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MOLTEN METAL APPLICATORS FOR GLASS FILAMENTS

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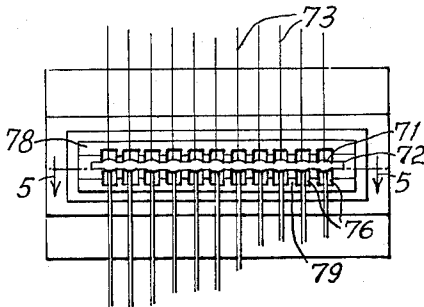


Fig. 4

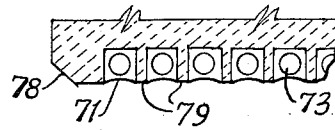


Fig. 5

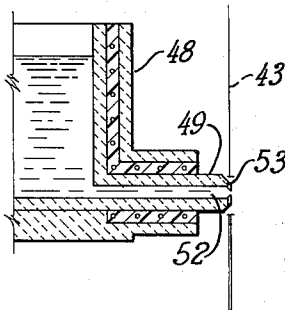


Fig. 1

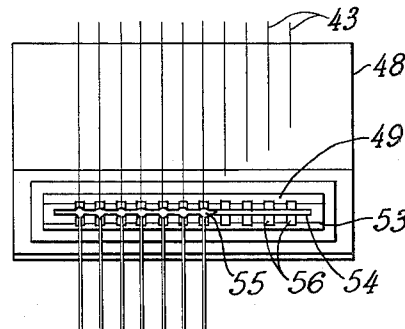


Fig. 2

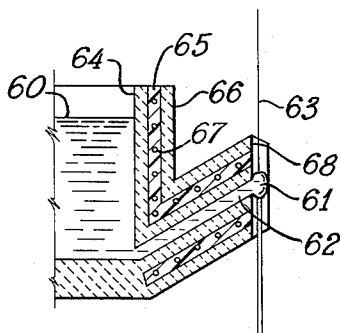


Fig. 3

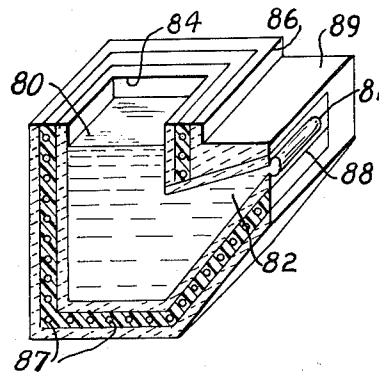


Fig. 6

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3,001,507 MOLTEN METAL APPLICATORS FOR GLASS FILAMENTS

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7 Claims. (Cl. 118—401)

This invention relates to metal coating of filaments or fibers, and more particularly to molten metal applicators for applying metal coatings to continuous glass filaments.

This application is a continuation-in-part of applications, Serial Number 319,724, filed on November 10, 1952, now Patent 2,772,518, and Serial Number 322,598, filed on November 26, 1952, now U.S. Patent No. 2,963,739, both filed in the names of the present inventors.

It is well known that glass filaments have extremely high strength characteristics as well as highly desirable flexing characteristics which make them of particular advantage for many uses and applications as reinforcing agents. Such fibers, however, have a weakness to surface abrasion which reduces their overall ability to withstand wear to the extent that it eliminates the possibility of their application for many uses in which the strength and flexibility of the filaments would be highly desirable. The coating of glass filaments with metal such as copper, zinc, aluminum, silver or alloys thereof, it has been found, is highly successful in providing protection against abrasion. Difficulty has been experienced, however, in applying the metal to such filaments at a high rate of speed and with uniformity so as to make it economically feasible to produce them in mass production.

As set out in the above mentioned copending applications, production of metal-coated glass filaments can be accomplished by passing the bare glass filaments through beads or globules of molten metal and coating by wetting each filament, to form a layer of the metal integrally associated with the glass filaments.

