

March 21, 1961

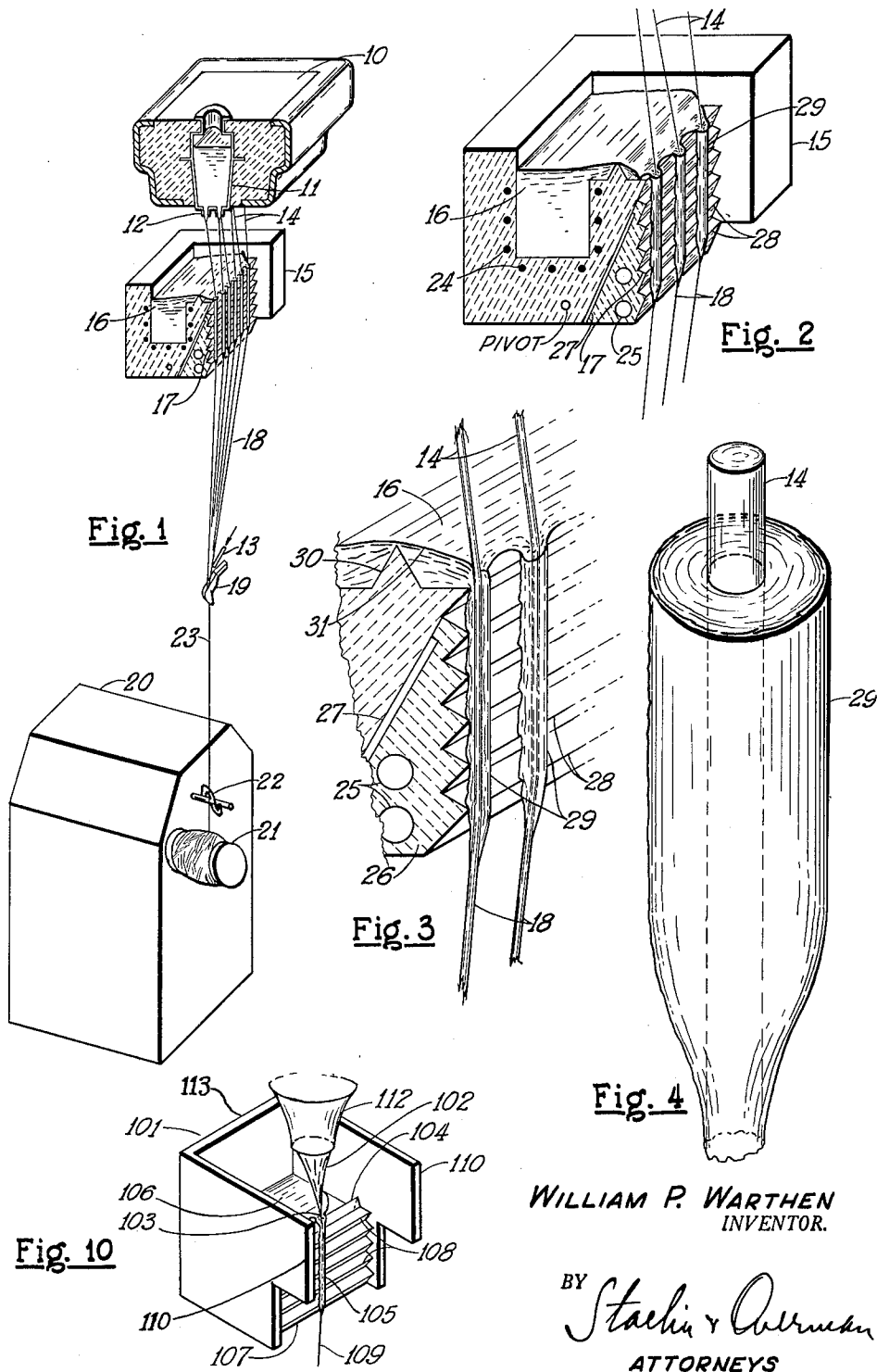
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2,976,177

