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METHOD AND APPARATUS FOR PRODUCING FIBROUS PRODUCTS

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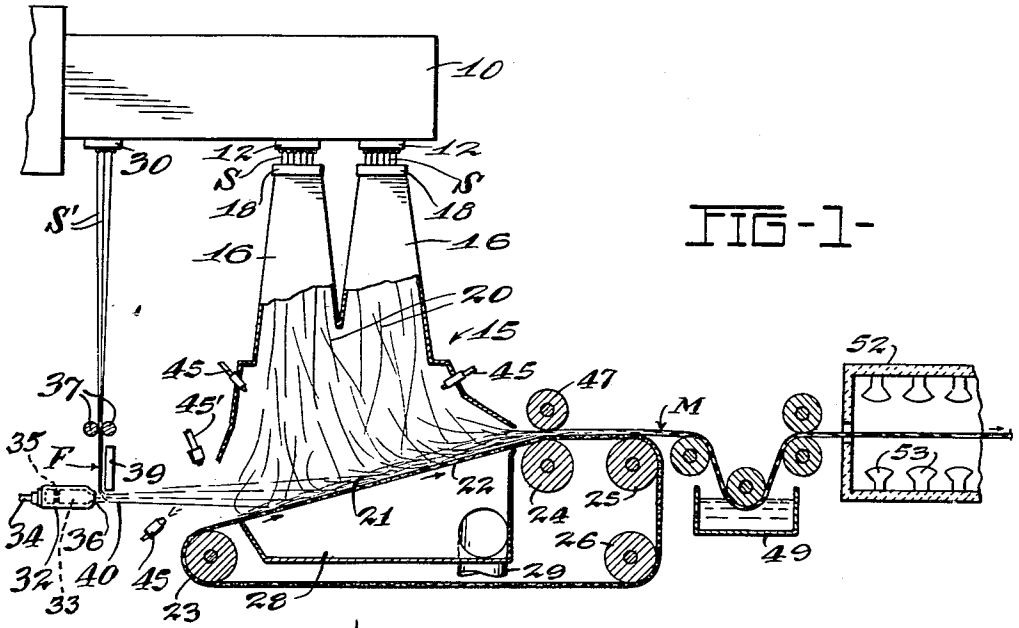

FIG-1-

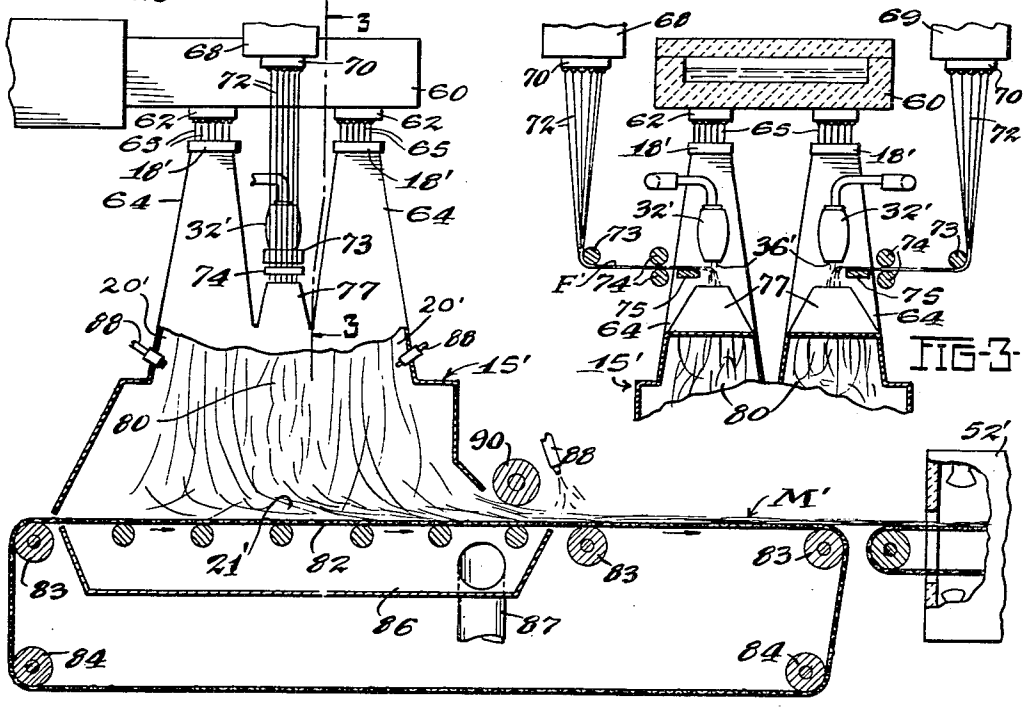

FIG-2-

FIG-3-

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METHOD AND APPARATUS FOR PRODUCING FIBROUS PRODUCTS

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This invention relates to method and apparatus for producing and commingling or combining relatively fine and coarse fibers and to the product formed therefrom.

