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METHOD AND APPARATUS FOR ATTENUATING
GLASS AND OTHER FIBERS

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2 Sheets-Sheet 1

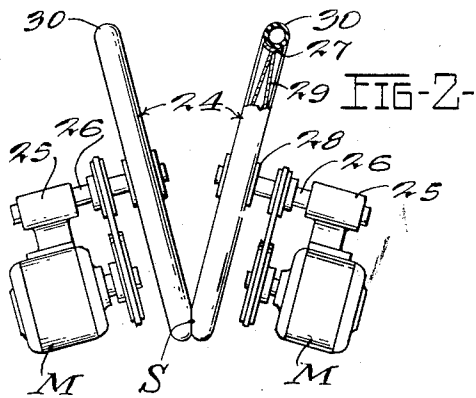
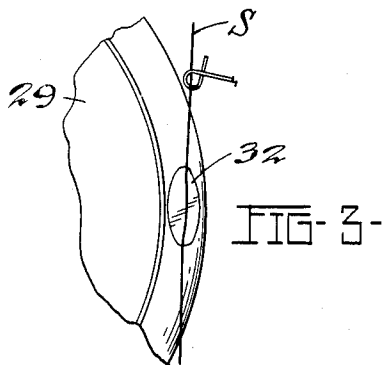
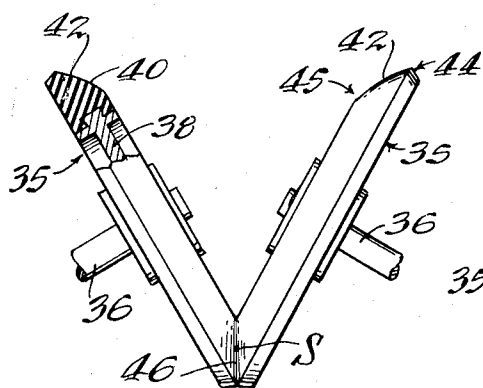


FIG-4-

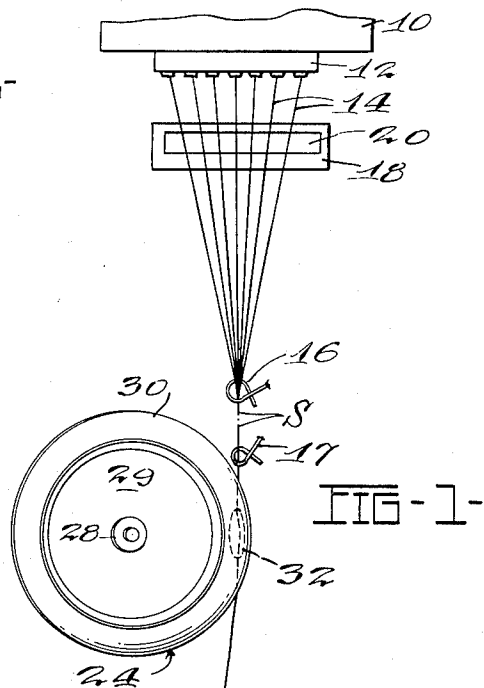
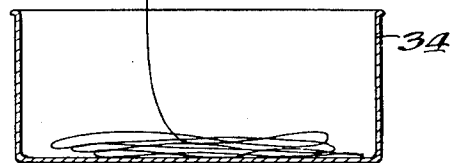
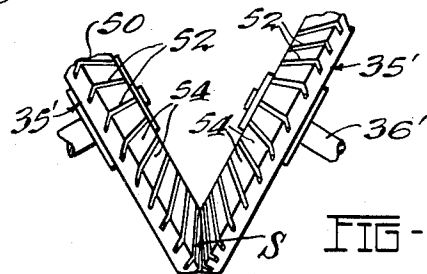


