March 7, 1961 R. G. RUSSELL 2,973,550

METHOD AND APPARATUS FOR FORMING FIBERS

Filed Feb. 14, 1956 3 Sheets-Sheet 1

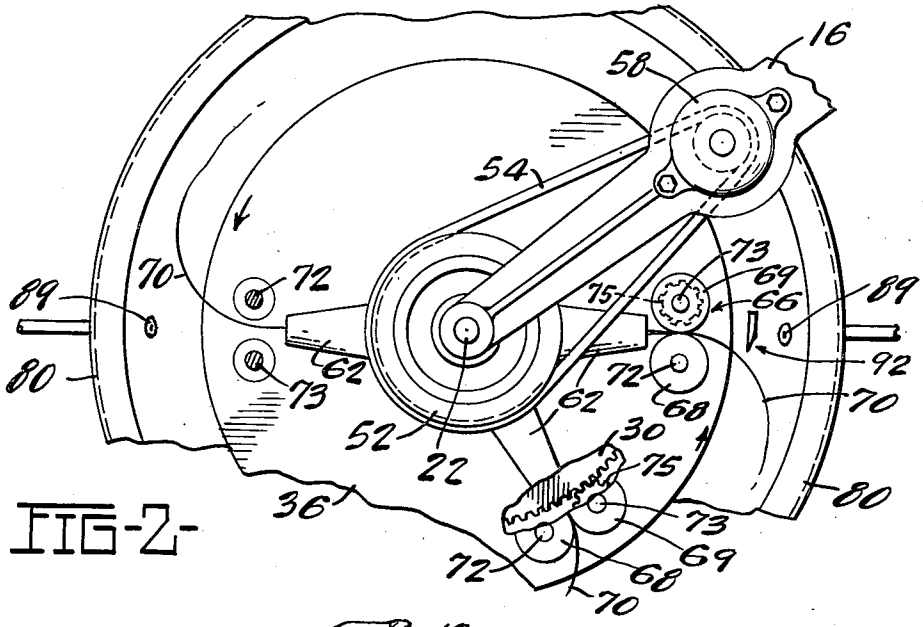


FIG-2-

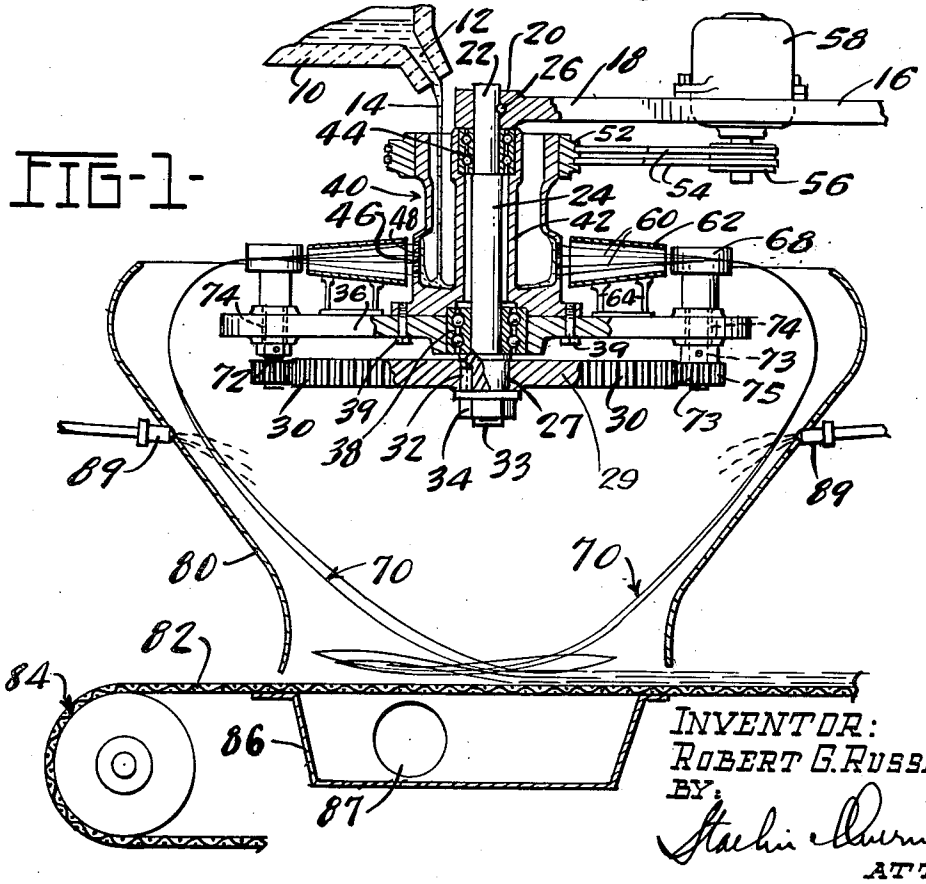


FIG-1-

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METHOD AND APPARATUS FOR FORMING FIBERS

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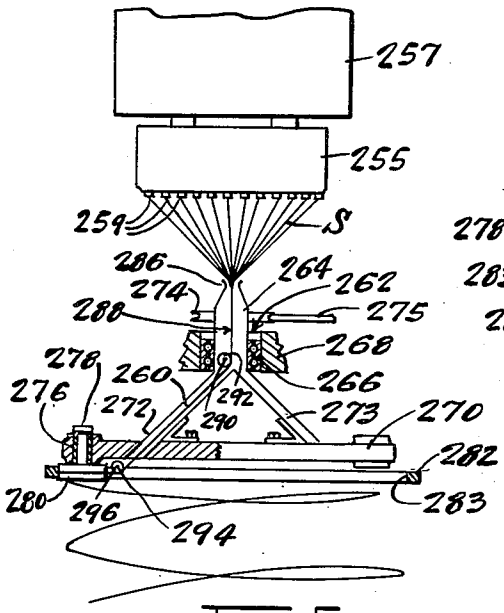