It has been the practice to form relatively coarse fibers from mineral materials as for example glass, slag, rock and the like through the utilization of high pressure jets or blasts of steam or air directed against a molten stream to attenuate the stream into fibers of varying lengths. Fibers produced by this method are usually referred to as blown fibers which may be readily formed into mat configurations and through the addition of suitable binders or adhesives provide mats of substantial mass integrity to facilitate handling and use. They have particular utility for general insulating purposes, as roof mats and other analogous purposes. However the insulating values of relatively coarse fibers are necessarily limited by reason of the fiber size. Furthermore during processing and collection of the fibers, they tend to abrade one another which reduces the fluffy condition of the mat as well as impairs its characteristics, particularly its insulating value. Reduction in fiber lengths by abrasion tends to produce a pulverized accumulation having little or no insulating characteristics.

The steps in the conventional method of producing blown fibers include flowing a plurality of streams of molten mineral material, as for example glass, from a forehearth or forebay of a glass furnace through a plurality of openings or orifices contained in a bushing attached to the forehearth, the streams being directed downward into a suitable hood or shroud. Disposed in a position adjacent the origin of the streams are blowers or nozzles for directing jets of steam or compressed air onto the streams whereby the velocity of the steam or air draws out or attenuates the molten stream into fibers.

The fibers are collected in a suitable manner and further processed into mat formation. Fibers formed by this process are of different lengths varying from a few inches to several feet, are of diameters usually ranging from four to 15 microns and are ordinarily considered coarse fibers.

In the commercial adaptation of this process, it is conventional to utilize a plurality or groups of streams of molten material projected into a corresponding number of hoods or shrouds, each being equipped with blowers or nozzles to carry on fiber attenuation in each shroud. Apparatus utilized for such purpose may be of the character disclosed in Kleist and Slayter Patent No. 2,287,006 issued June 16, 1942. Fibers produced in this manner are processed to form mats through the application or impregnation of the mass of fibers by a suitable binder for establishing mass integrity in the product. The treated mat may be passed through an oven in order to set or cure the binder.

It has also been a recent commercial practice to produce extremely fine fibers from molten glass or like materials through the use of an intensely hot blast of gases of combustion as an attenuating force. This method of fiber production involves feeding a body or filament of glass into a blast of intensely hot gases. A blast of this character is formed by burning a gaseous fuel and air mixture in a confined zone and discharging the burned or substantially burned gases or volatiles of combustion through a restricted orifice to provide the high velocity blast of a temperature exceeding the attenuating temperature of the glass whereby the blast continuously attenuates the filament into extremely fine fibers which are entrained in the blast and are conveyed thereby away from the attenuating zone. The fibers produced in this manner are of minute size, usually varying from one to two and one-half microns in diameter.

While both types and sizes of fibers have particular characteristics and advantages for specific purposes, each has certain disadvantages. For example, the fibers made by applying jets of steam or air into engagement with flowing streams of fiber forming material produce fibers that are relatively coarse and of a size wherein the adjacent fibers tend to abrade one another in handling, or in installations where vibration is encountered, it tends to reduce or pulverize the fibers thus lowering the insulating value of the mat or mass of fibers. Furthermore blown fibers are of lengths varying from a few inches to several feet which in mat formation provide paths of solid material facilitating transmission of heat, this factor decreasing the insulating value of the mass.

Extremely fine fibers produced by feeding a body or filament of glass of other fiber-forming material into a high velocity blast of intensely hot gases provide a mat of improved insulating characteristics but, by reason of the extreme finess of the fibers, many more are required to build up a mat of usuable size. Furthermore the impregnation of a mat formed solely of fine fibers by a bonding agent or adhesive tends to materially reduce the insulating value of a mat because the bonding agent tends to occupy the interstices provided between adjacent fibers.