METHOD AND MEANS FOR COATING OF FILAMENTS

Filed April 15, 1957

2 Sheets-Sheet 1



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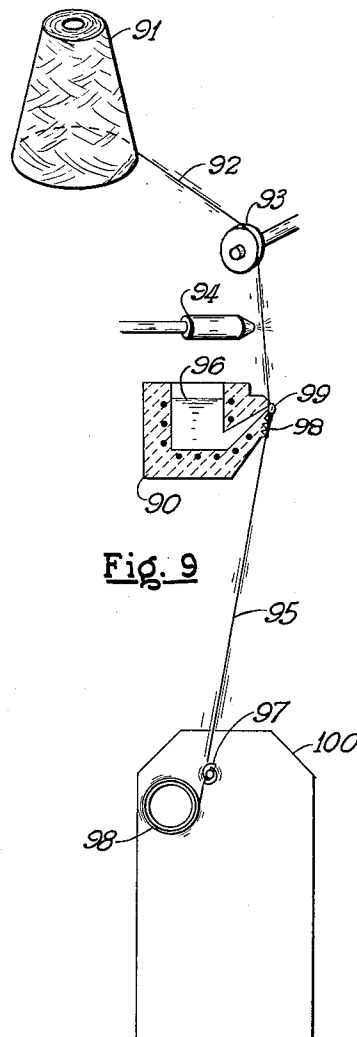
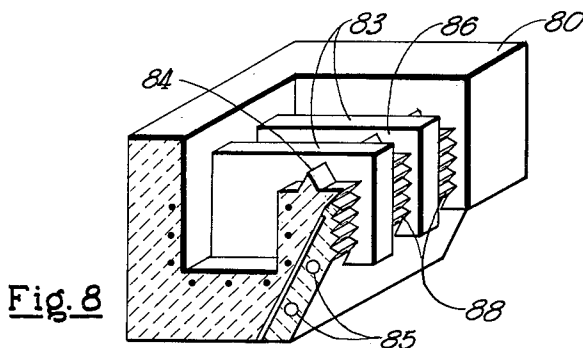
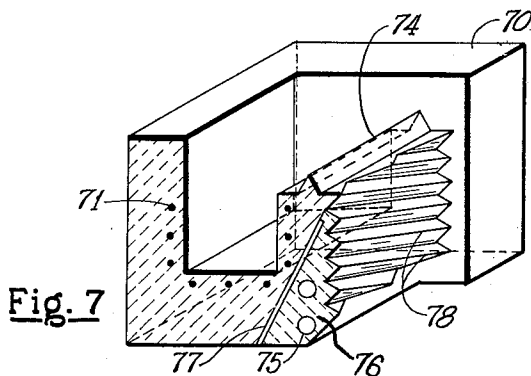
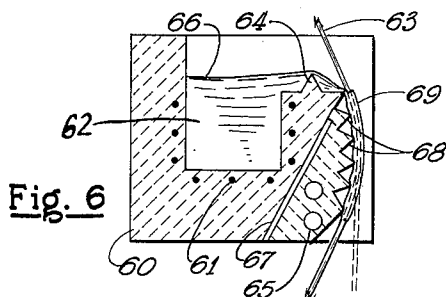
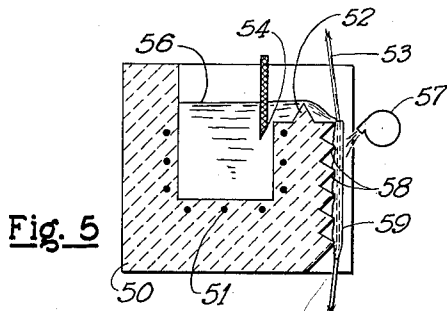
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METHOD AND MEANS FOR COATING OF FILAMENTS

Filed April 15, 1957

2 Sheets-Sheet 2



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2,976,177

METHOD AND MEANS FOR COATING OF FILAMENTS

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Filed Apr. 15, 1957, Ser. No. 652,995

12 Claims. (Cl. 117—119.2)

This invention relates to the coating of filaments or fibers with heat-softenable material and more particularly to a method and means for applying heat-softenable material to continuous filaments of high temperature material such as glass.

In manufacturing continuous fibers or filaments of material such as glass, extremely high rates of production are possible, the standard production rate for strands of such fibers frequently being in the order of 15,000 feet per minute or more. The magnitude of this rate can be appreciated more readily when translated to reveal that it amounts to 180 miles per hour or more. In some instances rates in the order of from 30,000 to 40,000 feet per minute have also been used. To coat fibers moving at such velocities presents a problem, especially when control of uniformity of diameter of the coating material is a requirement, and even more so when the material to be coated is to be applied in small thicknesses under which condition even small variations or incongruities result in wide percentage variations in the amount applied.

Dies are frequently used to provide coatings or predetermined thickness on forms such as wire, cords or strands of different materials, but where, as in the conventional production of strands of glass, individual filaments are to be coated simultaneously at high speed in groups of 204 or 408 filaments prior to being gathered into a strand, considerable difficulty would be experienced if each of the filaments in such groups required a separate die. A single filament breakage in such instance would require shut-down of an entire operation. Each individual filament would also be required to be separately threaded through a die at initiation of coating operations, entailing considerable time, both at startup as well as when breakages occur. Accordingly, a conventional apertured die arrangement for coating material on longitudinal filamentous forms, does not prove practical in high-speed production of strands of coated filaments. Still further in this regard, it will be recognized that where small filaments of material such as glass, which in many instances are as small in diameter as .00021 inch, dies would be quite tedious to thread and their cost would be high because of the precision work required in their manufacture.

In view of the foregoing, it is an object of the present invention to provide an economical high-speed method for coating continuous filaments with heat-softenable coating material.

It is another object of the present invention to provide a method and means for high-speed coating of continuous filaments to a diameter of predetermined magnitude.

It is still a further object of the invention to provide a new method and means for applying heat-softenable ma-

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terial to individual filaments of high-temperature material without requirement for passage of the filaments through apertures, and yet providing the effect of an apertured die in limiting the amount of coating material supplied or fed and applied to the individual filaments.

An additional object of the invention is to provide a method and means for coating continuous filaments which is not limited by the fact that the filaments are moving at an extremely high rate of speed, but actually utilizes the speed of the filaments in promoting the coating operation.

In brief, the present invention involves applying coatings of heat-softenable materials to filaments of high-temperature-resistant materials such as glass by utilizing the high linear speeds such as are imparted to the filaments in production thereof to draw or supply the coating material to the filaments. Still further, the tendency toward solidification on cooling of the coating material is utilized to form a tubular shell of the coating material itself about each filament, which shell simulates a die to limit the diameter of the coating material applied to the filament.