In the present instance it is a principal object of the invention to provide a new applicator means for applying metal to glass filaments which permits economical production of coated filaments at a high rate of speed, while at the same time providing uniformity without the need for great care and attention.

A further object of the invention is to provide applicator means for applying metal to glass filaments on a continuous basis controllable to provide a predetermined linear and peripheral uniformity of coating.

Another object of the invention is to provide applicator means for applying metal on glass filaments without disrupting or deleteriously affecting the desired physical characteristics of the filaments.

Still another object of the invention is to provide an efficient and economical applicator means for applying metal to glass filaments which readily lends itself to being adapted to conventional filament-forming means.

The application of metal to glass filaments in accordance with the above objects is accomplished in the present instance by pulling or drawing the filaments through an accumulation of molten metal such as a globule or bead of such metal. In particular, the apparatus is arranged so as to permit drawing of filaments through such metal in vertical paths which facilitates adapting such coating operations to conventional filament-forming means.

To accomplish this result, it has been found that a quantity of molten metal may be suspended without undersupport by allowing it to project from an orifice in a substantially vertical applicator face, thus providing an unobstructed path above and below such metal for free passage of filaments through the metal. By making the

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orifice small, such as a thin slot, the molten metal supplied thereto can project outwardly and overhang the edge of the slot to envelop the filaments at the applicator face without freely flowing because of the restriction to flow offered by the surface tension of the metal or its oxide. With a small orifice, the quantity of metal projecting therefrom can also be made independent of changes in pressure of the fluid over a range of heads within the limits of size of the container portion holding the molten metal.

A feature of the invention is that it permits the application of metal coatings to glass fibers at a very rapid rate.

Another feature lies in the fact that this invention is readily adapted to permitting application of metal coatings to glass filaments during their forming process.

Still another feature of the invention lies in the fact that metal may be controllably fed from a common source of supply to a multiplicity of filaments simultaneously with but a limited amount of care being required to effect the desired degree of coating.

A further feature of the invention is that the care and attention to operation required to produce metal-coated filaments in mass production are reduced to the extent that a greater degree of concentration may be directed to other factors of quality control.

Other objects and features which we believe to be characteristic of our invention are set forth with particularity in the appended claims. Our 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 partly broken away side-elevational view in cross section of a metal applicator comprising an embodiment of the present invention;

FIGURE 2 is a front-elevational view in part of the metal applicator of the invention shown in FIGURE 1 in which grooves are provided in the slotted applicator face;

FIGURE 3 is a cross-sectional side elevational view of a portion of another metal applicator unit in which the metal outlet portion is upwardly inclined;

FIGURE 4 is an enlarged view of the face of the metal applicator unit of FIGURE 3 showing the closely spaced filament grooves incorporated therein;

FIGURE 5 is a view of the face of the applicator unit of FIGURE 4 as taken on line 5—5; and

FIGURE 6 is a cross sectional perspective view of another metal applicator unit embodying the principles of the present invention.

Turning to the drawings in greater detail, FIGURES 1 and 2 show a slotted applicator 48 having vertical grooves 56 disposed in the face 53 to accommodate the filaments passed over the face to permit them to pass through the base of the longitudinal globule 55 emitted from the slot 54. The slot 54 extends across the width of the face and has the grooves 56 cutting thereacross at right angles. In this arrangement the slot portions between grooves 56 offer a partial and augmenting support for the longitudinal globule 55 in such cases where the temperatures of the metal are so high as to provide a limited amount of surface tension for support of the globules. The structure made in this manner, provides unobstructed filament paths over the face 53 through the grooves 56 and additionally eliminates the need for projection of the globule beyond the extremities of the face 53 in view of the fact that on passage through the grooves the filaments will pass through the metal emerging from the slot.