FIG-5-

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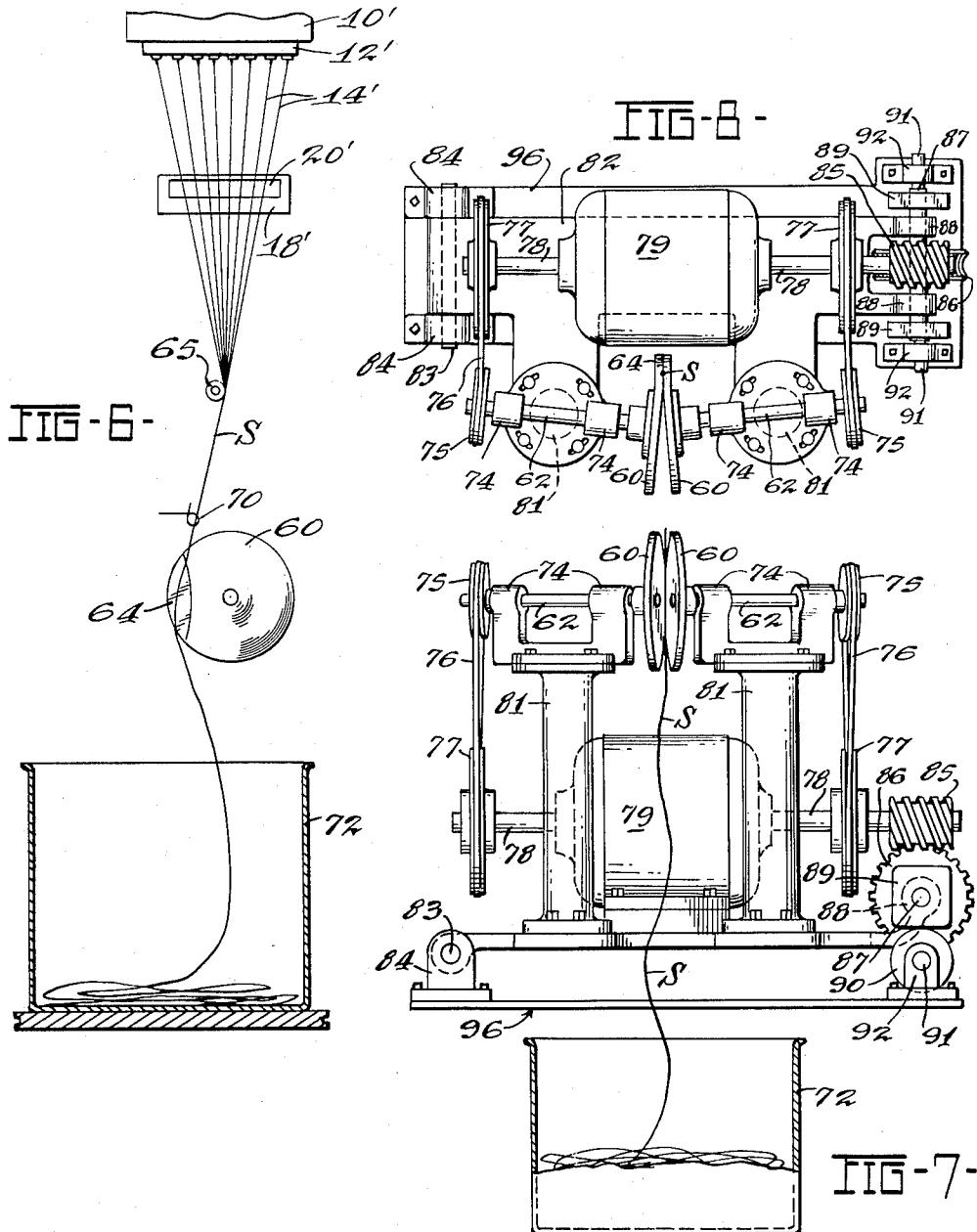
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METHOD AND APPARATUS FOR ATTENUATING GLASS AND OTHER FIBERS

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Continuation of abandoned application Serial No. 215,584, March 14, 1951. This application June 8, 1954, Serial No. 435,285

21 Claims. (Cl. 49—17)

This invention relates to method and apparatus for attenuating comparatively fine fibers from flowable or heat softenable fiber-forming materials and more especially to method and apparatus for continuously forming fibers of mineral materials, such as glass, fusible rock, slag or the like, the invention being particularly applicable for continuously drawing a plurality of streams of material into fibers by mechanical attenuating means engageable with the fibers gathered into strand or linear group formation.

The present invention has particular applicability in producing fibers in strand or linear group formation usable in the textile industry for fabricating or weaving various kinds and types of fabrics for many and various uses. Glass fibers have been utilized for textile purposes and are of two primary forms, strands or yarns made up of fibers of varying length of staple character and continuous fibers oriented into continuous strands or linear groups or bundles of fibers. Fibers of the former character have been produced by directing blasts of gas against molten streams of glass to form fibers of indiscriminate lengths or by directing an intensely hot blast against a body of glass to attenuate the same into fine fibers, in either method the fibers being collected into strands for producing yarns, rovings and other textile forms.

For many textile uses it is highly desirable that the strands or yarns be formed of continuous fibers especially where a high tensile strength or uniformity of strand size is desired. Strands or groups of fibers of continuous character have been produced by mechanical attenuation. For example, one commercial adaptation of a mechanical attenuating means comprises flowing streams of molten glass and winding the fibers formed by the streams on a rotating cylinder to attenuate and collect the group of fibers formed from the streams in cylindrical package or spool formation. This method however requires periodic interruption of attenuation in order to remove the completed package of strand material and insert a new package sleeve or cylinder. Such interruption of flow of the molten streams of glass requires considerable time after a new sleeve is inserted before satisfactory operating conditions may again be resumed. Moreover considerable waste of the packaged material is encountered in removing the material during further processing operations.

Another form of mechanical attenuation includes the utilization of pairs of pull rolls arranged to rotate in a common plane about parallel axes and to grip the fibers between the rapidly moving cylindrically shaped peripheries of the pull rolls. In this type of apparatus the attenuating rolls are formed with peripheral surfaces of flexible or deformable material such as rubber, and the rolls must be positioned or disposed so that an effective gripping force is established between the rolls and the fibers in order to attain satisfactory attenuation.

With such an arrangement it has been necessary to force the rolls into engagement with considerable pres-

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sure so as to deform the surfaces thereof sufficiently to create a rectangular area of contact large enough to securely grip the strand or linear group of fibers passing through the rolls. Such an arrangement causes very rapid flexing and working of the rubber of the rolls when they are rotated at high speeds thus generating excessive heat which greatly shortens the life of the rolls.

Attenuating rolls of this character satisfactorily produce continuous attenuated fibers but the speed at which the rolls may be rotated is necessarily limited by mechanical factors. In order to increase the speed of attenuation, an increase in the angular velocity of the rolls must be had, or rolls of a larger diameter utilized. However, there are serious mechanical limitations to the utilization of higher speeds of rotation of the rolls having sufficient thickness to engage the fibers and such construction requires a roll of considerable weight, a factor aggravating the problems of drive gearing and bearings which will withstand exceptionally high speeds thus making it difficult to attain the successful commercial production of fibers upon an economical basis and by apparatus occupying a minimum of manufacturing space.