FIG-5-

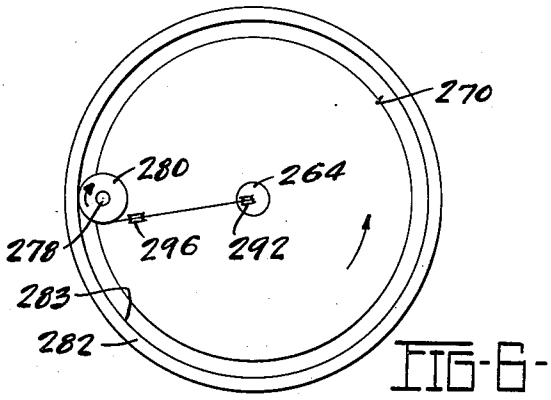


FIG-6-

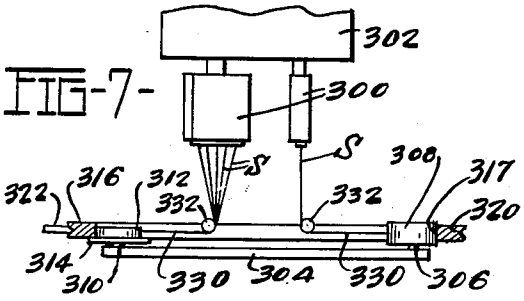


FIG-7-

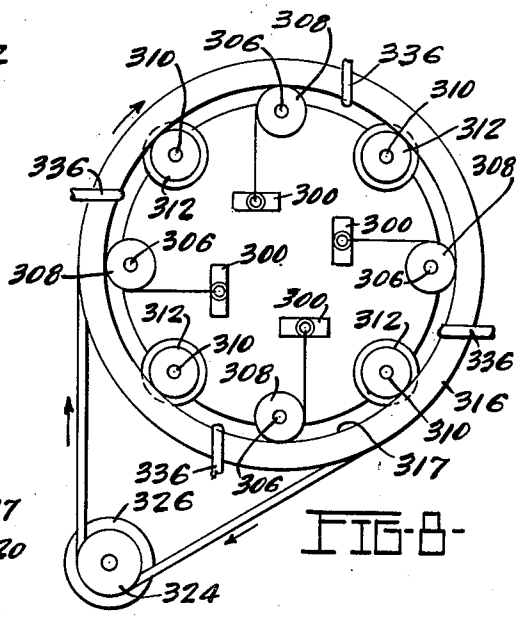


FIG-8-

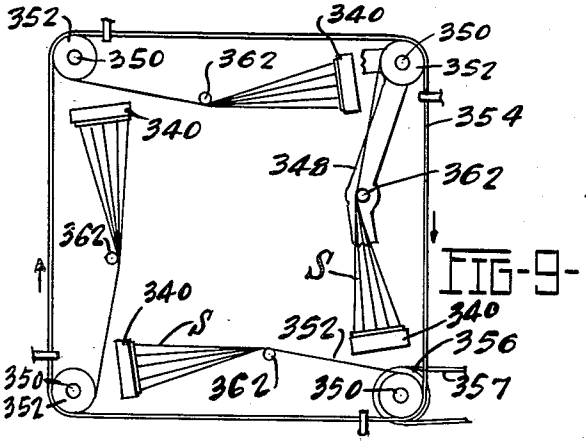


FIG-9-

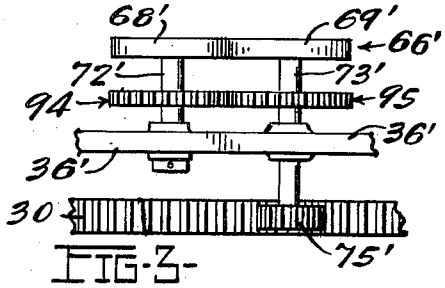


FIG-3-

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METHOD AND APPARATUS FOR FORMING FIBERS

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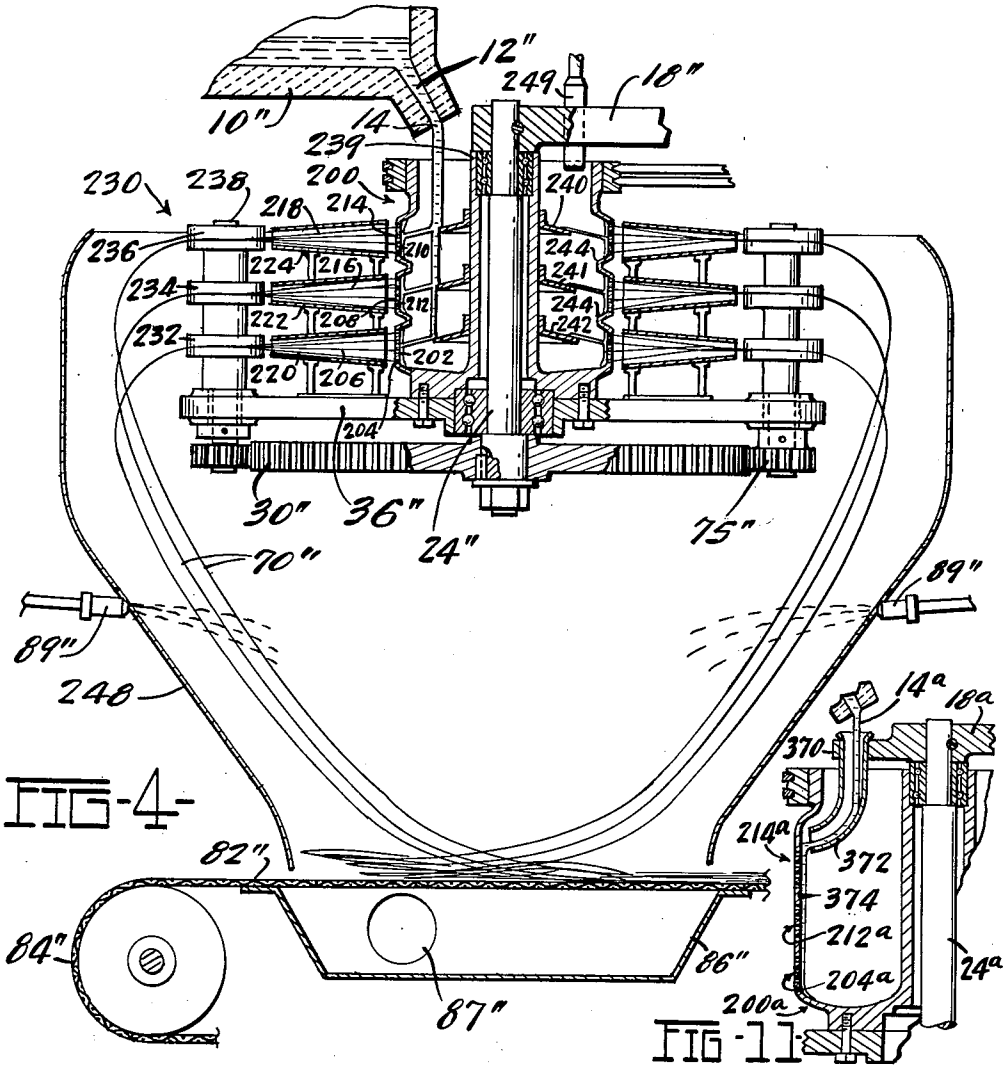