In the applicators made in accordance with the present

invention, the material contacted by the molten metal contained and supplied to the filaments is preferably of a type which is non-wettable by the molten metal. In particular, it is preferable that the face and channel or passage from which the metal is emitted be of material such as carbon or graphite which, in general, is not wettable by metal. With such an arrangement, the metal emitted from the orifice will not tend to clog in the channel nor flowingly spread over the face, but rather, will assume a configuration determined by the shape of the orifice from which it is emitted. The accumulation of metal thus emerging from the orifice additionally can be made to assure a globular form projecting beyond the applicator orifice boundaries.

A filament being formed can be passed through such a globule without displacing the globule from its position at the end of the passage, and as the filament passes through the globule, a coating of metal is imparted thereto. In the case of oxidizable metals, a film of oxide may form over the globule supported at the orifice which, in effect, forms a shell with the filament passing into and out of the shell and picking up metal while in the shell. As the metal is removed from the inside of the shell, additional metal flows into the shell to replace the metal that has been taken out by the coated filament.

In the use of materials such as carbon and graphite which generally will not become wet out by molten metals, it has been found that while the metals will not readily wet out over the surface of the material, the metal may be swaged or worked into solid clinging relationship with the non-wettable material such as with a wire brush to promote formation of an oxide film of the metal over predetermined areas of the face over which the fresh molten metal will readily flow. This property can be advantageously utilized in operation of applicator units of the present invention to cause globular accumulations of metal of most desirable configuration for fiber envelopment to be projected from the face of the applicator.

FIGURES 3, 4 and 5 show a metal applicator in which these properties are further utilized to advantage. Metal 60 contained within the applicator unit is fed to the face 68 through an upwardly sloping channel 62 to form a globular accumulation of molten metal 61 projecting from the face for envelopment of filaments 63 passed therethrough. The interior 64 of the container portion of the applicator unit is made of heat-resistant materials capable of withstanding the temperatures of the molten metal contained, while the exterior may be a different refractory material 66, if desired. Between the interior and exterior materials of the unit, heater elements 67 are embedded within a high temperature material and provide the heat for melting and retaining the metal 60 in molten condition.

The face 68 of the applicator unit is constructed so that the orifice at the end of channel 62 is bounded by material such as graphite which is relatively non-wettable by molten metal. Thus, on emergence from the orifice, the metal 61 will not of itself tend to cling to the boundaries of the orifice, but rather will remain self-contained and supported by its own surface tension. If desired, however, the edges of the orifice may be swaged to provide an oxide film within desired boundaries of the orifice edge over which the molten metal may flow to form a slightly larger globule and a clinging relationship of the molten metal to the orifice edges. The channel 62 is also preferably of non-wettable material so that tendencies toward formation and collection of oxide within the channel are minimized to the extent that difficulty from clogging by oxide formations is eliminated.

Experience with applicator units of this type indicates that the metal in the channel 62 is raised in the channel 62 to the level of the globule 61 by suction action which minimizes the dependence of metal emission from the orifice on the head of the metal 60 in the container portion of the unit. While not fully understood, the suction

or siphon-like action which causes the metal to be brought to the level of the globule 61 has been shown to be directly associated with the motion of the filament through the globule. In observing the dynamic action closely, it is seen that as the filaments pass through the globular accumulation, the wetting and coating of the glass surfaces causes a removal of metal from the globule which, it is postulated, forms a low pressure space within the globule and which is automatically replenished by molten metal drawn up through the channel 62 because of the low pressure condition. Removal of the molten metal from the globule appears to be caused by affinity of the metal for glass as well as by the interfacial friction between the moving filament and the metal through which it passes. The coating and replenishment of metal in the globule 61 also appears to be associated with the thermodynamic relationship of the molten metal in the globule and the hot filament passed therethrough. In this respect, the gradual change in temperature of the molten metal on emergence from the orifice seems to cause a greater adhesion of the metal to the glass by reason of greater viscosity.