At the present time strand or fiber pulling rolls of this character may be safely rotated at from two thousand to three thousand revolutions per minute with a resultant peripheral surface speed of about six thousand to ten thousand feet per minute for rolls of a diameter of approximately one foot or less. Through an arrangement of this character the strand material formed of continuous fibers may be mechanically attenuated at from six thousand to ten thousand linear feet per minute.

When it is attempted to effect substantial increases in the rate of attenuation and draw the glass into fibers at speeds of fifteen thousand to twenty thousand revolutions per minute, the speed of rotation of the rolls must be substantially doubled and such speeds of rotation not only cause excessive wear of bearings and driving mechanism but augment the danger and liability of the mechanism to disintegrate under excessive centrifugal forces of rotation. Moreover the equipment necessary to attain high speeds of rotation is exceedingly expensive to construct and difficult to maintain in continuous operation and requires constant attention by an operator.

It has been found that machines which will withstand the disruptive forces of centrifugal force must be of exceedingly large size necessitating the allocation of considerable floor space to each machine so that the total number of machines that can be housed in a plant or building is substantially reduced and the end result sought to be attained, namely, the increase in the output or production of fibers without a substantial increase in the machine size, plant size and number of operators, is very largely defeated.

In utilizing attenuating or pull rolls for forming fibers from molten material where the rolls are disposed in a uniplanar relation and the fibers gripped between the peripheries of the rolls, it has been necessary in most instances to force the rolls together with considerable pressure so as to deform the surfaces of the rolls sufficiently to grip securely the strand or group of fibers, a factor generating excessive friction heat and greatly reducing the useful life of the rolls.

The present invention contemplates a method and apparatus for attenuating fibers from heat softenable material at higher rates of linear speed than have heretofore been possible in a manner such that the difficulties heretofore encountered in attenuating fibers by mechanical means have been substantially overcome or greatly minimized whereby continuous fibers may be economically produced on a commercial scale with a min-

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imum of mechanism and wherein the devices occupy comparatively small floor space.

The invention has for an object the provision of improved apparatus wherein the attenuating speed has been greatly increased but the mechanism for accomplishing attenuation is of small and compact size, reliable in operation and requires a minimum of attention by an operator.

One object of the invention is the provision of attenuating elements disposed and arranged to establish an area of contact between the elements of sufficient expanse to securely grip the strand or linear group of fibers and attenuate the fibers at high linear speeds without involving a high degree of deformation of the elements and therefore reducing the degree of flexing or working of the fiber engaging surfaces.

An object of the invention is the provision of relatively movable means arranged to attenuate fibers at a comparatively high linear speed, the elements of the attenuating means being constructed and related whereby during operation they securely grip the strand or group of fibers in a manner minimizing the amount of flexing or working of the surfaces of the attenuating means with a commensurate increase in the longevity of the attenuating means.

Another object of the invention is the provision of mechanical attenuating means especially adaptable for attenuating fibers from heat softenable material at very high linear speeds in which the tendency of broken fibers or those insecurely held in the strand or linear group to adhere, wrap or lick around the attenuating means is substantially eliminated.

Another object of the invention is the provision of rotatable fiber attenuating means having deformable surfaces arranged for engagement with a strand or group of fibers in which an adequate linear area of gripping relationship between the strand or group of fibers and the rolls is established with a minimum of pressure or force whereby intermolecular friction and consequent heating of the attenuating means is greatly reduced effecting a substantial reduction in the amount of energy expended in carrying on high speed fiber attenuating operations on a commercial scale.

Another object of the invention resides in the provision of rotatable attenuating elements disposed and arranged in a manner whereby lateral or side surface areas of the elements are arranged for interengagement and for gripping engagement with the group of fibers being attenuated.

A further object of the invention resides in the provision of rotatable attenuating elements arranged for engagement with a group of fibers for attenuating the latter in a manner whereby centrifugal forces of the rotatable elements have little or no effect upon the path of the strand and to only a minor extent upon the character of engagement of the attenuating elements with the strand.

Still a further object of the invention resides in an arrangement for mechanically attenuating fibers at exceptionally high linear speeds wherein a nonrectilinear path or locus may be established for the strand for facilitating the distribution thereof in a strand collection or deposition zone.

Another object of the invention embraces the provision of relatively movable fiber engaging elements capable of attenuating fibers at comparatively high speeds wherein the character or method of attenuation results in the production of fibers of substantially uniform diameter and wherein continuous attenuation is carried on under optimum conditions of operation thus rendering the present method economical for the commercial production of high quality strand or linear material made up of continuous fibers.

Still another object of the invention is the provision of a novel method and apparatus for attenuating heat soft-

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able material into fibers and collecting the fibers in strand or linear group formation in a manner whereby the strand forms its own package during collection and provides a free end facilitating its withdrawal for further processing operations in the formation of yarns, rovings or other textile forms.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements 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 view of an arrangement for carrying out the method of attenuating fibers from fiber-forming material and particularly illustrating the character of engagement of the fibers with one form of attenuating means;

Fig. 2 is a top plan view illustrating a pair of attenuating elements of the invention, one of the elements being shown partially in section;

Figure 3 is an end view of one of the attenuating elements illustrating the shape or character of interengagement of the attenuating elements forming a fiber gripping zone;

Figure 4 is a view similar to Figure 2 illustrating a modification of attenuating elements resembling miter discs in configuration;

Figure 5 illustrates attenuating elements similar to those shown in Figure 4 incorporating specially configured fiber engaging surfaces;

Figure 6 is a view similar to Figure 1 illustrating another form of attenuating means of the invention;

Figure 7 is an elevational view of apparatus embodying attenuating elements of the character illustrated in Figure 6, the apparatus including an arrangement for imparting a nonrectilinear path to the strand or group of attenuated fibers leaving the attenuating elements; and

Figure 8 is a top plan view of the apparatus illustrated in Figure 7.