The present invention embraces a method and apparatus for concomitantly producing both relatively coarse and fine fibers and intermingling or commingling them in a manner whereby a fibrous mat having improved characteristics is produced.

An object of the invention is the provision of a method of producing relatively coarse fibers whereby large quantities of such fibers may be economically produced and of concomitantly forming and commingling relatively fine fibers with coarse fibers whereby the fine fibers tend to pad or cushion the coarse fibers in a manner minimizing or eliminating inter-abrasion of the fibers thus greatly prolonging the life of products formed from the fibers.

Another object of the invention resides in a method of producing relatively coarse and fine fibers and commingling them in a manner to form a mat having improved insulation characteristics and in which the weight of fibrous material per unit volume of mat is reduced over that of a mat made of blown fibers of relatively coarse size.

Another object of the invention is the provision of a method and apparatus for producing both relatively coarse and relatively fine fibers wherein the major constituent fibers of the commingled mass may be relatively coarse which may be produced at low cost, the fine fibers in the mass serving as interspacing media for the coarse fibers whereby a mat of substantial density is produced and

wherein the coarse fibers provide a high strength factor in the mat.

Still a further object is the provision of a fibrous mat composed of relatively coarse and fine fibers intermingled in a manner wherein the insulating value of the mat is augmented without sacrificing the strength characteristics of the mat.

Another object is the provision of apparatus provided with fiber-forming and attenuating units for simultaneously producing relatively fine and coarse fibers in which individual units may be selectively rendered operative or inoperative to vary the proportions or quantities of fine and coarse fibers in the collected mass.

Still another object is the production of a mat formed of interfitted or intermingled relatively fine and coarse fibers impregnated with a binding agent for establishing mass integrity in the mat structure.

Further objects and advantages are within the scope of this invention such 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 view illustrating a form of apparatus for carrying out the method of the invention;

Figure 2 is a semidiagrammatic view illustrating a modified arrangement of apparatus for carrying out the method; and

Figure 3 is a vertical sectional view taken substantially on the line 3—3 of Figure 2.

The method and apparatus of the invention are especially adaptable for forming both relatively coarse and fine fibers concomitantly from flowable fiber-forming materials and especially heat softenable mineral materials such as glass, but it is to be understood that the invention is susceptible of use in the formation of fibers from other kinds or types of thermoplastic fiber-forming materials.

With particular reference to Figure 1, there is illustrated a forehearth **10** of a furnace or other means for containing a supply of molten or flowable fiber-forming material, as for example, molten glass. Disposed beneath the forehearth **10** and supplied with the molten fiber-forming material therefrom is one or more bushings **12**, each of which is formed with a series of orifices or outlets for flowing streams S of the fiber-forming material from the bushings. Disposed beneath the bushings **12** is a hood or shroud **15** which may be formed with frusto-pyramidal shaped portions **16**, one of which is disposed beneath each of the bushings **12**, two of the bushings and hood portions being illustrated in Figure 1. Arranged immediately beneath each bushing and at the entrance of the adjacent portion **16** are blowers **18** disposed at each side of the streams emanating from the bushings which are configurated and arranged to direct jets or blasts of superheated steam or air under comparatively high pressure onto the streams of molten material, the jets or blasts being disposed to travel in the general direction of flow of the streams, i. e., downwardly as viewed in Figure 1. The high velocity blasts or jets of steam or air impinge upon the streams and draw or attenuate them to fibers **20** which pass downwardly through the portions **16** of the hood **15** as exemplified in Figure 1.

The fibers are directed to a collecting zone **21** and are preferably deposited upon a movable foraminous conveyor **22** of the endless type supported upon rollers **23**, **24**, **25** and **26**, the conveyor being actuated by suitable means (not shown) and adapted to travel in the direction of the arrows. Disposed beneath the upper level of the foraminous conveyor adjacent the collecting zone is a chamber **28** connected by means of a tube **29** to a suction device or means for establishing a subatmospheric or reduced pressure beneath the upper level of the conveyor **22** to facilitate the collection of the fibers upon the conveyor. The conveyor is supported and arranged adjacent the fiber collecting zone for movement in an upwardly inclined direction for a purpose hereinafter explained.