FIG-4-

FIG-11-

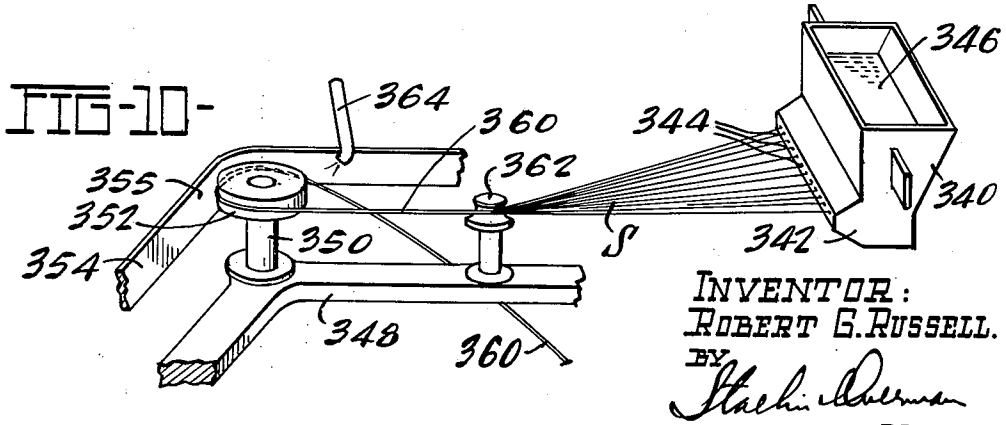


FIG-10-

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United States Patent Office 2,973,550 Patented Mar. 7, 1961

2,973,550

METHOD AND APPARATUS FOR FORMING FIBERS

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Filed Feb. 14, 1956, Ser. No. 565,381

7 Claims. (Cl. 18—8)

This invention relates to method and apparatus for forming fibers and more especially to a method and means for attenuating fine fibers or filaments from heat-softened materials, such as glass, slag, fusible rock, fiber-forming resins or the like.

It has been a usual practice to form continuous filaments or fibers wherein filaments in strand formation formed from streams of softened material are engaged between pulling wheels rotating about horizontal axes whereby the streams are attenuated to continuous filaments by rotating the pulling wheels. Filaments of this character have been utilized to produce a product known as mechanically bonded mat. This product is formed from strands of fibers which are deflected or oscillated by means engaging and traversing the strand over a collecting surface during collection of the strand to form a comparatively thin mat. A binder is distributed in the mat which when cured securely bonds the filaments in mat formation.

A mat formed by this method is satisfactory for use as pipe wrapping material and for other insulating uses. Production methods heretofore employed have not been economical from a commercial standpoint because of the limited capacity of strand, as a single strand lapped upon itself provides the mat formation.

The present invention embraces a method of attenuating filaments from heat-softened material in a manner and at a comparatively high rate of speed whereby products formed from a strand or strands of the filaments may be economically produced.

An object of the invention resides in a method of forming streams of material from a supply and engaging the fibers or filaments formed from the streams between surfaces and effecting relative movement between the surfaces whereby filaments are drawn from the streams and gathered into a strand or linear bundle which is delivered or deposited from the surfaces in overlapping loops without the use of secondary strand distributing means.

Another object of the invention embraces a method of forming a strand of mineral fibers wherein a degree of twist may be imparted to the strand concomitantly with the operation of attenuating the filaments or fibers of the strand from heat-softened fiber-forming material.

Another object of the invention is the provision of a method of forming a strand or strands of filaments of mineral material by engaging the strand with rotating surfaces moving in planetary paths whereby the strand is produced at a high rate of speed and collected in continuous form as a mat, or the strand may be severed or cut and the cut strands utilized in forming fibrous mats.

Another object is the provision of an apparatus embodying a rotating structure wherein the filaments of mineral material forming the strands are attenuated by relatively rotatable surfaces carried by the rotating element to provide an economical and high rate of production of strands.

Another object of the invention is the provision of a rotor or revoluble means adapted to receive molten mineral material which is distributed or fed outwardly of an axis of rotation by centrifugal forces to form elongated bodies of the material and attenuating the bodies to filaments or fibers by engaging the filaments or fibers with relatively movable surfaces carried by the revoluble means.

Another object of the invention is the provision of means for concomitantly attenuating several groups of streams of heat-softened mineral material to groups of filaments discharged from the attenuating means at spaced zones, the groups or strands of filaments coated with a binder or adhesive being collected into a mat formation and the mat of strand material delivered into a curing zone for setting the binder or adhesive.

Another object of the invention resides in delivering groups of continuous filaments to pairs of relatively movable surfaces whereby the filaments of a group are attenuated by one pair of surfaces to concomitantly produce a plurality of individual bundles of filaments or strands which may be delivered onto a collecting surface in loop or swirl patterns in overlapping formation providing a mat of strands or bundles of filaments having high strength characteristics in all directions of the major surfaces of the mat.

Another object of the invention relates to the provision of a method of delivering bodies of glass in a molten state from a feeding device and attenuating the bodies to filaments or fibers by engaging the filaments or fibers with surfaces movable about vertical axes or in orbits whereby the filaments are moved in substantially horizontal directions adjacent the zones of engagement of the surfaces with the filaments.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawing of a form of the invention, which may be preferred, in which:

Figure 1 is a semidiagrammatic vertical sectional view showing one form of apparatus for carrying out the method of the invention;

Figure 2 is a top plan view of a portion of the apparatus illustrated in Figure 1;

Figure 3 is a fragmentary elevational view illustrating a modified form of filament attenuating means;

Figure 4 is a modified form of apparatus of the character shown in Figure 1;

Figure 5 is a diagrammatic elevational view showing another form of apparatus for carrying out the method of the invention;

Figure 6 is a diagrammatic plan view showing the path of the strand of filaments formed by the arrangement shown in Figure 5;

Figure 7 is a semidiagrammatic elevational view with certain parts shown in section of a modified arrangement for carrying out the method of the invention;

Figure 8 is a top plan view of the arrangement shown in Figure 7;

Figure 9 is a diagrammatic plan view illustrating another arrangement for carrying out the method of the invention;

Figure 10 is a diagrammatic isometric view illustrating a method of feeding fiber-forming material to an attenuating means of the character shown in Figure 9, and

Figure 11 is a fragmentary sectional view illustrating another form of material distributing means.

While the method and apparatus of the invention are illustrated as particularly usable for forming fibers or

filaments from heat-softened material such as glass, it is to be understood that the invention may be utilized for forming fibers or filaments from other heat-softenable mineral materials such as slag, or fusible rock, or the method may be used for forming filaments from filament forming resins.

Referring to the drawings in detail, the arrangement shown in Figures 1 and 2 includes a means for delivering heat-softened material such as molten glass or other filament or fiber-forming material onto or into engagement with a rotating surface from which the material is delivered by centrifugal forces into elongated outwardly projected bodies or primary filaments which are gathered into strand or group formation and passed between or caused to engage in the nip or bight zone of one or more pairs of pulling or attenuating members or wheels rotating about their own axes and about a central orbit and at a speed for attenuating the outwardly projected bodies or primary filaments into fine filaments or fibers.