This application is a continuation of my co-pending application Serial Number 215,584, filed March 14, 1951, now abandoned.

While the method and apparatus of the present invention are especially adaptable and usable in the production or formation of fibers through attenuation of streams of molten glass, it is to be understood that the invention is susceptible of utilization in attenuating fibers from other fiber-forming materials such as fusible rock, slag, thermosoftenable fiber-forming resins and the like. The invention has particular utility in continuously attenuating fibers through the utilization of a novel attenuating means of a mechanical character functioning in a manner whereby the fibers formed from streams of fiber-forming material are gathered together or assembled into a strand, linear group or bundle formation which is directed to and engaged by rapidly moving attenuating instrumentalities or elements.

The apparatus of the present invention provides a simple yet effective means for substantially eliminating or preventing the tendency of fibers that may be broken or insecurely held in the group to lick or cling to and become wound upon the attenuating instrumentalities. The elimination of licking of the fibers facilitates continuous fiber forming operations under optimum conditions with a consequent result that a high efficiency is maintained in the production of fibrous strand material of uniform character and high quality.

Referring to the drawings in detail and first with respect to Figure 1, there is illustrated in semidiagrammatic form one arrangement of apparatus for carrying out the method of the invention. The same is inclusive of a forehearth or receptacle 10 adapted to contain a supply of fiber-form-

ing material in flowable condition as for example, glass or other thermoplastic or heat softenable, fiber-forming substance. Disposed beneath the receptacle 10 is a feeder or bushing 12 provided or formed with a plurality of orifices through which flow streams 14 of fiber-forming material. The streams 14 are drawn or attenuated into continuous fibers which are preferably gathered into a linear group, bundle or strand S through the utilization of a gathering member or eye 16.

It is desirable to apply a lubricant or sizing coating to the fibers to minimize interabrasion as well as to cause the fibers to cohere in strand or linear group formation. For this purpose a vessel 18 may be provided containing a supply of liquid lubricant or sizing material in which is journaled supported an applicator in the form of a roller 20, the latter acquiring a film of lubricant or size from the receptacle 18 which is transferred to the fibers taking over or engaging a portion of the cylindrical surface of the roller. The roller 20 per se may be partially immersed in the liquid or may be in surface engagement with another roller (not shown) which may be partially immersed so as to acquire a film of the material.

The fiber attenuating instrumentalities or means are preferably of a character capable or suitable for engaging the linear group or strand of fibers to draw them from the streams of material at an exceptionally high linear speed, being upwards of fifteen to twenty thousand feet per minute.

One form of fiber attenuating means of the present invention is illustrated in Figures 1 to 3. As particularly shown in Figure 2 the attenuating instrumentalities or rolls 24 are of wheel-like configuration and are respectively mounted upon shafts 26 arranged in angular relation and supported in bearings 25, the included angle of the axes thereof being approximately one hundred sixty degrees, although other degrees of angular relationship may be used if desired. The shafts 26 may be driven by motor M arranged for synchronous operation or by a single motor in a manner similar to that shown in Figures 7 and 8.

The instrumentalities or rolls 24 may be formed with a rim 27 joined to a hub 28 by means of wire spokes 29 or a lightweight disc-like body. The rim 27 carries an annularly shaped endless casing or tube 30 of rubber or pneumatic tire-like character which may if desired be inflated through suitable conventional valve means (not shown). By varying the pressure within the tube 30 and the extent of interengagement of the wheels 24, the effectiveness of the gripping force upon the strand S may be modified to attain satisfactory operation.

The instrumentalities 24 are arranged so that lateral surfaces or regions of the tubes 30 are in engagement of a nature whereby the contacting lateral portions of the tube walls are distorted into flat areas forming a fiber gripping zone of generally oval configuration as indicated at 32 in Figures 1 and 3. The strand S is suitably directed by the fiber gathering eye 16 or additional guide means 17 so as to pass between and substantially centrally of the flattened areas 32 at the engaging zones of the flexible walled tubes 30. The wheels or elements 24 rotate at speeds to move or advance the fibers at linear rates of upwards of fifteen thousand to twenty thousand feet per minute, the engagement of the lateral walls of the tubes is such as to tightly grip the strand 16 to move or advance the same in a linear direction to attenuate the streams 14 into fine fibers.

It should be noted that the strand or group of fibers is gripped between the flattened lateral or side walls of the tubes 30 at their region of interengagement indicated at 32. As centrifugal forces are effective in directions radially of the axis of rotation of the wheels 24, such forces have little influence on the direction of travel of the strand which follows a generally vertical path as indicated in Figures 1 and 3.

The instrumentalities of this character for attenuating

a strand of fibers, being arranged for rotation about axes disposed in angular relationship, substantially eliminate the tendency of individual or straggling fibers insecurely held in the strand to cling to and become wound upon the instrumentalities. This is believed to be due to the character of engagement of the wheels 24 with the strand whereby the latter is gripped between lateral surfaces of the attenuating wheels which are devoid of any cylindrical surfaces upon which the fibers might otherwise collect. Moreover the inertia of the fibers moving through the flattened surface zone 32 in a vertical path influences the fibers to maintain a rectilinear direction of travel.