The fibers **20** formed by drawing or attenuating the streams S are of a relatively coarse nature being substantially in a range of size from about four to fifteen microns in diameter. Such fibers by reason of their size are endowed with high strength characteristics and when interfelted into mat formation provide a mat of considerable strength. However, such fibers being relatively coarse provide direct paths of solid material facilitating the transmission of heat and hence the insulating value of a mat formed of such fibers is not as high as desired for many insulating purposes.

The present invention provides for intermingling other fibers with the fibers **20** that are of extreme fineness, and which when intermingled with the coarse fibers results in a mat of increased insulating value and of higher elasticity or resiliency. Furthermore the fine fibers form, in effect, an intermediary cushion or pad minimizing abrasion of the coarse fibers and hence improving the quality of the mat construction.

The apparatus for forming relatively fine fibers according to the instant invention is arranged for concomitant operation with the means for producing relatively coarse fibers whereby the two types of fibers may be intermingled and interfelted during their formation and attenuation to form a composite mat of relatively fine and coarse fibers. While the fiber-forming material utilized for producing the fibers **20** may be used for forming the relatively fine fibers, it is to be understood that other fiber-forming materials or compositions may be utilized for producing the relatively fine fibers.

In the arrangement illustrated in Figure 1, the same composition of fiber-forming material, as for example glass, is utilized to form the fine fibers. To this end a bushing **30** is arranged beneath the forehearth **10** and is provided with a plurality of openings or orifices to flow several streams S' from the bushing **30**. The apparatus utilized for producing fine fibers involves the production of a high velocity blast of intensely hot gases into which the fiber-forming material is conveyed and is attenuated by the hot, high velocity blast into fine fibers. As shown in Figure 1, a burner **32** is configurated with an interior chamber **33** forming a confined zone in which is burned a mixture of fuel gas and air introduced into the burner by a tube **34**. The burner is provided interiorly with a wall **35** having a plurality of small passages therein to admit the combustible mixture into the chamber **33**, the perforated wall forming a screen to confine combustion in the chamber. The burner **32** is formed with a restricted orifice **36** through which the burned or substantially burned products of combustion are discharged in the form of a high velocity blast of intensely hot gases well above the temperature of attenuation of the fiber-forming material.

In the use of the burner **32** for attenuating purposes, it is desirable that the streams of molten glass or other material be substantially chilled, increasing the viscosity of the glass whereby it approaches a solidified condition providing filaments F which may be fed or conveyed into the hot blast of gases. It is desirable to draw the streams S' into filament form by means of a pair of draw rolls **37** which engage the filaments formed by chilling of the streams S' as they move downwardly into engagement with the draw rolls **37**.

Disposed adjacent the filaments F between the draw rolls **37** and the blast of hot gases is a suitable guide **39** which may be formed of metal of hollow configuration and cooled by a suitable medium such as water circulated through the interior of the guide member **39**. The streams S' move through a suitable distance whereby the atmosphere chills the streams to a more viscous or plastic condition approaching solidity so that the draw

rolls 37 form them into suitable filaments F which are substantially solid at the moment they are fed into the blast 40 emanating from the burner 32.

The extremities of the filaments F formed from the streams S' as they are moved into the hot zone of the blast immediately adjacent the orifice 36 are heated above the attenuating temperature and rendered flowable whereby the blast of gases continuously attenuates the filaments into relatively fine fibers which are conveyed by the force of the hot blast to the collecting zone 21 and are deposited upon the foraminous surface 22 of the conveyor. The fine fibers are intermingled or interfelted in the collecting zone with the relatively coarse fibers 20 to form a composite mass of relatively coarse and fine fibers of substantial homogeneity, that is, the fine fibers are interspersed throughout the mass of relatively coarse fibers and serve to pad or cushion the coarse fibers forming a mat of improved quality.

In the form of apparatus illustrated in Figure 1, the conveyor 22 is canted upwardly at the fiber collecting zone. This disposition of the conveyor facilitates the interfelting or intermingling of the fine and coarse fibers whereby the fine fibers are distributed substantially uniformly throughout the mass. It is to be understood that the angularity of the conveyor at the collecting zone may be varied to modify the distribution or extent of interfelting of the fine fibers with the coarse fibers as may be desired.