Although the pressure head of metal according to the present invention is made to be less of a factor affecting stability of the globule, it has been found that for any given set of dynamic conditions of operation of the unit in applying metal to the moving filaments, the pressure head of the metal in the reservoir portion of the applicator can be utilized to determine or regulate the rate at which the metal flows to the globular accumulation. A wide range of heads may be utilized to control the thickness of metal applied and may range from a positive head for thick coatings to a negative head for thin coatings substantially without effect on the stability and effectiveness of the globule to provide the uniformity of coating desired. In many instances it has been found desirable to operate with a negative pressure head to produce thin coatings. Under such circumstances, coating operations are first initiated by application of a positive pressure to get the molten metal to the orifice and then to reduce the pressure to that for the desired coating after the operation is started.

FIGURES 4 and 5 show in greater detail the recesses or grooves 76 in the face 78 within which the filaments are guided and coated. The grooves are made wide enough to accommodate filaments 73 to pass therethrough but narrow enough that the metal emitted from the slot orifice 72 is permitted to project from the orifice and establish a bridging relationship under its own surface tension between the faces of the groove spacing projections 79. The width of the projections 79 is made sufficiently narrow that a maximum number of grooves may be formed in the face 78, but are made wide enough that a swaging of the face of the projections may be effected so that an oxide will form on the face of the separator portions to which the metal emitted from the slot orifice may cling. The metal is thus made to cling in bridging relationship between the faces of the projections 79 and to fill in the space of the grooves on emergence from the slot orifice. The metal emitted from the channel 62 is thereby caused to reach out to the front of the projections 79 and be retained in a stable condition over a still wider range of pressure heads exerted by the fluid in the container portion of the applicator.

The metal oxide on the face of the projections 79 in providing the clinging area for the molten accumulation, keeps the metal from falling back down the channel leading to the slot orifice 72. Metal oxide which can be made to form by swaging molten metal into the grooves at the points of emergence from the slot orifice is also an advantage in providing a film to cover the graphite over which the glass filaments ride. It has been found that although graphite is a material which has a low abrasion or wear action on glass filaments, an oxide of the metal to be coated on the filaments will act as a base

over which the molten metal can flow to permit the fluid metal to act as a lubricant for the glass filaments and thus further reduce the abrasive action on the filaments. The low abrasion material such as graphite, however, is still preferred as a backing material regardless of the lower abrasiveness possible with the presence of the oxide of the metal, because of conditions which might arise where the molten metal layer would break down and the glass filaments caused to make direct contact with the face of the applicator.

FIGURE 6 illustrates the principles of operation of another form of applicator unit in which the molten metal 80 heated by electrical heater elements 87 is supplied through a wide channel 82 which diminishes in size to the limits of a narrow slot orifice in the face 88 of the unit. The channel 82 slopes upwardly to the orifice which is located so that the globular accumulation 81 projected therefrom is conveniently located for passage of filaments therethrough.

The interior of the channel 82 is lined with difficult-to-wet or non-wettable material such as the graphite of the previous embodiments, while the interior 84 of the container portion of the applicator unit may be of refractory or other heat-resistant material capable of mechanically withstanding the temperature of the molten metal. The exterior 86 may be still another suitable refractory material, if desired. By aligning the interior of the channel 82 with non-wettable material, the formation of oxide on the interior surface is minimized, and by making the bottom portion of the channel wider, a clogging within the longitudinal portion thereof is made practically impossible.

The wide channel is provided without acting as a deterrent to the suction action effected by the filament motion through the globular accumulation 81 by reason of the fact that the hydrostatic relationship to draw the metal through the channel is primarily established at the slot orifice of narrow dimension. The space between the front vertical wall of the container portion of the applicator and the upwardly sloping upper portion of the channel 82 is filled in with heating-conductive refractory material 89 to further enhance the efficiency of thermal conditions established in the unit. The heat, rather than being dissipated from the exterior of the vertical wall above the channel 82, thus is instead transferred and retained within the unit by minimizing the exposed surface area of the unit. Heat transfer from the body of the metal is retained in the container portion to maintain the upper portion of the channel 82 at a higher temperature so that the molten metal as it passes through the channel 82 is maintained in a more fluid condition than if the upper portion of the channel were more freely exposed for dissipation of heat.