With this arrangement there is a minimum of flexing of the walls of the tube 30 and hence the heat generated by friction of flexing is held to a minimum. The bodies of the wheels 24 may be fashioned of lightweight spokes or thin discs and as the flexible walls of the fiber engaging tubes may be maintained in stiffened condition by the air pressure within the tubes, they also may be of a comparatively thin walled construction. Thus the complete wheel or roll assemblies while of comparatively large diameter facilitating the attainment of high linear travel of the strand without involving excessively high speeds of rotation, are not subjected to excessive centrifugal forces because of the weight of the wheels being held to a minimum. Hence the problems of bearing stresses and driving means present no difficulties because of the relatively low centrifugal forces involved.

In practical installations the wheels may be of diameters up to three feet or more dependent upon the desired linear speed of attenuation of the fibers and limitations of space requirements for accommodating the apparatus. Furthermore, a substantial saving of labor is effected in that a single operator is enabled to supervise the operation of several machines because the fiber attenuation is continuous requiring no interruptions for changing packaging spools or sleeves or to remove licking fibers from the attenuating wheels.

The strand or linear group of fibers may be collected in any suitable manner. As illustrated in Figure 1, the strand discharged from the attenuating wheels 24 may be collected in a suitable receptacle or container 34 which may be rotated by means (not shown) in a conventional manner to facilitate distribution of the strand therein. When the container is filled, the strand may be cut and directed into another container without interruption of the attenuation operation. Collection in this manner provides a free end of strand for subsequently withdrawing the same from the container during further processing.

A modification of attenuating elements or means is illustrated in Figure 4. The arrangement disclosed is inclusive of a pair of disc-like attenuating elements 35 mounted for rotation upon shafts 36 which are arranged in angular relation as shown. The peripheral cross-sectional contour of the elements 35 in engaging relation is similar to that of a pair of miter gears but without dental formation. The elements 35 may include lightweight members 38 of metal or molded material, to the periphery of which is bonded or otherwise secured an annular fiber engaging member 40 fabricated of semihard rubber or other material having some degree of flexibility or deformability.

It should be noted that the beveled or slanted lateral fiber engaging faces 42 of the discs or attenuating elements 35 are preferably formed slightly convex in cross section. It has been found that at high peripheral speeds, the peripheral zone 44 being the greatest distance from the axis of rotation is under the influence of the maximum centrifugal force and is flexed or stretched radially outwardly of the axis of rotation whereby the convex lateral face 42 is distended into virtually a uniplanar surface.

Through the provision of the initial concave configuration of the surface 42 of each rotor or attenuating element 35, the surfaces 42 thereof are flattened and are in such relation at the zone of gripping engagement with

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the strand of fibers S. If desired the body and peripheral portions of each of the elements 35 may be integrally molded or formed of fabric-reinforced, semihard rubber in lieu of the metal disc construction 38.

Due to the manner or character of engagement of the surfaces 42 with the strand at the gripping zone 46, very little relative distortion or flexure of the deformable elements 40 takes place so that the working or flexing of these elements is reduced to a minimum with a consequent reduction of heat generated by intermolecular friction.

By reason of the angular relation of the elements 35 and the provision of slanted lateral fiber engaging surfaces, the tendency of isolated fibers to cling to the surfaces 42 is minimized or substantially eliminated thus avoiding interruptions of the attenuating operation which might otherwise ensue if the fiber engaging surfaces were of a configuration fostering adherence of fibers thereto such as the periphery of a cylindrical or near-cylindrical surface. Moreover, the inertia factor of the strand moving in substantially a rectilinear direction tends to maintain movement of the fibers in a direction generally tangentially of the periphery of the elements 35. The shape of the zone or region of interengagement of the surfaces 42 is slightly rectilinear in configuration affording sufficient area of engagement with the strand so that the latter is securely gripped between the faces 42 of the elements 35 to attain attenuation of the fibers without appreciable slippage.

The shafts 36 carrying the attenuating instrumentalities or rotors 35 may be driven by individual electric motors in the manner shown in Figure 2, connected respectively to the shafts or they may be driven by a single motor or source of power by an arrangement similar to that illustrated in Figures 7 and 8.

Figure 5 illustrates a form of attenuating instrumentality or rotor 35' similar to that shown in Figure 4 in which the deformable peripheral member 50 of each attenuating rotor being formed of semihard rubber or the like is provided with a series of spaced notches or slots 52 preferably disposed in skew relation to the axis of rotation of the supporting shafts 36'. The formation of the skew slots 52 provides spaced portions 54 which are adapted for successive engagement with the strand S during rotation of the elements or rotors 35'. By reason of the skew positioning of the slots 52, the portions between adjacent slots designated 54 under the influence of centrifugal forces tend to be distorted or flexed radially outward of the axis of revolution or rotation of the elements 35 and serve as an added factor in providing an effective gripping of the fibers and insuring against licking of the fibers to the surfaces of the rotors 35'.

By staggering the slots of one rotor with respect to those of the other, or by utilizing unequal spacing of slots 52, the strand may be caused to move in an undulating path or is whipped to and fro by the alternate impingement of portions 54 on the respective rotors against the strand as it moves out of the zone of engagement with the elements or rotors 35'. This feature facilitates the distribution of the strand in a collecting receptacle or zone as it reduces the tendency of the strand to pile up in pyramidal shape.

Figures 6 through 8 inclusive illustrate a further form of fiber attenuating means of the invention. The attenuating means illustrated includes a pair of relatively thin disc-like elements 60 which are respectively mounted upon individual shafts 62, the discs being angularly arranged whereby the included angle of the axes of shafts 62 may be approximately one hundred seventy degrees. The discs 60 engage at a region or zone indicated at 64 and the strand S is gripped by the interengaging discs at the region 64, the interengagement of the discs causing them to be flexed into substantially parallel relation at the zone of engagement as shown in Figure 8.