As shown in Figure 1 there is provided a feeder or receptacle 10 having an orifice or passage 12 through which a stream 14 of heat-softened or molten glass or other fiber-forming material is discharged from the supply in the feeder 10. The feeder 10 may be connected to the forehearth of a glass furnace (not shown) or it may be electrically heated and the fiber-forming material delivered into the feeder in the form of spherical bodies or marbles which are reduced to molten condition in the feeder.

The fiber or filament forming apparatus is supported upon a frame 16, a portion of which is shown in Figures 1 and 2. The frame 16 is provided with a projecting arm 18 formed with a boss 20. The boss 20 is bored to receive a reduced portion 22 of a shaft 24 which is fixedly secured to the arm 18 by means of a key 26 or other suitable means.

The shaft 24 is provided with an enlarged portion 27 upon which is mounted a stationary member 29 having its periphery formed with teeth providing a relatively stationary gear 30. The member 29 is nonrotatably secured to the shaft portion 27 by means of a key 32, the shaft being provided with a threaded portion 33 adapted to receive a securing nut 34 for securely holding the member 29 on the shaft.

Disposed adjacent the member 29 is a rotatable element or plate 36 which is journally supported upon the shaft 34 by means of antifriction bearings 38. Secured to the member 36 by means of screws 39 is a cup-like rotor or rotating member 40. The rotor or member 40 is formed with a sleeve portion 42 which surrounds but is slightly spaced from the shaft 24. The upper end zone of the sleeve portion 42 is formed to accommodate antifriction or ball bearings 44. The antifriction bearings 38 and 44 serve to journally support the rotor 40 on the shaft 24.

The rotor 40 is provided with a peripheral wall 46 spaced from the sleeve portion 42 and formed with circumferentially spaced groups of small orifices or openings 48 through which molten material on the interior of the rotor is projected by centrifugal force.

The rotor 40 is provided with a pulley or sheave wheel 52 connected by belts 54 with a pulley 56 driven by a motor 58, the latter being carried upon the frame 16. The relative size of the pulleys 52 and 56 may be varied or changed to secure the desired speed of rotation of the rotor 40 and the plate 36.

Means are provided associated with the rotating plate 36 and the rotor for attenuating the material projected through the orifices 48 into continuous filaments or fibers. Each group of openings or orifices 48 in the rotor wall 46 is arranged to deliver the fiber-forming material in the form of elongated bodies or primary filaments 60 into an enclosure or guide 62. Each of the guides is mounted upon the member or plate 36 by means of supports 64 shown in Figure 1. The guide elements or enclosures 62 are preferably of frusto-conical shape to guide the bodies 60 into proper engagement with the attenuating means or units 66 as well as to retard cooling of the bodies.

In this form of the invention, an attenuating means or unit 66 is provided for each group of linear bodies or primary filaments 60 in the form of pairs of rotatable fiber or filament engaging elements. As particularly shown in Figure 2 each attenuating means or unit is inclusive of rotatable elements or wheels 68 and 69 disposed in frictional engagement as shown in Figure 2 and to frictionally engage the filaments attenuated from the bodies 60 to form a strand, sliver or bundle 70 of filaments or fibers.

The filament engaging elements 68 and 69 of each pair are respectively mounted upon shafts 72 and 73 journalled in bearings 74 carried by the rotatable plate 36. The shaft 73 carrying the attenuating element or wheel 69 is equipped with a pinion 75 which is in constant mesh with the relatively stationary gear 30 formed on member 29.

During rotation of the rotor 40 and the plate 36 in a counter-clockwise direction as viewed in Figure 2, indicated by the arrows, the attenuating wheels 68 and 69 are rotated in opposite directions to draw or attenuate the linear bodies 60 into fine filaments or fibers, the wheel 68 being driven by frictional engagement with wheel 69. The filaments or fibers are directed into the nip or bight zone of the pairs of rotating elements 68 and 69 and, by reason of their individual rotation and their travel in an orbit about the axis of the plate 36 in a planetary fashion, the bodies 60 of fiber-forming material are attenuated to fine continuous filaments or fibers at a very high linear speed.

The strands, slivers or bundles 70 of continuous filaments are directed downwardly as shown in Figure 1 into a hood or housing 80 disposed above the upper flight 82 of an endless belt conveyor 84. The conveyor belt is of foraminous or reticulated character and a suction box 86, connected with a source of reduced pressure or suction through a tube 87, provides a zone of reduced pressure adjacent and in registration with the outlet zone of the housing 80 to assist in collecting the strands or slivers 70 in a mat or mass formation upon the flight 82 of the conveyor. Applicators 89 may be provided for delivering binder, adhesive or other bonding medium onto the strands or linear bundles of fibers 70. The applicators 89 may be supported adjacent the hood or enclosure 80 to deliver the binder onto the strands while they are moving toward the conveyor flight 82 as illustrated in Figure 1.

The binder may be applied at other zones, as for example, on the linear bodies 60 just prior to their engagement with the wheels or rolls 68 and 69 of the attenuating units 66. Various types of binders or adhesives may be utilized of thermoplastic or thermosetting character, or starches, sugars and the like may also be used. It has been found that thermosetting binders, such as phenolformaldehyde or urea-formaldehyde, have been found to be satisfactory.

In the operation of this form of the invention, the molten fiber-forming material, such as glass or other mineral or resinous material, is delivered in molten form from a supply in the feeder or other receptacle 10 interiorly of the rotor 40. The rotor 40, plate 36 and the component parts carried thereby are rotated at a desired speed by the motor 58 through the medium of the pulleys 52 and 56 and belts 54. The rotor 40 is rotated at a speed sufficient to propel or project the molten material on the interior of the rotor by centrifugal forces through the orifices 48 in the rotor wall 46, forming the material into outwardly moving linear bodies or primary filaments 60. As the plate 29 is stationary, and the pairs of attenuating wheels 68 and 69

are carried by the movable plate 36, rotation of the plate 36 through the enmeshment of the gears 75 with the stationary gear 30 results in high speed individual rotation of the attenuating wheels 68 and 69 about their respective supporting shafts as they move in planetary fashion about the axis of the shaft 24. The attenuation of the bodies 60 to fine filaments or fibers is accomplished by the attenuating units 66 as they move in an orbit about the axis of shaft 24.

The slivers or strands 70 of filaments are discharged outwardly and move downwardly under the influence of gravity and the suction or reduced pressure in the suction box 86 and in spiral shape or pattern so that during collection they are formed in overlapping loops in a generally uniform pattern which produces a mat of strands which, when bound together with a suitable binder delivered onto the strands by the applicators 89, has very high strength characteristics in all directions in the planes of the major faces of the mat. The product may be utilized for many uses, as for example, pipe wrapping and for surface facing for fibrous mats or batts of various kinds, and is generally usable wherever high strength characteristics are desired with a minimum weight of product.