It is desirable in forming a mat to establish or set up a degree of mass integrity in the fibers so that the mat may be handled, transported and installed in a satisfactory manner. To attain this end, a binder or adhesive such as a resin in the form of phenol-formaldehyde may be injected into the fibrous mass by means of jets or applicators 45. The collected mass of fibers is continuously conveyed away from the collecting zone by movement of the conveyor 22 and the mass is preferably passed beneath a roll 47 which compresses the mass of fibers to a suitable thickness. If further fixation of the fibers is desired, the formed or compressed mat of fibers M may be conveyed through a suitable fluid solution of resin or binder contained in a receptacle 49, the impregnated mat being subsequently moved through a curing oven 52 in which suitable heating elements 53 elevate the temperature sufficiently to cure or set the resin or binder constituent.

It is to be understood that in certain forms of fibrous mat for particular uses, the step of dipping the mat into a solution in the receptacle 49 may be dispensed with where the amount of binder injected through the applicators 45 may be sufficient to establish desired mass integrity in the formed mat. Thus in the manner described, the relatively coarse and relatively fine fibers are formed concomitantly and continuously and are intermingled or interfelted so as to produce a mat having the desirable characteristics hereinbefore mentioned.

Figures 2 and 3 illustrate a modified form of arrangement for carrying out the method of the present invention. Figures 2 and 3 exemplify a form of apparatus wherein the supply of fiber-forming material for producing the relatively fine fibers may be contained in separate receptacles. Such an arrangement facilitates the use of a different composition for the fine fibers if desired. This form of apparatus discloses an arrangement for attenuating the fine fibers in the general direction of movement of the relatively coarse fibers during formation thereof for intermingling the fine and coarse fibers together.

A forethearth 60, similar to the forehearth 10 illustrated in Figure 1, is provided with bushings 62 having orifices through which flow streams of molten material such as glass contained in the forethearth. Disposed beneath the bushings 62 is a hood 15' provided with frusto-pyramidal portions 64 into which the streams 65 of molten material are discharged. Disposed at the entrances of the portions 64 are blowers 18' for directing jets or blasts of superheated steam or compressed air or other gas under pressure against the streams in the general direction of flow thereof to draw or attenuate them into relatively coarse fibers 20' of diameters between four and fifteen microns.

Disposed between pairs of bushings 62 is a burner 32' of the character described in connection with the form of apparatus illustrated in Figure 1 for burning a gaseous fuel and air mixture to produce blasts of intensely hot gases projected through restricted orifices 36'. Disposed above the burners 32' are receptacles 68 and 69 adapted to contain molten fiber-forming material for producing relatively fine fibers. The receptacles 68 and 69 may contain fiber-forming materials of different character or composition from that contained in the forehearth 60 for producing fine fibers. However, the receptacles 68 and 69 may be integrated into a single container if the same composition is desired to be conveyed to the burners 32'.

The receptacles 68 and 69 are provided with bushings 70 each formed with a series of orifices to produce streams 72 of fiber-forming material flowing from the bushings. As in the arrangement illustrated in Figure 1, the streams 72 preferably flow a considerable distance through open atmosphere so that they become chilled and of a highly viscous or plastic constituency approaching solidity as they pass around the guide rolls 73. Sets of draw rolls 74 are provided and adapted to engage each group of filaments F' formed from the streams 72 to draw the streams to filament form and to convey the filaments into the intensely hot blasts produced by the burners 32' in directions substantially normal to the blasts. Suitable guides 75 cooled by circulating water or the like may be disposed adjacent the filaments as they enter the blasts in order to guide them into the zone of highest temperature of the blast, that is, adjacent the discharge orifices 36' of the burners. The fine fibers 80 produced in this manner are of a size from one to two and one-half microns in diameter.

The hood or shroud 15' may be formed with intermediate tapered portions 77 having entrances to receive the relatively fine fibers formed and discharged into the hood 15' by the blasts of intensely hot gases emanating from the burners 32'.

The fine fibers 80 are intermingled and intermixed in the hood 15' with the relatively coarse fibers, the mixing being augmented by the turbulence of the moving gases in the hood. The fine fibers and the coarse fibers are deposited in a collecting zone 21' upon a conveyor 82 which is of the foraminous type being supported in a suitable manner as by rollers 83 and 84, the conveyor being moved by a motor (not shown) in the direction of the arrows illustrated in Figure 2. A chamber 86 is disposed beneath the collecting zone 21' and the upper level of the conveyor 82, the chamber 86 being connected by means of a tube 87 with a means for establishing reduced pressure in the chamber 86 to facilitate collection of both types of fibers in intermingled or interfelted relation and to carry away the attenuating gases discharged into the hood. A binder or resin may be injected onto the accumulated fibers by means of applicators or nozzles 88. A binder such as phenol-formaldehyde may be used or other suitable material which will impart mass integrity to the mat M' formed of the fibers. A roll 90 may be disposed adjacent the exit of the hood 15' for compressing the mass of fibers into a mat of predetermined thickness. The mat M' may be conveyed into a suitable oven 52' for curing the binder or adhesive in the mat. If desired the mat may be passed through a solution of binding material in the manner illustrated in Figure 1.