As illustrated in Figure 6, the elements or discs 60

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during rotation are adapted to attenuate the streams 14' of fiber-forming material emanating or flowing from a plurality of orifices in the feeder 12' disposed beneath a forehearth or receptacle 10' containing a supply of heat softenable fiber-forming material such as glass in molten condition. The fibers forming the strand S may pass over a roller 20' adapted to receive a film of lubricant or size contained within the receptacle 18' in the manner hereinbefore explained in connection with the arrangement disclosed in Figure 1. The individual continuous fibers formed from the streams 14' are gathered into a strand or linear group by means of a gathering element or guide 65.

One of the discs or attenuating instrumentalities 60 is illustrated in Figure 6 and exemplifies the approximate path or locus of the strand as it passes between the rotating discs 60, the interengaging region or zone of the discs being shown at 64 and is of a modified oval configuration as illustrated. It should be noted that immediately upon entry of the strand between the engaging portions of the discs, the strand is moved generally in a curved path to the point of discharge from the discs. In order that the strand may properly enter the zone of engagement with the discs 60, a supplemental strand guiding means 70 may be disposed near the discs. The strand of fibers may be collected by any suitable means as by being discharged into an open receptacle 72 disposed beneath the attenuating means 60.

The attenuating discs 60 are preferably fabricated of rubber reinforced with fabric or cords providing a material similar in character to belting. Thus the discs may be made relatively thin and of light weight. Due to the particular positioning of the discs 60 at an angle of convergence of about ten degrees, very little flexing of the discs at their zone of engagement takes place so that there is very little friction heat developed through flexing of the discs during high speed rotation thereof. The tendency of the discs 60 to rotate in their respective planes sets up an inertia factor providing a satisfactory gripping engagement of the engaging zones of the discs with the strand S for attenuating purposes. As the discs 60 are of comparatively light weight, they may be rotated at comparatively high speeds to attenuate fibers without encountering undue heating of the discs.

As shown in Figures 7 and 8 the discs are mounted upon independent shafts 62 which are in turn journaled in suitable bearings or pairs of bearings 74, each shaft supporting a pulley 75 driven by means of a belt 76 from a pulley 77 mounted at each end of a shaft 78 of a motor 79 or other source of power. In the form of the invention thus described, a single motor may be utilized for concomitantly rotating both attenuating elements but independent motors may be employed for driving the discs if desired.

Figures 7 and 8 also illustrate a means for causing oscillatory bodily movement of the attenuating means, an arrangement that may be utilized to advantage in imparting an undulating motion or wavy path to the strand as it moves away from engagement with the attenuating discs. To this end the bearing constructions 74 are mounted upon pedestals or standards 81 which are fixedly supported upon a platform or base member 82, the latter being relatively movable as by pivotally supporting one end upon a shaft journaled in bearings 84 mounted upon a base plate 96. The motor 79 may also be securely mounted upon the platform 82 as shown in Figure 7.

The arrangement includes a means for oscillating the platform 82 and associated mechanism carried thereby including the attenuating discs 60. Mounted upon an extension of the motor shaft 78 is a worm 85 which is in enmeshment with a worm wheel 86 secured upon a shaft 87 journaled in bearings 88 formed on extending portions of a yoke formation of the platform 82. Also fixedly secured upon the shaft 87 are multilobed

cams or members 89 which are arranged for engagement and cooperation with rollers 90 journaled upon a shaft 91 carried in suitable bearings 92 mounted upon the base plate 96.

Thus during operation of the motor 79 causing high speed rotation of the attenuating discs 60, the worm 85 rotates the worm wheel 86 at a comparatively low speed to rotate the cam 89. As the lobes of the cams ride over the periphery of the rollers 90, the platform 82 is oscillated about the axis 83. As the platform 82 carries the attenuating discs 60, the oscillatory movement causes relative bodily movement of the discs causing the strand S to be moved or discharged from the discs in an undulating or wavy path as illustrated. The strand is thereafter collected in the receptacle 72 and by reason of the to and fro movement of the strand, the same is distributed more uniformly in the receptacle 72 thus minimizing stacking or pyramiding of the collected strand.

Due to the angular interrelation of the discs and the fact that the engaging lateral or side surfaces thereof when in a zone of engagement are coincident, that is, they are parallel and there is thus no surface provided to which the fibers may cling because they are discharged downwardly in a generally tangential direction with respect to the peripheries of the discs. Thus licking of the fibers is completely eliminated in this form as any tendency of individual fibers to adhere to the lateral faces of the discs would be instantly counteracted by centrifugal forces of the rotating discs.

It will be noted that in all forms of the attenuating means disclosed, the operator may very quickly and with ease and facility start the attenuating operation by moving the strand into the V-shaped configuration formed by the angular disposition of the attenuating disc wheels or elements and the strand will be picked up at the engaging zone of the pairs of attenuating elements so that starting of attenuation may be quickly and simply accomplished. Furthermore, as the strand moves into the central region of the zone of engagement between the attenuating discs its speed will be gradually increased so as to minimize the shock upon the fibers and thereby minimize breakage thereof at the starting of attenuation.

It will be apparent from the foregoing descriptions of the method of attenuation of this invention and the means of carrying out the method of attenuation that the method or process is continuous, that it is capable of attenuating fibers at sustained high speeds without severe wear of parts or elements and with a minimum of heat generated by friction of the interengaging attenuating discs, wheels or elements. Furthermore, the wheels or discs are of comparatively light weight and hence may be of a larger diameter than heretofore possible with a corresponding reduction in the speed of rotation of the elements and yet are adaptable for attaining high speed attenuation of upwards of fifteen to twenty thousand or more linear feet per minute of continuous strand material formed of continuous fibers of uniform size.