While it may be preferable to collect the strands or linear bundles of fibers or filaments in continuous form, they may be severed into lengths by a suitable severing means. As shown in Figure 2, a cutting device or severing means 92 may be disposed in the path of the moving strands 70 so that the strands engage the cutting device 92 to sever the strands into lengths. It is to be understood that one or more cutters may be utilized disposed in the paths of the strands depending upon the lengths of cut strands to be formed. The conveyor 84 is advanced by suitable driving means (not shown) to convey the binder impregnated mat of strands to a drying, curing or binder setting zone or oven (not shown) for drying or setting the bonding medium.

Figure 3 is a fragmentary view showing a means of positively driving both wheels or rolls of a fiber-forming or attenuating unit. The wheels 68′ and 69′ of the attenuating unit 66′ are mounted upon shafts 72′ and 73′ respectively, the shafts being journalled in bearings carried by the rotatable plate or member 36′. The pinion 75′ mounted on shaft 73′ is enmeshed with the teeth of the stationary gear 30. Shafts 72′ and 73′ are respectively provided with gears 94 and 95 which are enmeshed as illustrated in Figure 3. Through the arrangement illustrated in this Figure 3 both pulling or attenuating rolls or wheels 68′ and 69′ are positively driven at the same speed. This arrangement may be applied to any number of attenuating units carried by the movable member 36′.

Figure 4 illustrates a modified form of the apparatus shown in Figures 1 and 2 for concomitantly attenuating a large number of groups of bodies or primary filaments of fiber-forming material to fine filaments or fibers. In this arrangement a frame or arm 18″ carries a shaft 24″ which is relatively stationary and which supports the stationary gear 30″. Rotatably journalled upon bearings associated with the shaft 24″ is a rotor or rotating element 200 driven through a belt and pulley arrangement similar to that shown in Figure 1 for driving the rotor 40. The rotor 200 is mounted upon the plate 36″ and both the rotor 200 and the plate 36″ are revolubly supported upon the stationary shaft 24″ in the manner illustrated in Figure 1.

A peripheral wall portion 202 of the rotor 200 is formed with circumferentially-spaced groups of orifices or openings 204 through which heat-softened or molten material on the interior of the rotor is projected or delivered by centrifugal forces in the form of linear bodies or primary filaments 206.

The rotor 200 is also formed with vertically spaced peripheral wall portions or zones 208 and 210, each of the peripheral zones 208 and 210 being formed respectively with circumferentially spaced groups of openings 212 and 214 through which molten material on the interior of the rotor is discharged or delivered by centrifugal forces in the form of linear bodies. The bodies projected through the orifices 212 are designated 216 and the bodies of material projected through the openings 214 are designated 218. The elongated or linear bodies of fiber-forming material 206, 216 and 218 are delivered through guides or enclosures designated respectively 220, 222 and 224, these guides or enclosures being mounted upon the plate 36″ and adapted for rotation with the plate.

Disposed adjacent the exit zones of the guides or enclosures 220, 222 and 224 is an attenuating unit 230 comprising pairs of rolls or pulling wheels 232, 234 and 236 supported upon shafts 238 in the manner illustrated. One set of the attenuating wheels or rolls and one of the supporting shafts 238 are shown in Figure 4, and it is to be understood that the arrangement of pairs of fiber or filament engaging attenuating wheels is similar in construction and mounting to the construction and mounting of the pairs of attenuating wheels forming components of the attenuating units 66 shown in Figures 1 and 2. One of the shafts 238 of each pair is equipped with a pinion 75″ which is enmeshed with the teeth of the gear 30″ whereby during rotation of the rotor 200 and plate 36″, rotation is imparted to the several pairs of attenuating wheels 232, 234 and 236 forming components of each of the attenuating units 230.

Disposed above the rotor 200 is a feeder or receptacle 10″ provided with an orifice or outlet 12″ through which a stream of molten glass or other fiber-forming material 14 is discharged, the stream flowing into the interior of the rotor 200.

Means is disposed within the rotor 200 for directing the molten fiber-forming material into contact with the peripheral zones 202, 208 and 210 whereby a film or quantity of the fiber-forming material is maintained in each of said peripheral zones of the rotor for discharge under centrifugal forces through the groups of orifices in the perforated peripheral zones of the rotor. The rotor 200 is provided with an inner sleeve portion 239 and supported upon the sleeve portion 239 in vertically spaced relation are material deflecting means or baffles 240, 241 and 242 for engagement with the stream 14 of molten fiber-forming material. As illustrated in Figure 4 the material deflecting baffles may be of different diameters for the purpose of intercepting and redirecting portions of the stream of material 14 to apportion the molten material among the vertically spaced perforated zones of the rotor 200. As illustrated in Figure 4 the uppermost baffle 240 intercepts a portion of the stream 14 and directs the same into contact with the peripheral wall zone 210 of the outer rotor wall. The baffle 241 disposed beneath baffle 240 may of a greater diameter to intercept another portion of the stream 14 of material and deflect or redirect the intercepted portion into contact or engagement with the zone 208 of the outer wall of the rotor. The baffle 242 is of a diameter to intercept the remainder of the stream 14 and deflect or redirect the same into engagement with the zone 202 of the outer wall of the rotor.

In this manner the three vertically spaced circumferentially arranged perforated zones of the rotor receive substantially equal amounts of molten material so that linear bodies of material 206, 216 and 218 may be continuously delivered from the groups of orifices in the outer rotor wall. The groups of linear bodies 206, 216 and 218 are attenuated to groups of fibers by the pairs of wheels 232, 234 and 236.

It should be noted that the perforated zones 202, 208 and 210 of the rotor are separated by inwardly extending ridges or circumferential beads 244 to assist in maintaining a film or quantity of the molten fiber-forming material adjacent each of the perforated zones.

The strands or linear bundles of attenuated filaments or fibers 70'' descend through a hood 248 and are deposited or collected upon the upper flight 82'' of an endless type foraminous conveyor 84'', the collection of the strands or bundles of the filaments or fibers being facilitated by means of reduced pressure or suction existent in a suction box 86''. A bonding medium or adhesive may be applied to the strands by means of applicators 89'' associated with the hood or enclosure 248. It is to be understood that a binder or adhesive may be applied to the filaments or fibers at other zones if desired. If desired, the strands or bundles 70'' of filaments may be severed into lengths by means of a cutter of the character shown at 92 in Figure 2 or by other suitable strand severing means.

A burner 249 disposed to direct hot products of combustion or burning gases into the rotor 200 may be utilized to aid in maintaining the fiber-forming material within the rotor in a flowable condition.