The simulated die is formed by controllably cooling the molten coating material borne by spaced support points of the face of a coating applicator. The cooling of the coating material by spaced support points effects a withdrawal of heat from the coating material to a limited extent such that only the exterior of the coating material surrounding each filament is cooled to form a semi-solid or solid tubelet about each filament. Each tubelet then acts as a die held by the applicator for the filament passing therethrough.

The coating material is applied to each filament within its respective tubelet, and replenishment of the material taken therefrom is effected by passage of the fiber through a small quantity of the molten coating fluid prior to passage of the filament through the tubelet. The small quantity of molten coating fluid is so connected to a larger reservoir that replenishment of the small quantity is automatically effected by rapid passage of the filament through the small quantity. The continued introduction and supply of molten fluid to the tubelet retains the interior of the tubelet in a constantly fluid state of viscosity determined by the speed of passage of fibers through the tubelets to replace already applied material with new coating material at high-temperature. The tubelets then act to uniformly restrain excesses from being applied to the filaments to provide a coating of uniform diameter on the exterior of each filament.

Other objects and features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention, however, both in organization and manner of construction, together with further objects and advantages thereof may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 is a somewhat schematic side elevation view partially in cross-section of apparatus of the present invention for producing coated glass filaments;

Figure 2 is an isometric view partially in cross-section of an applicator for applying coatings to filaments, the applicator being an enlargement of that of Figure 1;

Figure 3 is a cross-sectional view in part of the applicator of Figures 1 and 2 enlarged to indicate more clearly the manner in which coating material is supported at the face of the applicator for supply to the filaments;

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Figure 4 is an enlarged view of a part of a filament surrounded with coating material under the conditions in which it exists at the face of a coating applicator;

Figure 5 is a side elevational view, partially in cross-section, of an applicator arrangement similar to that of Figures 1 to 4, but having a blower at its face to supply gas of controlled temperature for modification of coating conditions at the applicator face;

Figure 6 is a side elevational view in cross-section of still another applicator incorporating the principles of the present invention;

Figure 7 is a still further embodiment of an applicator incorporating the principles of the present invention wherein supporting points for the material supplied to the filaments exist in the form of projections formed by serrations extending diagonally across the path taken by the filaments in passing over the face of the applicator;

Figure 8 is a further embodiment of the present invention wherein support points for coating the material at the face of the applicator are combined with guide projections for the material and filaments passed thereacross;

Figure 9 is a side elevational view, partially schematic and partially in cross-section, of an arrangement wherein strands or yarns of material may be drawn from packages and heat-cleaned prior to passage through coating material; and

Figure 10 is still another embodiment of an applicator incorporating the principles of the present invention wherein a reservoir of molten material is supplied with heat from the forming cone of a filament coated by the applicator.

Although the invention is herein exemplified and described principally in relation to the coating of heat-softenable coating material on glass filaments as they are being formed, it will be understood that the filament material is not necessarily limited to glass but can be wire such as of aluminum, copper or steel or other materials such as nylon, polyglycol terephthalate, rayon, and many others, just so long as the filament material is capable of withstanding the temperature of the coating material as it is being applied. Heat-softenable materials such as various metals like zinc, aluminum, copper, lead, tin, silver and alloys thereof can be coated on filaments according to the present invention as well as a wide range of thermoplastic materials like polyethylene and tetrafluoroethylene. The principles of the invention are also not necessarily limited to coating of fibers as they are being formed, but can be utilized in coating of fibers already formed just so long as the speed of supply of the filaments is sufficient to draw in molten coating fluid at a sufficient rate to retain the interior of the tubelets formed thereof in a molten state for coating of the filaments. Still further, the principles also have application in coating of other forms than singular filaments but can be applied to coating of combinations of filaments such as in strands and yarns.

Turning to the drawings in greater detail, Figure 1 shows a general layout of apparatus for producing fibers or filaments of glass coated with heat-softenable material which in the present instance is exemplified by metal. A melter 10 of suitable type for melting glass is provided with a feeder or bushing 11 provided with a series of outlets in its bottom from which flow a plurality of streams of molten glass. The outlets exist in projections or tips 12 at the bottom of the feeder and are preferably arranged in one or two rows so that the streams are all substantially in the same plane. The bushing 10 is made of high-temperature-resistant conductive material such as platinum surrounded by refractory material retained in a steel casing. As the streams flow from the outlets, they are drawn out into the fibers or filaments 14 by means of a rotating collet-supported collecting tube 21 which winds the fibers thereon in strand form and also supplies the force of attenuation of the filaments from the

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streams flowing from the tips 12. A gathering member 19 for collection of the filaments into a strand 23 is provided in a position intermediate the feeder 11 and the collecting tube 21. The type of gathering member shown in Figure 1 is commonly termed a pad holder in that in practice it usually supports a felt-like pad of material which acts as a wick to retain sizing or lubricating fluids fed thereto from a source connected to a supply tube 13 having its outlet disposed above the gathering member 19. Sizing materials may be applied separately from the gathering member, however, such as at a roll-type applicator disposed thereabove. Sizing materials such as those set out in U.S. Patent 2,234,986, issued on March 18, 1941, may be applied, or when metal coatings are applied to the filaments, material may be applied which is more lubricant in nature, such as petroleum oil, vegetable oil, molybdenum disulfide or other lubricants.