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. A method of forming fibers including the steps of flowing streams of fiber-forming material, of continuously attenuating the streams to fibers by directing the fibers into engagement with lateral surfaces of rotating elements, and of rotating the elements about converging axes whereby the fibers are gripped between lateral engaging regions of the rotating elements with sufficient force to attenuate the streams to fibers.

2. A method of producing fibers from thermoplastic material which includes the steps of flowing streams of the material from a supply, gathering fibers formed from the streams into a linear group, disposing a pair of ele-

ments for rotation about angularly related axes and with lateral portions of the elements in interengaged relation providing a uniplanar surface region, causing rotation of the elements at comparatively high speed, and of directing the linear group of fibers into the uniplanar surface region of the interengaging elements whereby the streams are attenuated to fibers at a linear speed substantially equal to the angular velocity of the interengaging region of the elements.

3. A method of forming fibers including the steps of flowing streams of fiber-forming material, of continuously attenuating the streams to fibers by directing the fibers into a zone of interengagement of noncylindrical surfaces, and of rotating the surfaces about angularly related intersecting axes whereby the fibers are gripped between the noncylindrical surfaces at their engaging region with sufficient force to attenuate the streams to fibers without appreciable slippage between the fibers and the elements.

4. A method of forming fibers including the steps of flowing streams of fiber-forming material, of continuously attenuating the streams to fibers by directing the fibers between interengaging regions of elements disposed for rotation about angularly related axes, and of rotating the elements at a speed whereby the fibers are gripped between the interengaging regions with sufficient force to attenuate the streams to fibers without appreciable slippage between the fibers and the rotatable elements.

5. A method of producing fibers from thermoplastic material which includes flowing streams of the material from a supply, gathering fibers formed from the streams into a linear group, applying a size to the fibers, directing the fibers into engagement with contacting surfaces movable in intersecting planes whereby the fibers are gripped between the contacting surfaces, and of moving the surfaces in directions to attenuate fibers from the streams at comparatively high linear speeds.

6. A method of producing fibers from heat softenable fiber-forming material which includes flowing streams of the material from a supply thereof, of directing the streams to form continuous fibers by gathering the fibers into a linear group, engaging the linear group of fibers in a zone of engagement of surfaces movable in intersecting planes, rotating the surfaces at comparatively high speed whereby the surfaces during rotation exert an effective force to attenuate the streams to fibers at a comparatively high linear rate of speed, the engaging surfaces rotating in directions substantially eliminating tendency of the fibers to adhere to the surfaces.

7. Apparatus for producing fibers from heat softenable material including, in combination, means for flowing a plurality of streams of the material from a supply, attenuating means including elements disposed for rotation about angularly arranged axes and having surface portions in interengaging relation, guiding means for directing the fibers formed from the streams between the engaging surface portions of the elements whereby the fibers are gripped by said surface portions, and means for causing relative rotation of the elements for attenuating fibers from said streams at comparatively high linear speeds.

8. Apparatus for producing fibers from heat softenable material including, in combination, means for flowing a plurality of streams of the material from a supply, attenuating means including elements relatively movable in intersecting planes and formed with laterally disposed interengaging surfaces, guiding means for directing the fibers formed from the streams into the interengaging zone of said surfaces, said elements being positioned whereby the interengaging surface portions establish a gripping engagement with the fibers, means for causing relative movement of the elements for attenuating fibers from said streams at comparatively high linear speeds, and means for applying a medium to the fibers in advance

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of their engagement with the movable elements for maintaining the fibers in a linear group.

9. Apparatus for producing fibers from heat softenable fiber-forming material including, in combination, a receptacle adapted to contain a supply of the material and having a plurality of orifices from which flow streams of the material, means for gathering the fibers formed from the streams into a linear group, a pair of relatively lightweight elements arranged for rotation about angularly disposed axes, said elements being positioned whereby lateral surfaces thereof are in engaging and gripping relation with the linear group of fibers, means for rotating the elements at comparatively high speeds whereby the streams are attenuated to fibers, and means for collecting the group of fibers discharged from engagement with the rotatable elements.

10. Apparatus for producing fibers from heat softenable fiber-forming material including, in combination, a receptacle adapted to contain a supply of the material and having a plurality of orifices from which flow streams of the material, means for gathering the fibers formed from the streams into a linear group, a pair of elements arranged for rotation about angularly disposed axes, said elements having deformable lateral surfaces in engaging and gripping relation with the linear group of fibers, and means for rotating the elements at comparatively high speeds whereby the streams are attenuated to fibers.

11. Apparatus for producing fibers from heat softenable fiber-forming material including, in combination, a receptacle adapted to contain a supply of the material and having a plurality of orifices from which flow streams of the material, means for gathering the fibers formed from the streams into a linear group, a pair of wheels having annular portions of deformable material arranged for rotation about angularly disposed axes, said elements being positioned whereby lateral surfaces of the annular portions are in engaging and gripping relation with the linear group of fibers, and means for rotating the elements at comparatively high speeds whereby the streams are attenuated to fibers.

12. Apparatus for forming and attenuating fibers from heat softenable material including, in combination, means for flowing a plurality of streams of the fiber-forming material from a supply, means for gathering fibers produced by attenuating the streams into a linear group, attenuating means including a pair of rotatable elements having lateral surfaces adjacent their peripheries formed of yieldable material, said rotatable elements being disposed for rotation about converging axes, means for directing the linear group of fibers into the region of engagement of said lateral surfaces whereby the linear group of fibers is advanced generally in a rectilinear direction at a high rate of speed for attenuating the streams to continuous fiber form, the angular relation of said rotatable elements in respect to their engagement with the group of fibers being such that tendency of the fibers to adhere to said elements is substantially eliminated.