The operation of the arrangement shown in Figure 4 is similar to the operation of the arrangement shown in Figure 1. One or more streams 14 of substantial size of molten fiber-forming material are delivered into the interior of the rotor 200. The rotor 200 is revolved at a speed sufficient to project or discharge molten material from the groups of perforated zones in the rotor wall in the form of linear bodies or primary filaments. During rotation of the rotor 200 and the plate 36'', the stream or streams 14 of molten material are distributed laterally by means of the baffles 240, 241 and 242, so as to substantially uniformly apportion the material to the vertically spaced perforated zones 202, 208 and 210 providing them with an ample supply of fiber-forming material.

Under the centrifugal forces set up by rotation of the rotor 200, the molten material adjacent the perforated zones of the rotor is projected by centrifugal forces through the orifices 204, 212 and 214 into the guides or enclosures 220, 222 and 224. The groups of filaments formed from the bodies 206, 216 and 218 are advanced into the nip zones of the pairs of attenuating wheels 232, 234 and 236.

It is to be understood that the attenuating wheels in the several forms of attenuating units are faced with a semihard material, as for example, synthetic rubber or other similar material adaptable for frictionally gripping the filaments or fibers so as to carry on the attenuation of the elongated bodies at high speeds without appreciable slippage. The strands or linear bundles of filaments or fibers are collected in overlapping loop formation on the upper flight 82'' in any desired thickness to form a mat, the thickness being determined by the rate that the conveyor flight 82'' is advanced to convey the mat of strands away from the strand collecting zone.

The formed mat may be conveyed by the conveyed 84'' through a binder curing or drying zone, and if heat is required to cure the binder, the mat may be conveyed through a heated oven. The arrangement shown in Figure 4 is especially adapted to attenuate molten material to filaments or fibers at high production rates. It is to be understood that while each filament attenuating unit illustrated comprises three fiber or filament attenuating means arranged in superposed relation, the number of attenuating zones may be increased if desired.

Figures 5 and 6 illustrate another form of apparatus for carrying out the principles of the method of the invention. As shown in Figure 5 a feeder or bushing 255 is adapted to receive molten fiber-forming material from a forehearth 257. It is to be understood that the feeder 255 may be heated as for example by electrical means and spherical bodies or marbles of glass or other fiber-forming material delivered directly into the feeder 255 and melted therein. The feeder 255 is provided with a plurality of tips or projections 259 on its bottom wall formed with orifices through which streams S of molten glass or other fiber-forming material flow from the feeder 255.

Disposed beneath the feeder 255 is a rotatable arrangement for attenuating the streams to fine filaments or fibers 260. This arrangement includes a rotor 262 formed with a hollow shaft portion 264, the latter being supported for rotation by means of antifriction bearings 266 carried by a support 268. Disposed beneath the shaft portion 264 and forming a part of the rotor construction is a plate 270.

The plate 270 is connected with the shaft 264 by means of arms 272 and 273 or by other suitable means. The shaft portion 264 is provided with a pulley or pulley wheel 274 which is adapted to be driven through the medium of a driving belt 275 from a motor (not shown) or other suitable source of power.

The plate or element 270 is provided near its periphery with a bearing 276 in which is journalled a shaft 278 which supports a wheel or roll 280 adapted to engage primary filaments 260 to attenuate the same to fine filamenst or fibers.

Arranged concentrically with the axis of the rotor 262 is an annular member 282 which is relatively stationary and may be supported by suitable means (not shown). The inner wall 283 of member 282 forms a curved surface, raceway or track adapted to be frictionally engaged by the periphery of the attenuating wheel or rotatable element 280. The upper end of the shaft portion 264 of the rotor is formed with a means 286 for guiding or gathering the primary filaments 260 formed from the streams S into a strand, sliver or linear bundle of filaments 288.

The interior zone of shaft 264 is provided with a transversely extending pin 290 on which is journalled a guiding element or pulley 292 which is engaged by the strand of filaments 288 as shown in Figure 5. The arm 272 of the rotor construction is of hollow or tubular configuration to accommodate the strand, sliver or bundle of filaments. The plate 270 is formed with a projection supporting a pin 294 upon which is supported a second strand guiding means or pulley 296 similar to the pulley 292.

The guide means 296 is disposed so as to direct the filaments of the strand, sliver or linear bundle into engagement with the periphery of the rotatable attenuating wheel or roll 280. The strand, sliver or bundle of filaments, extending partially around the periphery of the attenuating wheel 280, is frictionally gripped between the engaging zones of the track or raceway 283 and the periphery of the attenuating wheel 280. The surface 283 of the member 282 or the peripheral surface of the wheel 280 is formed of semihard material, as for example, synthetic rubber, so as to establish a frictional driving connection between the wheel 280 and the raceway 283.

The operation of the arrangement shown in Figures 5 and 6 is as follows: The filaments formed from the streams S of molten glass or other fiber-forming material are gathered or directed into a strand, sliver or linear bundle by the gathering or guiding means 286. Each of the streams S forms an individual filament and the strand or bundle 288 of filaments or fibers passes downwardly through the hollow shaft 264 around the guide member 292 and guide member 296 and around the attenuating wheel 280 into the bight zone or zone of engagement of the wheel 280 with the curved surface or raceway 283 of the annular member 282. The rotor construction 262 including the plate 270 is rotated at the desired speed by a motor connected with the driving belt 275. During rotation of the rotor 262, the attenuating wheel 280, being in frictional engagement with the raceway 283, is continuously rotated about the axis of its supporting shaft 278.

As the strand, sliver or linear bundle of filaments or fibers is securely gripped in the b'ght zone between the wheel 280 and the curved surface 283, the movement of

wheel 280 in its orbit about the axis of the shaft 264 draws or attenuates the streams S to filaments or fibers at a linear rate equal to the peripheral travel of the wheel 280. Stated in another manner the linear feet of filaments of the strand or sliver attenuated in a given unit of time is equal to the circumferential distance of the surface 283 multiplied by the number of rotations of the rotor 262 occurring in the given unit of time.

Through an arrangement of this character the filaments or fibers may be attenuated at rates of ten thousand feet or more per minute. Another feature of the arrangement shown in Figures 5 and 6 is that the rotation of the rotor imparts a twist to the strand, sliver or bundle of filaments which integrates the filaments into a yarn-like bundle and in this manner the filaments are more securely held together. The strand, sliver or bundle of filaments 288 descends downwardly in a spiral formation from the interior of the surface 283 as illustrated in Figure 5. The strand may be collected in the manner shown in Figures 1 and 4 or by other suitable means.

The arrangement shown in Figures 7 and 8 is especially adapted for concomitantly attenuating several groups of streams of fiber-forming material to fibers or filaments to form several strands, slivers or linear bundles of filaments. In this embodiment of apparatus of the invention, four feeders 300 are provided which may be supplied with molten glass or other fiber-forming material from a forehearth 302, or each feeder may be supplied with preformed spheres or marbles of glass to be reduced to molten condition within the feeders by heat applied thereto.