Traversal of the strand 23 at the winder in order to form a package on the tube 21 may be effected by a suitable traversing means such as a spiral wire traverse 22 arranged to sweep the strand back and forth on the collection tube with each revolution.

Filaments 14 are individually coated at points between the feeder and the gathering member 19 by drawing each across the face 17 of a coating applicator 15. As may be seen more clearly in Figures 2 and 3, the applicator or coater is in general a container made of ceramic or refractory material such as graphite having properties of temperature resistance sufficient to withstand the temperature of the molten material to be contained therein. Embedded within the refractory is a series of electrical conductors 24 such as of Nichrome which provide the heat to melt and maintain the molten material within the container portion of the applicator at desired temperatures. Principles of induction heating as well as conductive heating may be utilized to melt and maintain the temperature of the material.

The applicator has a coating face 17 of graphite located at one side thereof which has a series of horizontal projections formed by parallel serrations extending along the length of the applicator. The face 17 of the applicator in the construction of Figures 1 to 3 is provided in a separate block 26 of high temperature material such as graphite which is attached to the container portion, but thermally insulated therefrom by a separating gap 27 extending for substantially the major portion of the area of abutment of the face block with the container portion. Insulating material may be inserted within the gap 27, such material being any of a wide variety of insulating materials, but for example may be a refractory glass wool which further isolates the face of the applicator from the reservoir or container portion. Tubular channels 25 are provided within the face block through which thermally controlled fluid may be passed to fix the face block at a given uniform temperature. The upper edge of the container portion of the applicator, adjacent the area of abutment of the facing block is provided with a projection 30 which acts in a sense as a dam or weir for fluid transferred from the container or reservoir portion to the upper edge of the face block.

To effect initial transmittal of the molten fluid 16 within the container portion to the upper edge of the face block 26, the entire applicator structure is tilted about a fixed axis marked "pivot" in Figure 2 and extending along the base of the container portion parallel to the face of the applicator. Coating fluid is thus poured over the weir projection 30 to the upper edge of the applicator face 17.

The fibers 14 are drawn over the face of the applicator in generally parallel paths to the face projections and also toward the gathering member 19. An accumulation of the molten material on the face side of the weir projection 30 is caused to be of such size that it projects in overhanging relationship from the upper edge of the face

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in the path of the individual fibers 14 so that it surrounds each of the filaments 14. The movement of the fibers or filaments across the face projections causes them to draw a portion of the material through which they pass in extended relation as channels or trailing paths across the face projections along with the filaments. The face block 26 is cooled by passage of cooling fluids, such as water at a low temperature through interior channels 25 passing through the block thereby to cause the entire isolated face block 26 to be cooled to a temperature lower than the coating fluid drawn across the face projections 28. Since the coating fluid or material drawn across the face with the filaments is then in contact with at least the apices of the projections 28, heat is withdrawn from at least the outer surface of the longitudinal channels surrounding the filaments. The channel of molten fluid is thus provided a casing of high viscosity in semi-plastic or even solid condition which acts as a cylindrical tubelet, casing or shell surrounding the filament portion passing over the facing projections. The fluidity of the material within the tubelet, trailing channels 29 is maintained constant by drawing in new fluid material at high temperature from the container portion of the applicator so that the interior of the tubelet is retained at a higher temperature than the exterior from which the heat is withdrawn. The more rapid the passage of filaments through the tubelets, the greater is the amount of molten material carried through the tubelets. Thus, replenishment is made to correspond to the necessity for additional material required to coat filaments at higher speeds. The interior of the tubelets is in this way provided with an automatically regulated amount of material dependent upon the velocity of the filaments therethrough.

The withdrawal of fluid from the upper edge of the face block 26 is accomplished by frictional engagement of the filaments with the coating material and retention of a supply thereof at the upper edge by exertion of such forces through the medium of the fluid itself passing over the weir projections 30. The exterior surface of the fluid is somewhat more viscous than the interior by reason of its exposure to the atmosphere and also the fact that its composition may be somewhat different. For example, if the fluid is metal, the exterior surface of the body 16 is more likely to be a mixture of the molten metal, and the solid oxide of the metal in finely divided form which mixture has properties of greater viscosity than the molten metal itself. The surface of the molten metal can thus be tensioned by reason of its being somewhat stiffer than the fluid portion under the surface. The skin or tension surface can thus act as a membrane which will permit siphoning of the molten fluid thereunder across the projecting weir 30, the siphoning action being greatest with higher speeds of the filaments 14.