As an example of the increase in efficiency of heating the molten metal within the channel 82, zinc which was originally required to be raised to a temperature of about 975° F. within the container portion of the applicator unit for a bead or globule 81 at 820° F., in the instant embodiment need only be heated to a value of about 920° F. to provide a globule of molten metal at the same temperature.

Although the apparatus and method herein shown and described are illustrated in connection with collection of coated filaments in strand form, it will be readily recognized that the nature of the invention is such that the filaments may also be collected individually for applications where conditions dictate the need for single metal coated filaments.

Various metals and alloys of metal may be applied to the glass fibers according to the present invention. Metals such as aluminum antimony, cadmium, cobalt, chromium, copper, nickel, silver, tin or alloys may be applied. In the latter respect alloys such as zinc-titanium, lead-zinc, tin-lead, brass, bronze and others can also be applied.

Different kinds of glasses may be employed to form

the filaments, for instance, calcium borosilicate glasses. Also glasses of selected composition may be used to facilitate the coating and adherence of the metal to the glass filament surface. A suitable glass may contain:

	Percent
SiO ₂ -----	45.0-65.0
Al ₂ O ₃ -----	4.0-17.0
B ₂ O ₃ -----	2.0-13.0
CaO -----	3.0-18.0
Na ₂ O -----	0.2-15.0

and including from 4 to 15% by weight of an oxide of a metal from the group including copper, zinc, lead, tin, aluminum, silver and titanium.

More particularly the glass from which the filaments are formed may comprise:

	Percent
SiO ₂ -----	53.0-59.0
Al ₂ O ₃ -----	5.0-16.0
CaO -----	5.0-12.0
B ₂ O ₃ -----	3.5-10.5
Na ₂ O -----	0.2-3.0
CuO -----	5.0-12.0

The temperature of the metal as it is coated onto the glass filaments will vary with the kind of metal being used. However, by adjusting the point at which the applicator for the metal contacts the filament being formed, it is possible to regulate the relation of the temperatures of the cooling glass filament and molten metal at the point at which they come into contact.

Modifications in operation, such as operation of the applicator units with their faces in the vicinity of a synthesized atmosphere, may also be effected to produce optimum coating properties. For example, it has been found that operation of the units with the points of application in a synthesized atmosphere of somewhat less than 20% oxygen but not completely devoid of oxygen produces coatings of high quality and uniformity.

Metal coated glass in the form of fibers, strands, yarns and the like produced by the apparatus of the invention may be used in many products including the following: decorative fabrics, tapes, fishing lines, awnings, upholstery material, roofs, reinforced resins, movie screens, clothing, clutch facings; reinforcing cords for rubber products including tires, garden hose, fire hose, conveyor belts, blankets, fan belts, motor belts, erasers, rug padding, gloves; oxidizable material in flash bulbs; conductors for electrical circuits in radio, television and other electronic equipment; radiation shields, protective wrappings in the form of foil or fabric, laminated products comprising thin foils of glass and metal, heating elements, resinous table tops and the like; reinforcement of metal products and carbon products such as motor brushes, and many more.

While we have shown certain particular forms of our invention, it will be understood that we do not wish to be limited thereto since many modifications may be made within the concept of the invention, and we, therefore, contemplate by the appended claims to cover all such modifications which fall within the true spirit and scope of our invention.

We claim:

1. An applicator for coating glass fibers or the like with metal comprising a generally vertical surface forming a face across which fibers to be coated are drawn, said face having an orifice comprising a longitudinal slot from which molten metal is supplied in horizontally projecting relation for coating of fibers drawn across said face, a supply channel leading to said orifice through which said molten metal is fed, said supply channel being inclined upwardly toward said orifice, said channel having interior surfaces of material substantially non-wettable by said metal whereby tendencies for compounds of said metal to form on said surfaces are reduced.