Positioned beneath the feeders 300 is a relatively stationary member or plate 304 upon which a series of vertically extending shafts 306 is mounted. Journally supported on each of the shafts 306 is a filament attenuating or pulling wheel 308. Mounted upon the stationary plate 304 is a second series of shafts 310 extending in a vertical direction. Each of the shafts 310 journally supports an idler roll or wheel 312, each of the wheels 312 being provided with a peripheral flange 314. The flanges 314 of the wheels 312 support an annularly shaped member 316. The member 316 is arranged to rotate about an axis and is maintained in such position by means of the idler rolls or wheels 312.

The member 316 is adapted to be driven by suitable means. In the embodiment illustrated, the periphery of the member 316 is formed with a groove 320 adapted to receive a driving belt 322 which engages with a pulley 324 driven by a motor 326. As shown in Figure 8 an idler wheel or roll 312 is disposed between each pair of attenuating wheels 308. The attenuating wheels 308 have their peripheral surfaces in frictional engagement with the interior surface 317 of the annular member or element 316. The attenuating wheels 308 may be faced with a semihard material such as a rubber, synthetic rubber or the like to establish an effective frictional contact or engagement with the inner curved surface 317 of the member 316.

Each of the feeders 300 is provided with a plurality of orifices through which flow streams S of glass or other fiber-forming material in molten condition. The filaments or fibers attenuated from the streams S are gathered into a strand, sliver or linear bundle 330, each strand or bundle passing around a guide means or roller 332 as shown in Figure 7.

Each strand, sliver or bundle of filaments or fibers moves in a substantially horizontal direction and into the nip or bight zone obtaining at the region of engagement of an attenuating roll 108 and the inner curved surface 317 of the element 316. The attenuating wheels 308 through their frictional engagement with the inner surface of the annular member 316 are rotated thereby. The strands, slivers or bundles of filaments 330 are frictionally gripped between the peripheral surfaces of the wheels 108 and the inner surface 317 of member 316 whereby the streams S are attenuated to filaments or fibers at a high rate of speed dependent upon the speed of rotation of the annular member 316.

The strand, sliver or bundle of attenuated filaments lying in contact with or adjacent the inner surface 317 of the member 316 may be removed by a suitable stripping means. As illustrated in Figure 8 a plurality of tubes or nozzles 336 are disposed so as to project blasts or jets of air under pressure or other gas onto the surface 317 and engaging the strands or slivers to direct them away from the surface 317. The strands or slivers descend from the attenuating means and may be collected upon an endless conveyor in the manner hereinbefore described or by other suitable means.

The several strands or slivers, if collected upon a moving foraminous conveyor, are deposited in overlapping loops to form a mat. A binder may be applied to the strands or slivers which may be subsequently cured in order to impart mass integrity to the formed mat of strands. If desired, the strands discharged from the attenuating means shown in Figures 7 and 8 may be severed into lengths by engaging the strands with suitable cutting or severing means (not shown).

Figures 9 and 10 illustrate semidiagrammatically another form of apparatus for concomitantly attenuating several groups of streams of fiber-forming material to filaments or fibers in strand, sliver or linear bundle formation. The isometric view of Figure 10 illustrates movement in a horizontal direction of the streams of fiber-forming material and the filaments or fibers formed therefrom. The arrangement shown in Figures 9 and 10 is inclusive of a plurality of feeders 340 or means for discharging groups of streams of fiber-forming material. Each of the feeders 340 is formed with a generally horizontally extending portion 342 having a zone provided with orifices or outlets 344 through which streams S of fiber-forming material are delivered for movement in a substantially horizontal direction as shown in Figure 10. The feeders 340 may be connected with a forehearth construction (not shown) for delivering a supply of molten glass 346 into the feeders 340. The feeders 340 may be independently heated as for example by electrical means connected with connector bars 341 formed on the feeders, the latter being adapted to receive glass marbles which may be reduced to molten condition in the feeders.

The arrangement is inclusive of a support 348 and mounted upon the support 348 are shafts 350, each of the shafts journally supporting an attenuating wheel or attenuatng means 352. An endless belt 354 surrounds and engages the zones of the perpheral surfaces of the attenuating wheels 352 in the manner shown in Figure 9. One of the attenuating wheels 352 is equipped with a pulley 356 engaged by a belt 357 which is adapted to be driven by a motor (not shown). The inner surface of belt 354 is in frictional engagement with peripheral surface zones of the attenuating wheels or rolls 352 whereby the rolls are driven by movement of the belt 354.

The groups of filaments or fibers attenuated from the streams S are gathered into strand, sliver or bundle form 360 by means of guides or filament gathering means 362 which are mounted upon the support 348.

As particularly shown in Figure 10, each group or strand of filaments formed from a group of streams takes over an adjacent attenuating wheel 352 so that the strand or group of filaments is frictionally gripped or anchored between the periphery of the attenuating wheel 352 and the inner surface 355 of the endless belt 354. During relative movement of the attenuating wheels or rolls 352 and the endless belt 354, the strand or bundle of filaments attenuated from each group of streams is advanced at a linear speed substantially equal to the linear speed of the belt 354.

The rate of attenuation of the streams to filaments or fibers may be regulated by varying the speed of travel

of the endless belt 364. Each strand or bundle of filaments 360 moving away from an attenuating wheel 352 is stripped from the surface 355 of the endless belt by means of a blast or jet of air projected from a nozzle or tube 364. A stripping device of this character is disposed adjacent each of the attenuating wheels so that the strands are immediately stripped from the inner surface 355 of the endless belt and directed downwardly away from the attenuating apparatus.

The strands, slivers or bundles of filaments 360 may be collected upon an advancing endless belt conveyor in overlapping loops to form a mat. A suitable binder or adhesive may be applied to the strands or bundles 360 which may be cured or dried to impart mass integrity to the formed mat. The strands 360 may be collected independently by winding the same upon spools in a manner conventional in the textile art or by other suitable means. The endless belt 354 is formed of yieldable or flexible material so as to establish an effective strand gripping zone between the inner surface 355 of the belt and the peripheral zones of the attenuating wheels 352. In the arrangement shown in Figures 9 and 10, the streams of fiber-forming material and filaments or fibers attenuated therefrom move in horizontal directions and hence provide for a very compact apparatus occupying a minimum vertical space. It is to be understood that vertical feeders of the type shown in Figure 7 may be used in the arrangement shown in Figures 9 and 10 if desired. The continuous strands, slivers or bundles of filaments 360 may be cut into desired lengths by engaging them with suitable cutting devices (not shown).