The face projections 28 in contact with the channels of fluid drawn across the face 17 with the filaments 14 limits the area of contact of the facing block 26 with the material surrounding the filaments to the extent that only a small amount of heat is withdrawn from the shell, such amount being that which is just sufficient to establish the state of solidity or semi-plasticity in the shells or tubelets 29 to permit the tubelets to act as dies for the filaments drawn across the face. If the channels were to contact the facing block 26 for their full length, then the withdrawal of heat it has been found would extend to the interior of the tubelets to the extent that the wiping or die type action would not exist to wipe the filaments to the thickness of coating desired on each. The base or bottom of each tubelet 29 tapers or necks down generally to the final thickness of coating applied to the individual filaments. The coating operation is such that no dripping of the fluid from the tubelets takes place. This is accomplished by causing each channel or tubelet to act in a sense like a test

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tube filled with molten fluid having an orifice at its bottom which meters the amount of coating material applied to a filament. The opening in the bottom of the tubelet is narrower than that at the top thereof in view of the progressive cooling which takes place along the length of the shell and the correspondingly greater thickness of the shell wall at the bottom. Since the bottom of the shell thus has the smallest internal diameter along the length of the shell, the amount of material coated on the filament is governed by this portion.

It should be noted that the tilt of the applicator need not be retained once the coating operation is initiated since even when the head of the molten fluid within the container portion falls below the upper edge of the projection 30, a flow of fluid across the upper edge of the projection is continued by reason of the siphoning action of the fluid thereunder under the influence of forces provided by the passage of filaments across and through the molten fluid at the upper edge of the face block 26. Thus, the weir-like projection 30 acts to prevent continued flow of fluid when the filaments are not passed over the face of the applicator, but while the fluid is being siphoned thereover, it acts to screen or filter out particles which might otherwise interrupt continuity of coating operations at the coating face. The mechanics of operation of the coater of the present invention thus involves supplying molten fluid to a point along the length of high speed moving filaments which draw the molten fluid across a series of projections which in turn withdraw heat from the molten fluid to form casings and which then act like dies to meter the amounts of fluid coated on the filaments.

As another successful method for starting a coating operation, the face of an applicator can be wetted out by use of a probe dipped in the coating material and wiped across the face. After the face is wet out properly with a layer of coating material, more of the coating fluid can be readily supplied thereto simply by raising the head within the applicator to cause the material to flow over the weir-like projection and across the face. After the filaments are started across the face for a coating, however, the head may then be lowered such as by removal of one or more floats provided for such purpose within the container portion, or by withdrawal of coating material with a squeeze bulb.

The thickness of metal on each of the filaments can be controlled for each given speed of a moving filament by controlling the head of coating material within the container portion. If, however, the coating material head drops an excessive amount below the weir-like projection, which with some materials amounts to, for example, $\frac{1}{2}$ " to $\frac{3}{4}$ " below the upper edge of the projection, the siphoning action over the weir from the container portion becomes irregular and provides undesirable incomplete coatings. From the point of full head level at the level of the weir-like projections to the point of irregular siphoning action, the coating thickness on the filament has been found to decrease as the head of the coating material is lowered, and in many instances the relatively thin coatings thus obtained have proven highly desirable for the purposes of protection of the filaments without damage thereto.

Figure 5 illustrates another type of applicator structure incorporating the principles of the present invention wherein the applicator 50 is heated by electrical conductors 51 embedded within its refractory container portion in which the molten coating fluid 56 is contained. The coating face in this instance is an integral part of the container portion which is supplied with coating fluid over a weir-like projection 52 from an opening 54 in the front wall portion of the container formed by an offset in the wall or a separate wall member disposed behind the front of the applicator. Such an offset wall aids in preventing excesses of coating material from being splashed to the coating face. The coating fluid

at the face of the applicator is in this instance cooled by a blower 57 disposed to provide a flow of cool gas across the face, thereby to effect the formation of tubelets 59 extending across the applicator face and through which the filaments 53 are passed while at the same time permitting the applicator to be run hotter than applicators not otherwise cooled. The face of the applicator, like that of the constructions in the previous embodiment, consists of a series of cooling and supporting projections 58 formed by serrations extending parallel to each other across the width of the applicator face. Both the face of the applicator and the coating fluid drawn thereover are cooled by the flow of gas from the blower 57 which makes possible cooling of the shells 59 in the coating zone on the face side of the applicator as well as the opposite side against which the gas is blown. Molten fluid is drawn from the container portion over the weir 52 in siphon-like fashion in a manner similar to that of the construction of Figures 1 to 3, but in addition, the fluid is drawn up through the opening 54 from the container portion. After initiation of the coating operation, the level of the fluid in the container portion may be lower than that of the tip of the weir-like projection 52 in view of the siphon-like action provided by passage of the filaments 53 across the face of the applicator.

Figure 6 is still another embodiment of the invention in which a coating applicator 60 similar to that of the first embodiment has a serrated face extending over an arcuate path across which the fibers 63 are drawn to effect a coating thereof. The degree of contact of the fibers in the coating zone can be modified in this arrangement by changing the angle of withdrawal of the coated filaments from the bottom of the applicator face. As illustrated in dotted lines, the path of withdrawal of coated filaments may be along a vertical path instead of being over an arc in full contact with the face as shown in solid lines, thereby making possible controllable variations in the degree of contact with the face. In this way, the degree of cooling of the tubelets 69 may be modified to provide the thickness of coating desired on each of the filaments. The actual construction as indicated is like that of the first embodiment and includes the container portion 62 for a molten coating fluid 66 heated by electrical conductors 61. The coating fluid 66 is drawn over a weir-like projection 64 for introduction to a zone immediately above the coating face. The coating face is formed on a face block which is insulated from the container portion by a gap 67 within which insulating material may be inserted for further isolation from the container portion while a cooling of the face block can be effected by passage of cooling fluid such as cold water through channels 65 of the face block. Projections 68 formed by serrations in the face block vary in their degree of projection in front of the applicator to form an arcuate pattern to which the fibers are desired to conform in the coating zone. Tubelets 69 are formed about the filaments and extend across the projections 68 at the coating face, matching the degree of arc to the extent determined by the angle of withdrawal of the fibers from the bottom of the face of the applicator.