13. Apparatus for forming and attenuating fibers from heat softenable material including, in combination, means for flowing a plurality of streams of the fiber-forming material from a supply, means for gathering fibers produced by attenuating the streams into a linear group, attenuating means including a pair of rotatable elements of disc-like configuration and formed of yieldable material, said rotatable elements being disposed for rotation about converging axes, means for rotating the elements at comparatively high speed, the lateral surfaces of said rotatable elements being in engagement throughout a substantial radial angle thereof, means for directing the linear group of fibers into the region of engagement of said lateral surfaces whereby the linear group of fibers is advanced at a high rate of speed for attenuating the streams to continuous fiber form, the angular relation of said rotatable elements in respect of their engagement with the group of fibers being such that tendency of fibers

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to adhere to the surfaces of said elements is substantially eliminated.

14. Apparatus for forming and attenuating fibers from heat softenable material including, in combination, means for flowing a plurality of streams of the fiber-forming material from a supply, means for gathering fibers produced by attenuating the streams into a linear group, attenuating means including a pair of rotatable elements having beveled surfaces adjacent their peripheries formed of yieldable material, said rotatable elements being disposed for rotation about converging axes and with said beveled surfaces in engaging relation, means for rotating the elements at comparatively high speed, means for directing the linear group of fibers into the region of engagement of said beveled surfaces whereby the linear group of fibers is advanced generally in a rectilinear direction at a high rate of speed for attenuating the streams to continuous fiber form, the angular relation of said rotatable elements and the character of engagement of the beveled surfaces with the group of fibers being such that tendency of fibers to adhere to the elements is substantially eliminated.

15. Apparatus for forming fibers from thermoplastic material including, in combination, means for flowing a plurality of streams of the material from a supply, a member arranged to gather continuous fibers formed therefrom into a linear group, a pair of rotatable elements arranged for rotation about converging axes and disposed whereby lateral surface portions thereof are in interengagement, means for directing the linear group of fibers between the interengaging lateral surface portions of the elements and in gripping engagement therewith, means for rotating the elements to attenuate the streams to fibers, and means for oscillating the elements concomitantly with rotation thereof for discharging the group of fibers in an undulating path from the elements.

16. Apparatus for forming fibers from thermoplastic material including, in combination, means for flowing a plurality of streams of the material from a supply, a member arranged to gather continuous fibers formed therefrom into a linear group, means for applying a medium to the fibers to maintain them in linear group formation, a pair of rotatable elements having flexible side surfaces arranged for rotation about converging axes and disposed whereby adjacent side surface portions thereof are in interengagement, said linear group of fibers being directed between the interengaging side surface portions of the elements and in gripping engagement therewith, and means for rotating the elements to attenuate the streams into fibers.

17. Apparatus for forming fibers from thermoplastic material including, in combination, means for flowing a plurality of streams of the material from a supply, a member arranged to gather continuous fibers formed therefrom into a linear group, a pair of rotatable elements arranged for rotation about converging axes and formed with beveled surface portions of flexible material in interengaging relation, said beveled portions being formed with circumferentially spaced slots providing spaced fiber engaging sections, means for directing the linear group of fibers between interengaging sections of the beveled portions of the elements and in gripping engagement therewith, and means for rotating the elements to attenuate the streams into fibers, the angular relation of the rotatable elements and the character of engagement of the beveled fiber engaging sections with the linear group of fibers being such that tendency of fibers to adhere to the elements is substantially eliminated.

18. Apparatus for forming fibers from thermoplastic material including, in combination, means for flowing a plurality of streams of the material from a supply, a member for gathering fibers formed from the streams into a linear group, means for attenuating the streams into continuous fibers including a pair of rotatable elements mounted for rotation about converging axes, said ele-

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ments being formed with lateral surfaces of yieldable material, the lateral surfaces of said elements being in contact at a limited angular zone spaced from their axes of rotation, said linear group of fibers being directed into the zone of contact of said elements and in gripping relation therewith, and means for rotating said elements at comparatively high speed whereby the streams are attenuated to fibers.

19. Apparatus for forming fibers from thermoplastic material including, in combination, means for flowing a plurality of streams of the material from a supply, means for gathering the continuous fibers formed from the streams into a linear group, a pair of elements arranged for rotation about angularly disposed axes, each of said elements supporting an annularly shaped, hollow, flexible walled member adapted to contain air under pressure, said elements being disposed with surface portions of said flexible walled members in interengagement, said linear group of fibers being directed into the zone of interengagement of said members and in gripping engagement therewith, and means for rotating the elements and members to attenuate the streams to fibers.

20. A method of producing fibers from heat-soften-

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able material which includes the steps of flowing streams of material from a supply, of establishing a fiber-advancing zone between engaging surfaces, of rotating the surfaces at high speed about angularly disposed axes, and of directing fibers formed from the streams into the fiber-advancing zone whereby the fibers are attenuated by movement of the surfaces.

21. A method of producing fibers from molten glass which includes flowing streams of glass from a supply, gathering fibers formed from the streams into a linear group, applying a coating to the fibers, establishing a fiber-advancing zone between engaging surfaces movable in intersecting planes, directing the fibers into the fiber-advancing zone in a manner whereby the fibers are gripped between the surfaces, and moving the surfaces in their respective planes at high speed to attenuate fibers from the streams.

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