It is to be understood that the molten material in the forehearth 60 may be used for the production of both fine and coarse fibers, in which event the bushings 70 may be affixed to the forehearth, eliminating the use of

receptacles 68 and 69. While the form of apparatus employed in producing the fine fibers by intensely hot blasts is arranged to continuously feed the filaments of fiber-forming material into the blasts in directions substantially normal thereto, modification may be employed in the arrangement. For example, the method and arrangement disclosed in Slayter and Fletcher Patent No. 2,489,242, granted November 22, 1949, may be utilized.

In the arrangement illustrated in Figures 2 and 3, there are six fiber attenuating units, four bushings 62 and associated blowers for producing relatively coarse fibers and two bushings and burners 32' for producing relatively fine fibers. It is to be understood that any number of attenuating units may be utilized for producing streams or groups of relatively fine and relatively coarse fibers dependent upon the desired ratio of fine fibers to coarse fibers in the ultimate product. In practical operation of the method, one or more attenuating units may be shut off or a selected number of fine fiber attenuating units and coarse fiber attenuating units simultaneously operated to secure different ratios of fine to coarse fibers in the end product. Thus by regulating the proportion of fine and coarse fibers, mats may be produced endowed with particular characteristics for particular uses.

I claim:

1. A method of concomitantly forming relatively coarse and fine fibers including the steps of flowing streams of molten fiber-forming material; of directing a blast of gas of a temperature below that of the molten material into engagement with the streams to continuously attenuate the same into relatively coarse fibers; of concomitantly establishing a high velocity blast of intensely hot gases of a temperature above the attenuating temperature of the fiber-forming material; of continuously feeding a body of fiber-forming material into the blast of intensely hot gases to attenuate the body into relatively fine fibers; of directing both coarse and fine fibers during their attenuation into a mixing zone wherein the coarse and fine fibers are interfelted in a common mass.

2. A method of producing a mat of fibers including the steps of flowing a plurality of streams of molten fiber-forming material; of impinging a blast of gas against the streams of material of a temperature below that of the molten material to attenuate the streams to form relatively coarse fibers; of burning a combustible gaseous mixture in a confined zone and discharging the products of combustion in a manner providing a high velocity blast of intensely hot gases of a temperature above the softening temperature of the fiber-forming material; of continuously feeding a body of fiber-forming material into the blast of hot gases to attenuate the body of material into fibers of extreme fineness, and of concomitantly commingling both types of fibers while entrained in the blasts; of providing a zone of reduced pressure for collecting the commingled fibers into a mat and conveying away the gases of the blasts, and of applying a resinous binder to the fibers to establish mass integrity in the fibrous mat.

3. A method of producing a mass of fibers of varying fineness including the steps of flowing a plurality of streams of molten fiber-forming material; of impinging a blast of gas against the streams of material of a temperature below that of the molten material and in the general direction of flow of the streams to attenuate the same to form relatively coarse fibers; of burning a combustible gaseous mixture in a confined zone and continuously discharging the products of combustion in a manner providing a high velocity blast of intensely hot gases; of continuously feeding a filament of fiber-forming material into the blast of hot gases in a direction generally normal thereto to soften and attenuate the filament into fibers of extreme fineness, and of concomitantly and continuously commingling both type of fibers as they are conveyed by the blasts from the attenuation zones, and collecting the fibers in a common mass.

4. A method of producing a mass of relatively fine and coarse fibers including the steps of flowing a plurality of streams of fiber-forming material; of directing a blast of gas into contact with the streams in the general direction of flow thereof whereby the streams are attenuated to form relatively coarse fibers; of concomitantly burning a combustible mixture in a confined zone and discharging the products of combustion through a restricted orifice to establish a high velocity blast of extremely hot gases; of feeding a body of fiber-forming material into the blast of extremely hot gases in a manner whereby the body is attenuated to form relatively fine fibers, and of commingling and collecting the relatively fine and coarse fibers into a common mass wherein the fine fibers are substantially uniformly distributed throughout the mass.