In Figure 7 another applicator structure is shown having a face with serrations extending angularly or diagonally downwardly from left to right across the face of the applicator. In this arrangement, the leading edge of the face across which the fibers are drawn act as guides for groups of fibers to retain them within given zones of the coating face. In being angularly oriented, the projections 78 formed by the serrations in the face provide a zig-zag upper edge which acts as a series of adjacent V-cuts to group the fibers and fix the path over which they are drawn across the face of the applicator. The face is cooled by cooling fluid passing through chan-

nels 75 extending through the block 76 on which the face is formed and which is insulated from the container portion by a thermal gap 77. The container portion is surrounded by electrical conductors 71 through which current is passed to heat the contained fluid.

Figure 8 is still another embodiment of the invention in which the applicator construction 80 incorporates a sectionalized serrated face having parallel face projections 88 similar to those in the embodiments of Figures 1 to 3 and cooled by passage of cooling fluid through channels 85. The face is sectionalized by partition walls 83 which extend through the container portion to form separated compartments for containing the coating fluid. These walls also project through to the face to divide it into zones, each of which is supplied with coating fluid from its respective container compartment. At the upper edge of each separate zone of the applicator face, a weir-like projection 84 is provided over which the coating fluid in the respectively associated compartment is required to pass prior to introduction to the serrated face section of the zone. By such an arrangement, gaps 86 are provided between each pair of partitioned walls 83 to guide filaments over the zone between the walls.

The compartments formed by the walls extending through the container portion are made sufficiently narrow that the walls themselves act as surfaces to which the coating fluid can cling by surface tension and adhesion, thereby permitting reduction in the head of the fluid in the container portion a considerable amount more than would be possible if the container portion extended for the full width of the applicator. In other words, the surface of the coating fluid in each compartment acts in a sense as a more securely held membrane enclosing the coating fluid thereunder to enable siphoning of fluid over the weir-like projections 84. This more securely held membrane promotes a reduction in head a greater amount below the upper edge of the associated projection 84 than a membrane with less peripheral anchoring per unit of area, and correspondingly enables a wider range of coating thicknesses on the fibers coated from each of the compartments.

The gap 86 between each partitioned wall acts as a guide for one or more filaments of a subdivided group of a larger number of filaments passed over the coating face of the applicator. Suitable means are provided in the compartments to maintain their fluid levels uniform, such as by having a bank of probes each of which is associated with an individual compartment to establish a fixed level across the entire length of the applicator or by providing a small passage between adjacent passages to enable self equalization of levels.

In each of the embodiments described above it will be understood that material removed from the container portions thereof can be readily replenished by incorporation of a level seeking probe associated with automatic material supply means actuated when a signal is transmitted from the probes to call for material. In view of the many such arrangements already available in the art, it has been deemed unnecessary to show such an arrangement in the embodiments as herein disclosed.

As indicated above, the principles of the present invention are not necessarily limited to coating of individual filaments but may also be used to coat filamentous yarns and strands of filaments. In such instances, however, it is a frequent requirement that the yarns or strands which have already been formed and which were subject to the effects of uncontrolled atmosphere, first be cleaned such as by subjecting them to heat of a burner, prior to application of a coating thereto. To exemplify such arrangement, a yarn 92 is drawn from a package 91 and is drawn over an idler 93 prior to being subjected to the cleaning action of a burner 94. The heat cleaned yarn then is passed over an applicator having molten coating fluid 99 suspended in the path of the yarn above face projections 98. The molten coating fluid 96 within the applicator 90

is supplied through a channel to a slot in the applicator face to form the accumulation 99. After startup, motion of the yarn across the face of the applicator draws the fluid to the applicator face by the action of frictional forces which siphons the coating fluid to the face. The coated yarn 95 is then wound into a package 98 supported on the winding collet of a winder 100. The package is traversed by a spiral wire traverse 97 to distribute the package over the length of the tube.

Figure 10 illustrates another applicator adaptable to coating of fibers and utilizing the principles of the present invention. In the structure of this embodiment, the applicator 101 is designed for disposition immediately below a feeder or bushing from which a cone 102 of glass is attenuated into a fiber 103. The fiber is drawn across the face 107 of the coating applicator having serrations 108 which form projections in adjacent relationship with the path of the fiber 103. Molten coating material is supplied from the reservoir 106 of the applicator to the top or leading edge 104 of the applicator face from which the fiber draws to tubelet 105 extending across the applicator face. Above the reservoir 106 and in integral relationship with the immediate applicator portion of the coating unit are a pair of wing-like projections 110 which extend on opposite sides of the cone 102 and which are joined by a back structure 113 extending upwardly from the rear of the reservoir 106. This arrangement provides a zone enclosed on three sides by a shield which is made of heat-absorbing material such as copper which absorbs radiant energy from the cone 102 as well as heat transmitted thereto by conduction through the space between the cone and the surrounding structure. The reservoir portion of the applicator is heated by conduction of heat from the wings 110 downwardly into the reservoir as well as by heat radiated from the cone to the molten material contained within the reservoir. In this way the amount of heat required to be supplied to the molten material within the reservoir by electrical or other means is reduced, thereby making the heating efficiency of the applicator considerably greater as a unit in itself as well as a component forming part of the fiber-forming apparatus. An arrangement such as this, by way of example, can be constructed of cast iron or of stainless steel. When refractory material is to be used in producing a coater, as determined by the temperature characteristics and the affinity of the coating material for other materials, graphite alone or a mixture, also by way of example, of 50-50 by volume of graphite and Alundum as a core with an Alundum case cast in a mold and fired has been found successful.