Figure 11 illustrates a modified form of means for feeding molten fiber-forming material into a rotor of the general character shown in Figure 4. The supporting arm 18*a* carrying the stationary shaft 24*a* is formed with a projection 370 upon which is mounted a material directing means or tube 372 arranged to convey the material of the stream 14*a* into engagement with the outer or peripheral wall 374 of the rotor 200*a*. The material flows downwardly along the rotor wall over the vertically spaced groups of orifices or outlets 214*a*, 212*a* and 204*a* to provide a supply of the fiber-forming material adjacent the perforated zones of the wall. The material is projected through the orifices by centrifugal forces of rotation of the rotor.

If desired, a number of streams may be provided from a feeder or forehearth equal to the number of vertically spaced perforated zones in the rotor wall. A material directing and conveying tube may be utilized with each stream, the lower extremities of the tubes terminating respectively adjacent the perforated zones to deliver material to each zone at a predetermined rate.

It should be noted that in all forms of the apparatus disclosed for carrying out the method, the filaments or fibers or groups of filaments or fibers engage vertically disposed surfaces of the attenuating means and move in substantially horizontal directions. Furthermore, attenuation of the streams, plastic bodies or primary filaments of fiber-forming material takes place at zones adjacent the feeders where the material is in an attenuable state or condition and the filaments or fibers are already in their attenuated or final forms when they are engaged by the attenuating wheels or the cooperating attenuating surfaces.

Another feature of the invention is that filaments or fibers of different sizes may be mixed and combined or embodied in a single strand, sliver or thread. This result may be accomplished by providing orifices or outlets of different sizes in the rotor wall in the forms of the invention shown in Figures 1 and 4 or by varying the size of orifices in the feeders shown in the arrangements of Figures 5 through 10 of the apparatus of the invention. Hence, by varying the sizes of openings through which the fiber-forming material is discharged, a mat or product may be formed embodying strands or threads formed of filaments of different sizes, and in this manner the strength characteristics of the mat or resulting product may be controlled.

It is apparent that, within the scope of the invention, modifications and different arrangements may be made other than is herein disclosed, and the present disclosure is illustrative merely, the invention comprehending all variations thereof.

I claim:

1. The method of producing concomitantly a plurality of strands wherein each strand is composed of a plurality of continuous filaments of glass including flowing groups of streams of heat-softened glass from a supply, concomitantly gathering each group of continuous filaments formed from a group of streams into a strand and directing each of the strands into contact with an individual surface, moving the surfaces in planetary paths while simultaneously rotating the surfaces to attenuate the groups of streams to groups of continuous filaments forming the strands, and collecting the strands in a matted layer on a support.

2. The method of producing concomitantly a plurality of strands wherein each strand is composed of a plurality of continuous filaments of glass including projecting groups of streams of heat-softened glass by centrifugal forces, converging continuous filaments formed from each group of streams into a strand, engaging each strand with an individual surface, moving the surfaces in planetary paths while concomitantly rotating each of the surfaces to attenuate the groups of centrifuged streams to groups of filaments forming the strands, and collecting the strands in a matted layer on a support.

3. Apparatus for forming filaments from heat-softenable fiber-forming material including, in combination, a rotor having a peripheral wall formed with openings, means for delivering fiber-forming material in a flowable state into the rotor, a member associated with the rotor, filament attenuating means carried by the member including an attenuating wheel journally supported upon the member and being rotatable about an axis spaced from the axis of the rotor, means for concomitantly rotating the rotor and rotating the attenuating wheel about its axis, the rotation of the rotor being at a speed sufficient to project fiber-forming material through the openings in the rotor wall forming elongated bodies of the material, the filaments formed from the bodies being arranged to be engaged with the attenuating wheel whereby individual rotation of the wheel and movement of the wheel in an orbit about the axis of the rotor attenuates the bodies to filaments.

4. Apparatus for forming fibers from heat-softenable fiber-forming material including a rotor, means for delivering flowable fiber-forming material into the rotor, a plate adapted to rotate with the rotor, said rotor having zones provided with groups of orifices with the zones arranged in vertically spaced relation, fiber attenuating means including sets of attenuating wheels with a plurality of wheels in each set, the wheels of one set being respectively in engagement with adjacent wheels of another set, means for rotating the rotor, plate and sets of attenuating wheels about the axis of the rotor and for concomitantly rotating the attenuating wheels of each set about their respective axes, said rotor being revolved at a speed sufficient to project fiber-forming material through the groups of orifices in the vertically spaced zones of the rotor to form primary filaments, said pairs of attenuating wheels being respectively disposed in the paths of the groups of projected primary filaments, said attenuating wheels attenuating the groups of primary filaments to form fine filaments in linear bundles.

5. Apparatus for forming fibers from heat-softenable fiber-forming material including a rotor, means for delivering molten fiber-forming material into the rotor, a plate adapted to rotate with the rotor, said rotor having a zone provided with groups of orifices, fiber attenuating

means including sets of attenuating wheels with a pair of wheels in each set, the pairs of wheels of each set being in engaging relation, means for rotating the rotor, plate and sets of attenuating wheels about the axis of the rotor and for concomitantly rotating the attenuating wheels of each set about their respective axes, said rotor being revolved at a speed sufficient to project fiber-forming material through the groups of orifices to form primary filaments, said pairs of attenuating wheels being respectively disposed in the paths of the groups of primary filaments, said attenuating wheels simultaneously attenuating the groups of primary filaments to form fibers in linear bundles.

6. Apparatus for forming fibers from fiber-forming material including a plurality of feeders, each of said feeders being provided with a plurality of orifices, said feeders adapted to contain fiber-forming material discharged through the orifices to form a group of streams adjacent each feeder, a plurality of attenuating rolls disposed in spaced relation, a shaft journally supporting each of the attenuating rolls, each roll being rotatable about the axis of its supporting shaft, and endless belt arranged to engage the peripheral surfaces of said rolls, the groups of fibers formed from the groups of streams respectively engaging the peripheral surfaces of the rolls, means for simultaneously rotating the rolls and the endless belt for gripping the groups of fibers to attenuate the streams to fibers, means engaging the fibers of each group to form bundles of fibers, and means for removing the bundles of fibers from engagement with the surface of the endless belt as the bundles of fibers move away from the attenuating rolls.

7. Apparatus for forming filaments from heat-softenable mineral materials including a plurality of feeders each adapted to contain a supply of fiber-forming material and each being formed with a group of orifices from

which flow streams of the filament forming material, a relatively stationary member, a plurality of rotatable filament engaging rolls disposed in spaced relation upon said stationary member, an annular element supported adjacent said stationary member and adapted for rotation relative to the member, means for rotating the element and the filament engaging rolls, a surface of said element being in constant frictional engagement with the peripheral surfaces of said rolls, the groups of filaments formed from the groups of streams from the feeders being directed into the nip zones at the engaging areas of the annular element with the rolls whereby the filaments are gripped by the surfaces in said nip zones and the streams attenuated to filaments by relative movement of the engaging surfaces of said rolls and the annular element, and means for collecting the groups of attenuated filaments.

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