2. An applicator for coating glass fibers or the like

with metal comprising a generally vertical surface forming a face across which fibers to be coated are drawn, said face having an orifice from which molten metal is supplied for coating of fibers, a supply channel leading to said orifice through which said molten metal is fed having interior surfaces of material substantially non-wettable by said metal, said supply channel being inclined upwardly toward said orifice, said supply channel having a larger cross-sectional area than said orifice at a distance along its length away from said orifice and gradually diminishing in cross-sectional area on approach toward said orifice to a size such that the surface tension of molten metal issuing from said orifice is of magnitude sufficient to block the free flow of metal from said face but permits the metal to assume a projected globular form to cause envelopment of the fiber portions drawn across said face.

3. An applicator for coating glass fibers or the like with metal comprising a surface forming a face across which fibers are drawn for a coating, said face having a longitudinal slot therein from which molten metal is supplied for coating the fibers, said slot having a sufficiently small dimension transverse to its longitudinal dimension such that the fluid coating material issuing therefrom is blocked from freely flowing from said face by its own surface tension, said face having fiber-accommodating grooves therein having a generally right-angular orientation with respect to said slot, said slot and grooves being bounded and defined by material which is substantially non-wettable by said metal.

4. An applicator for coating glass fibers or the like with metal comprising a surface forming a face across which fibers are drawn for a coating, said face having a longitudinal slot therein from which molten metal is supplied for coating the fibers, said face having fiber-accommodating grooves generally oriented at right angles to said slot, the projecting portions of said face between adjacent grooves being surfaced with material which is substantially wettable by said molten metal, whereby said molten metal is retained in said grooves influenced by establishment of a clinging relation with said projecting face portions.

5. An applicator for coating glass fibers or the like with metal comprising a surface forming a face across which fibers are drawn for a coating, said face having a longitudinal slot therein from which molten metal is supplied for coating the fibers, said face having fiber-accommodating grooves generally oriented at right angles to said slot, said grooves being wide enough to accommodate individual fibers passed therethrough, the projecting portions of said face between adjacent grooves being surfaced with material which is substantially wettable by said molten metal, said grooves being sufficiently narrow that molten metal emitted from said slot will bridge the individual grooves in clinging relation with said projecting portions of said face, whereby fiber portions residing in said

grooves on passage therethrough are fully enveloped by said molten metal to impart a coating to the fibers.

6. An applicator for coating glass fibers or the like with molten material comprising a reservoir portion for material in molten condition, a surface providing a fiber-coating face across which fibers to be coated are drawn, said face having an orifice from which the molten material is supplied for coating of fibers, a supply channel extending between said reservoir portion and said orifice, said supply channel being inclined in generally acute angular relationship from a side of said reservoir portion to said orifice, the portion of said applicator within the acute angle defined by the side of said reservoir portion and said supply channel being composed of solid matter conducive to conductive transfer of heat to said channel, whereby the heat of the molten material contained in said reservoir aids in maintaining a high temperature of material passed through said supply channel.

7. An applicator for coating glass fibers or the like with metal comprising a reservoir portion for metal in molten condition, a generally vertical surface providing a fiber-coating face across which fibers are drawn for a coating, said face having an orifice from which the molten metal is supplied for coating of fibers, a supply channel extending between said reservoir portion and said orifice, said supply channel being inclined in generally acute angular relationship from a side of said reservoir portion to said orifice and having interior surfaces of material substantially non-wettable by said metal, the portion of said applicator within the acute angle defined by the side of said reservoir portion and said supply channel being composed of solid matter conducive to conductive transfer of heat to said channel, the inlet portion of said supply channel at the end nearest said reservoir portion being generally greater in cross-sectional area than said orifice, said channel diminishing in cross-sectional area on approach to said orifice to a size such that the surface tension of molten metal issuing from said orifice is of magnitude sufficient to block the free flow of metal from said face but permits the metal to assume a projected globular form to cause envelopment of the fiber portions drawn across said face.

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