The arrangements of this invention have proven particularly useful in coating metal on filamentous forms of glass which it has been found have greater abrasion resistance than bare glass fibers. It is believed that the improved abrasion resistance in metallized glass fibers occurs by reason of the higher thermo-conductivity of metal compared to glass, permitting removal of heat at a more rapid rate from zones of point contact along the length of abrading fibers. Metal-coated fibers have greater application in use by reason of such higher abrasion resistance, but in addition can be utilized advantageously in the molding of resins wherein the metal on the fibers can be inductively heated for curing or setting of the resin in which the fibers are incorporated during molding. Condensers can also be made of metallized continuous fibers such as by winding alternate layers of a stack of glass fibers with metallized glass fibers. Metallized glass fibers can also be used to reinforce hoses such as petroleum hoses, or can be used to provide anchoring zones in plastic or resin products wherein a concentrated mass of metallized fibers act as spiders in fastening zones which permit threading or more solid anchoring of bolts, screws, or other fastening devices to the product.

By way of example, glass fibers can be coated with the following compositions of metal among others which can be adapted to uses such as those expressed above:

Alloys of aluminum

- (1) 5% calcium, 95% aluminum
- (2) 5-10% zinc, 90-95% aluminum
- (3) 22% copper, 78% aluminum
- (4) 5% magnesium, 5% zinc, 90% aluminum
- (5) 20% magnesium, 10% zinc, 70% aluminum
- (6) 30% magnesium, 70% aluminum

Alloys of lead

- (1) 1 to 30% zinc, 1.5% cadmium, 68.5 to 97.5% lead
- (2) 1% zinc, 1.5% silver, 97.5% lead
- (3) .5% zinc, 5% tin, 94.5% lead
- (4) .08% copper, 99.92% lead
- (5) .05% tellurium, 99.95% lead
- (6) 7% antimony, 94% lead
- (7) 1.5% silver, 98.5% lead
- (8) 1.5% cadmium, 98.5% lead

In coating metal on the fibers at an open applicator face, controlled variation in operating conditions other than those described above can also be effected. For example, the face can be subjected to blasts of gas of controlled composition to condition the coating material as it is being coated on the fibers. Still further, the face or coated fibers can be subjected to gaseous blasts or the flame of a burner to condition the coating material or to controllably modify coating operations.

In view of the foregoing, it will be understood that while I have shown certain particular forms of my invention, I do not wish to be limited thereto specifically since many modifications may be made within the concepts of the invention, and I therefore contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

I claim:

1. The method of coating a continuous filament with heat-softenable material comprising continuously moving the filament axially, supplying molten coating material in surrounding relation with said moving filament at a given point along its path of motion, said molten material being supplied at a temperature and in a condition of fluidity such that a trailing channel of the coating material is drawn along the path of said filament by the moving filament itself, forcefully cooling said channel of material in a given zone along the path of the filament to the extent that an outer non-fluid tube-like shell of the coating material is formed for said channel, restraining said shell from movement with said filament, and regulating such cooling to maintain said shell, whereby said shell restricts the amount of fluid coating material applied to the filament in said zone and thereby to meter the quantity of said material coated on said filament.

2. The method of producing a strand of coated continuous filaments each having a coating of heat-softenable material, comprising continuously moving filaments axially along generally parallel paths, supplying molten coating material in enveloping relation with each of said filaments at given points along their paths of motion, maintaining the temperature and viscosity of the molten material at such values that each filament draws a trailing channel of the coating material along its path from its respective point of supply coating material, forcefully cooling each of said channels in a given zone to an extent such that an outer non-fluid tube-like shell of the coating material is formed for each channel, restraining said shells from movement with said filaments, regulating such cooling to maintain said shell, whereby said shells restrict the amount of fluid coating material supplied to each filament within its respective shell and thereby to meter the quantity of material coated on said filaments, and then gathering said coated filaments into a strand.

3. An applicator for coating filaments with heat-softenable material, comprising a member of high-temperature resistant material, said member having a generally vertical face portion across which filaments may be

drawn to receive a coating of said material, said face having a succession of spaced projections arranged so that each filament drawn across said face has a series of said projections extending in immediately adjacent relationship therewith, means for supplying molten coating fluid in the zone immediately adjacent said face where filaments drawn across said face pass through the coating fluid, means for maintaining the coating fluid in said zone at a temperature and viscosity such that a trailing channel of the coating fluid is drawn by each of such filaments into contact with each of the series of projections extending adjacent such filaments, and means for controllably cooling said projections to withdraw heat from said trailing channels to form stiff non-fluid shells therefor to meter the coating fluid applied to the filaments.