5. A method of producing a mass of relatively fine and coarse fibers of mineral material including the steps of forming a pluralty of streams of molten mineral material; of causing a blast of gas under high pressure and of a temperature below that of the molten material to impinge upon the streams in the general direction of flow thereof to attenuate them to relatively coarse fibers; of concomitantly burning a combustible mixture of fuel and air in a confined zone and discharging the products of combustion through a restricted orifice to establish a high velocity blast of extremely hot gases; of continuously feeding a body of fiber-forming mineral material into the blast of extremely hot gases to attenuate the body into relatively fine fibers, of carrying on the attenuation of both fine and coarse fibers in a common zone, and of commingling and collecting the relatively fine and coarse fibers as they are formed into a mass wherein the fine fibers are substantially uniformly distributed throughout the mass.

6. A method of producing fibers of fiber-forming material including the steps of flowing streams of material; of directing a blast of gas of a temperature lower than that of the flowing material against the streams in the general direction of flow thereof whereby the streams are blown to fiber formation; of concomitantly supplying filaments of fiber-forming material; of establishing a blast of intensely hot gases of a temperature above the attenuating temperature of the filaments; of feeding the filaments into the blast of hot gases in a manner whereby the filaments are softened and attenuated to fine fibers; of directing the respective blasts in directions whereby the fibers formed in the blasts are intermingled as they are collected in a mass, and of continuously conveying the mass of blown and fine fibers from the fiber collecting zone.

7. A method of concomitantly producing and commingling relatively fine and coarse fibers to form a mat including the steps of flowing spaced groups of streams of fiber-forming material from a supply; of directing blasts of gas at relatively low temperature against and in the general direction of movement of the streams of one group whereby the streams are attenuated to relatively coarse fibers; of flowing the other group of streams to form filaments; of directing the formed filaments into an intensely hot zone of burned gases moving at high velocity whereby the filaments are attenuated to form relatively fine fibers; of controlling the directions of movement of the relatively coarse and fine fibers whereby they are intermingled and collected in a common zone in a mass wherein the fine fibers are substantially uniformly distributed throughout the mass; of applying a resinous binding agent to the mass of fibers to form a mat, and of conveying the mat to a zone for curing the binding agent to establish mass integrity in the mat.

8. A method of concomitantly producing and commingling relatively fine and coarse fibers including the

steps of flowing streams of fiber-forming material from a supply; of directing blasts of gas at relatively low temperature against the streams whereby the same are converted to relatively coarse fibers; of establishing a blast of intensely hot gases moving at high velocity; of feeding filaments of fiber-forming material into the blast of hot gases in a manner whereby the filaments are attenuated to relatively fine fibers, and of controlling the directions of flight of the relatively coarse and fine fibers whereby they become intermingled and interfelted to form a substantially homogeneous mass of fine and coarse fibers.

9. Apparatus for producing fibers from fiber-forming material including, in combination; a receptacle adapted to contain a supply of flowable fiber-forming material; a bushing disposed adjacent the receptacle having a plurality of orifices through which flow streams of the material; a shroud into which the streams are directed; means for establishing a blast of gas of a temperature below that of the stream of material directed against the streams as they enter the shroud for attenuating the streams to fibers within the shroud; a second bushing having means for flowing a body of fiber-forming material to form a filament; a chamber for burning a combustible mixture and having a restricted orifice to produce a high velocity blast of hot gases of a temperature above the attenuating temperature of the fiber-forming material; means for supporting the chamber to direct the blast of hot gases to attenuate the filament to fibers and convey the fibers into the shroud, and a movable conveyor disposed adjacent the shroud for continuously collecting fibers formed by both fiber attenuating blasts into a common mass.

10. Apparatus for producing fibers from fiber-forming material including, in combination, a receptacle adapted to contain a supply of molten material; means for flowing streams of molten material from the receptacle; a shroud into which the streams are directed; means for establishing a blast of gas of a temperature below that of the molten material directed against the streams as they enter the shroud for attenuating the streams to fibers; a chamber for burning a combustible mixture and having a restricted orifice to produce a high velocity blast of hot gases of a temperature above the attenuating temperature of the fiber-forming material; means for feeding a body of fiber-forming material into the high velocity blast of hot gases; means for supporting the chamber to direct the blast of hot gases to attenuate the body to fibers and convey the fibers into the shroud, a foraminous conveyor, and means for establishing a zone of differential pressure adjacent the conveyor to direct the fibers onto the conveyor as they are formed.

