the drawn out streams into very fine fibers by the heat and force of the blast.

6. Apparatus for producing glass fibers comprising means for producing a ring-like blast of gas having a temperature exceeding the softening temperature of glass and having a velocity sufficiently high to attenuate softened glass into fibers, a rotor supported within the confines of the ring-like blast and having concentric recesses therein for supporting a body of heat softened glass, and means for rotating the rotor at a speed determined to provide the centrifugal force required to flow the heat softened glass successively through said recesses and to project the glass beyond the periphery of the rotor into the blast.

7. Apparatus for producing glass fibers comprising a rotor having an annular recess in the top surface adapted to retain a body of heat softened glass and having a second annular recess in said surface concentrically arranged with respect to the first recess, an annular upstanding rib separating the recesses, an annular upstanding flange at the periphery of the rotor forming the outer wall of the outermost recess, means for rotating the rotor at a speed determined to provide the centrifugal force required to flow the heat softened glass from the inner annular recess generally radially outwardly over the top surface of the annular rib into the outer annular recess and over the top surface of the upstanding peripheral flange into the space beyond the periphery of the rotor, and means for attenuating the heat softened glass entering the space beyond the rotor including a blast of gas having a temperature exceeding the softening temperature of the glass and having a velocity sufficiently high to draw out the softened glass into fibers.

8. Apparatus for making glass fibers comprising means for producing a ring-like blast of gas having a temperature exceeding the softening temperature of glass and having a velocity sufficiently high to attenuate heat softened glass into fibers, a rotor supported within the confines of the ring-like blast with the plane of rotation thereof substantially normal to the direction of movement of the blast, said rotor having an inner annular recess adapted to contain a body of heat softened glass and having an outer annular recess, an annular rib separating the recesses and having a multiplicity of circumferentially spaced grooves in the top surface thereof, an annular upstanding flange at the periphery of the rotor forming the outer wall of the outermost annular recess and also having a multiplicity of circumferentially spaced grooves in the top surface thereof, means for rotating the rotor at a speed determined to provide the centrifugal force required to flow the heat softened glass from the inner annular recess radially outwardly over the grooved top surface of the rib into the outer annular recess and over the grooved top surface of the peripheral flange into said blast.

9. Apparatus for producing glass fibers comprising a rotor supported for rotation, means for depositing a body of heat softened glass on the top surface of the rotor, means for rotating the rotor at the speed determined to provide the centrifugal force required to flow the glass generally radially outwardly from the peripheral edge of the rotor, a ring surrounding the periphery of the rotor in radial spaced relation thereto and positioned to intercept the glass flowing outwardly from the periphery of the rotor, and means for rotating the ring as a unit with the rotor.

10. Apparatus for producing glass fibers comprising a rotor having provision for supporting a body of heat softened glass on the top surface thereof, means for producing a blast of gas having a temperature which exceeds the softening temperature of glass and having a velocity high enough to attenuate the heat softened glass into fibers, means for flowing the blast past the periphery of the rotor in a direction extending in the general direction of the rotor axis, means for rotating the rotor at a speed determined to provide the centrifugal force required to flow the heat softened glass generally radially outwardly along the top surface of the rotor and to project the glass beyond the periphery of the rotor toward the blast, and a ring surrounding the periphery of the rotor in radial spaced relation thereto and rotatable as a unit with the rotor, said ring being located to intercept the glass flowing from the periphery of the rotor and to direct the glass leaving the outer edge thereof into said blast.

11. The process of making glass fibers which includes burning a combustible mixture of gases and discharging the burned gases in the form of a ring-like blast of gas moving at a rate sufficient to attenuate glass into fine fibers, moving a mass of heated glass by centrifugal force in a generally radial direction transverse to the movement of the blast, separating the mass of glass as it flows under the influence of centrifugal force into a multiplicity of individual elongated bodies of glass, projecting the elongated bodies of glass with sufficient force to enter but not go through the ring-like blast, and reheating and drawing out the elongated bodies into fine fibers by the heat and force of the blast.

12. The process of making glass fibers which includes burning a combustible mixture of gases and discharging the burned gases in the form of a ring-like blast of gas moving at high velocity, moving a body of heated glass by centrifugal force in a generally radial direction transverse to the movement of the blast, separating the body of glass as it moves under the influence of centrifugal force to form a multiplicity of rods of glass, projecting the rods with sufficient force

to enter but not go through the ring-like blast, and reheating and drawing out the rods into fine fibers by the heat and force of the blast.

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UNITED STATES PATENT OFFICE

Certificate

Patent No. 2,609,566 Patented September 9, 1952

Games Slayter and Charles J. Stalego

Application having been made jointly by Games Slayter and Charles J. Stalego, the inventors named in the patent above identified, and Owens-Corning Fiberglas Corporation, Toledo, Ohio, a corporation of Delaware, the assignee, for the issuance of a certificate under the provisions of Title 35, Section 256 of the United States Code, deleting the name of the said Games Slayter from the patent as a joint inventor, and a showing and proof of facts satisfying the requirements of the said section having been submitted, it is this 27th day of March 1962, certified that the name of the said Games Slayter is hereby deleted from the said patent as a joint inventor with the said Charles J. Stalego.

[SEAL]

EDWIN L. REYNOLDS,
First Assistant Commissioner of Patents.

Notice of Adverse Decision in Interference

In Interference No. 86,795 involving Patent No. 2,609,566, C. J. Stalego, Method and apparatus for forming fibers, final judgment adverse to the patentee was rendered Jan. 30, 1958, as to claims 2, 11 and 12.

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