4. An applying unit for coating filaments with heat-softenable material comprising a face structure having a coating face across which filaments can be drawn to receive a coating of said material, said face having a succession of spaced projections formed by serrations extending generally parallel to each other in a direction transverse to the paths of filaments drawn across said face, means for supplying molten coating fluid in the zone immediately adjacent said face where filaments drawn across said face pass through the coating fluid, whereby trailing channels of the coating material are drawn by each such filament from said zone across said face projection, means for cooling said face projections and trailing channels to form non-fluid metering shells of the coating material about the respective channels.

5. An applying unit according to claim 4 wherein the cooling means comprises fluid channels in said face structure immediately behind said face and means for circulating cooling fluid through said channels in quantities to permit controllable cooling of said face projections.

6. An applying unit according to claim 4 wherein the cooling means comprises blower arranged to direct cooling gases across said face and trailing channels.

7. An applying unit for coating filaments with heat-softenable material comprising a reservoir containing coating material in molten condition, a coating face across which filaments can be drawn to receive a coating of said material, a weir disposed between said reservoir and said face over which the molten material is flowed to the leading edge of said face, said face having a series of projections formed by serrations extending generally parallel to each other in a direction transverse to the paths of filaments drawn across said face, means for axially moving filaments across said face in generally parallel relationship in paths through the molten material supplied to said leading edge, whereby trailing channels of the coating material are drawn by each such filament from said leading edge across said face projections, and means for cooling said face projections and trailing channels to form non-fluid metering shells of coating material for the respective channels drawn by each of such filaments.

8. An applying unit for coating filaments with heat-softenable material having a coating face across which filaments are drawn to receive a coating of said material, said face having a succession of spaced projections formed by serrations extending generally parallel to each other in a direction transverse to the paths of filaments drawn thereacross, means for supplying molten coating fluid in the zone immediately adjacent said face where filaments drawn across said face pass through the coating fluid whereby trailing channels of the coating material are drawn by each such filament from said zone across said face projections, means for cooling said face projections and trailing channels to form non-fluid metering shells of the coating material about the respective channels, said face having a generally arcuate profile such that said projections are arcuately oriented to define correspondingly arcuate paths for filaments drawn across said succession of projections.

9. An applying unit for coating filaments with heat-

softenable material having a coating face across which filaments are drawn to receive a coating of said material, said face having a succession of spaced projections formed by serrations extending generally parallel to each other in a direction diagonal to the paths of filaments drawn thereacross, means for supplying molten coating fluid in the zone immediately adjacent said face where filaments drawn across said face pass through the coating fluid, whereby trailing channels of the coating material are drawn by each such filament from said zone across said face projections, means for cooling said face projections and trailing channels to form non-fluid metering shells of the coating material about the respective channels.

10. An applying unit for coating filaments with heat-softenable material comprising a reservoir containing coating material in molten condition; a coating face across which filaments are drawn to receive a coating of said material; a weir disposed between said reservoir and face over which the molten material is flowed to the leading edge of said face; said reservoir, weir, and face being divided into zones by spaced wall partitions extending through said applicator in a direction generally normal to said face; each zone of said face defined by said partitions having a series of projections formed by serrations extending generally parallel to each other in a direction transverse to the paths of filaments drawn across said face; means for axially moving filaments across said face in generally parallel relationship in paths through the molten material supplied to said leading edge, whereby trailing channels of the coating material are drawn by each such filament from said leading edge across said face projections; and means for cooling said face projections and trailing channels to form non-fluid metering shells of coating material for the respective channels drawn by each of such filaments.

11. An applicator unit for coating filaments with heat-softenable material comprising a reservoir containing coating material in molten condition, a face block providing a coating face across which filaments are drawn to receive a coating of said material, said face block being thermally insulated from said reservoir and incorporating tubular channels for passage of coating fluid there-through, means for supplying molten material from said reservoir to the leading edge of said face, said face having a series of projections formed by serrations extending generally parallel to each other in a direction transverse to the paths of filaments drawn across said face, means for axially moving filaments across said face in generally parallel relationship in paths through the molten material supplied to said leading edge, whereby trailing channels of the coating material are drawn by each such filament from said leading edge across said face projections, and means for controllably circulating cooling fluid through said tubular channels to cool said face projections and trailing channels to form non-fluid metering shells of coating material for the respective channels of coating material drawn by each of such filaments.

12. An applicator unit for coating a filament of thermoplastic material with heat-softenable material comprising a reservoir containing coating material in molten condition, a coating face across which a filament can be drawn to receive a coating of said material, a molten source of thermoplastic material, means for attenuation of said thermoplastic material into a filament, thermally conductive members extending from said reservoir into close heat transfer relation with the zone of attenuation of said filament from the source of thermoplastic material, means for supplying molten coating material from said reservoir to the leading edge of said face, said face having a series of projections formed by serrations extending generally parallel to each other in a direction transverse to the path of a filament drawn across said face, means for axially moving said filament across said face in a path through the molten material supplied to said leading edge, whereby a trailing channel of the coating mate-

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rial is drawn by said filament from said leading edge
across said face projections.

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