11. Apparatus for producing fibers from fiber-forming material including, in combination, a receptacle adapted to contain a supply of heat softenable material; a hood; means for flowing streams of the material into the hood; means for establishing a blast of gas of a temperature below that of the streams of material directed against the streams as they enter the hood for attenuating the streams to relatively coarse fibers; means including a chamber for burning a combustible mixture in a confined zone; said chamber having a restricted orifice to produce a high velocity blast of hot gases of a temperature above the attenuating temperature of the fiber forming material; means for supporting the chamber to direct the blast of hot gases into the hood; means for feeding a body of material into the blast of hot gases in a manner attenuating the body into fine fibers; a fiber collecting zone; and means for establishing reduced pressure effective at said zone to influence the movement of both fine and coarse fibers toward the fiber-collecting zone and convey the attenuating gases away from the hood.

12. Apparatus for producing fibers from heat softenable material including, in combination, a fiber attenuating unit; means for supplying continuous streams of the heat softenable material to said unit; said unit including nozzles for directing gas under pressure and of a temperature below that of the streams of material into engagement with the streams in the general direction of flow thereof to attenuate the streams into fibers; a second fiber attenuating unit including a chamber adapted to burn a combustible mixture in a confined zone; said chamber having a restricted orifice through which the gases of combustion are discharged as a high velocity blast of intensely hot gases of a temperature above the softening temperature of the material; means for continuously supplying an elongated body of fiber-forming material into the blast of intensely hot gases in a manner to attenuate the body into fibers; a hood; said attenuating units being arranged to continuously attenuate the material to fibers and direct the fibers into the hood; a foraminous fiber collecting surface, and means for establishing a zone of reduced pressure adjacent the fiber collecting surface to direct the fibers to the surface and convey the attenuating gases from the hood.

13. Apparatus for producing fibers from heat softenable material including, in combination, a fiber attenuating unit; means for supplying molten streams of the material to said unit; said unit including nozzles for directing gas under pressure and of a temperature below the solidifying temperature of the molten streams into engagement with the streams in the direction of flow of the streams to attenuate the same to relatively coarse fibers; a second fiber attenuating unit including a chamber adapted to burn a combustible mixture; said chamber having a restricted orifice through which the gases of combustion are projected as a high velocity blast of intensely hot gases; means for feeding fiber-forming material into the blast of hot gases whereby the material is attenuated to relatively fine fibers; said fiber attenuating units being disposed whereby the fibers produced thereby are intermingled in a common zone, and means including a foraminous surface for collecting the intermingled fibers in mass formation.

14. Apparatus for producing fibers including, in combination, means including a plurality of bushings provided with orifices for flowing spaced groups of streams of fiber-forming material; means for directing jets of steam into engagement with certain groups of streams and in the general direction of flow of the streams to attenuate the same into fibers; means for establishing high velocity blasts of intensely hot gases of a temperature above the attenuating temperature of the streams; means for drawing the other groups of streams into filaments and directing the filaments into the blasts of hot gases to attenuate the filaments into fine fibers; a hood disposed to receive the fibers; a movable conveyor disposed adjacent the hood upon which the fibers are collected; means for establishing reduced pressure adjacent the conveyor to direct the fibers to the conveyor; means for directing a resinous binding agent into the collected fibers; a curing oven; said conveyor being effective to continuously move the collected fibers through the oven.

15. A method of producing a mass of relatively fine and coarse fibers from fiber-forming material including the steps of flowing a group of streams of the material; of directing a blast of gas of a temperature lower than that of the flowing material against the streams in the general direction of movement thereof whereby the streams are formed into coarse fibers; of concomitantly flowing a second group of streams of fiber-forming material spaced from said first mentioned group of streams; of drawing the second group of streams into filaments; of directing the filaments into a blast of intensely hot gases of a temperature above the attenuating temperature of the filaments whereby they are softened and attenuated to relatively fine fibers; of directing the blast

of intensely hot gases in a direction whereby the fine fibers are entrained and conveyed by the blast to a zone where they are intermingled with the coarse fibers as they are formed, and of conveying the mass of intermingled fibers from the fiber attenuating zone.

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