

[54] **PROCESS OF CASTING FILAMENT**

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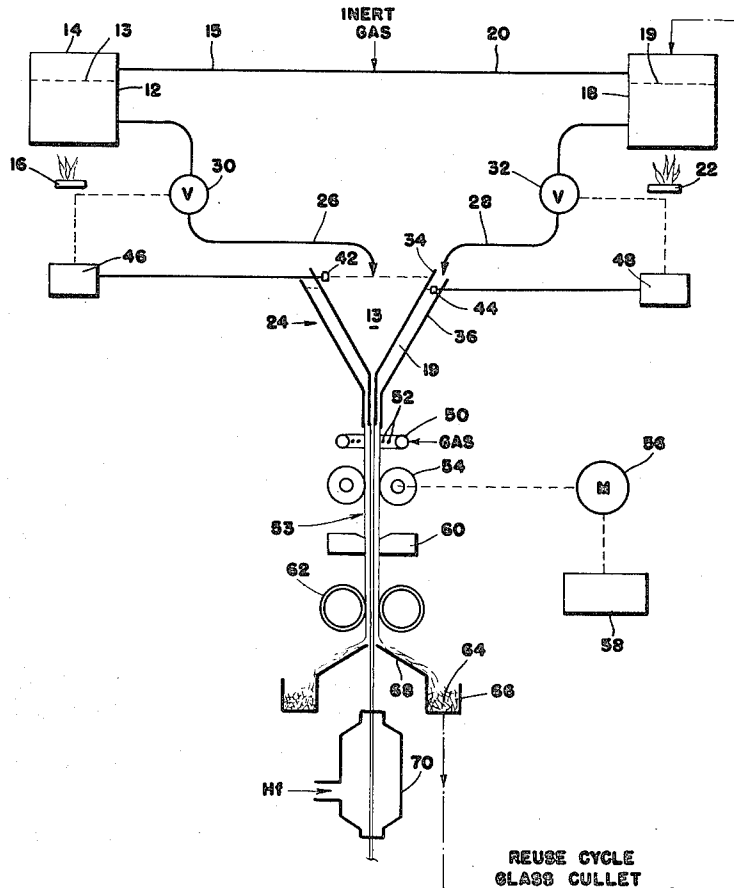
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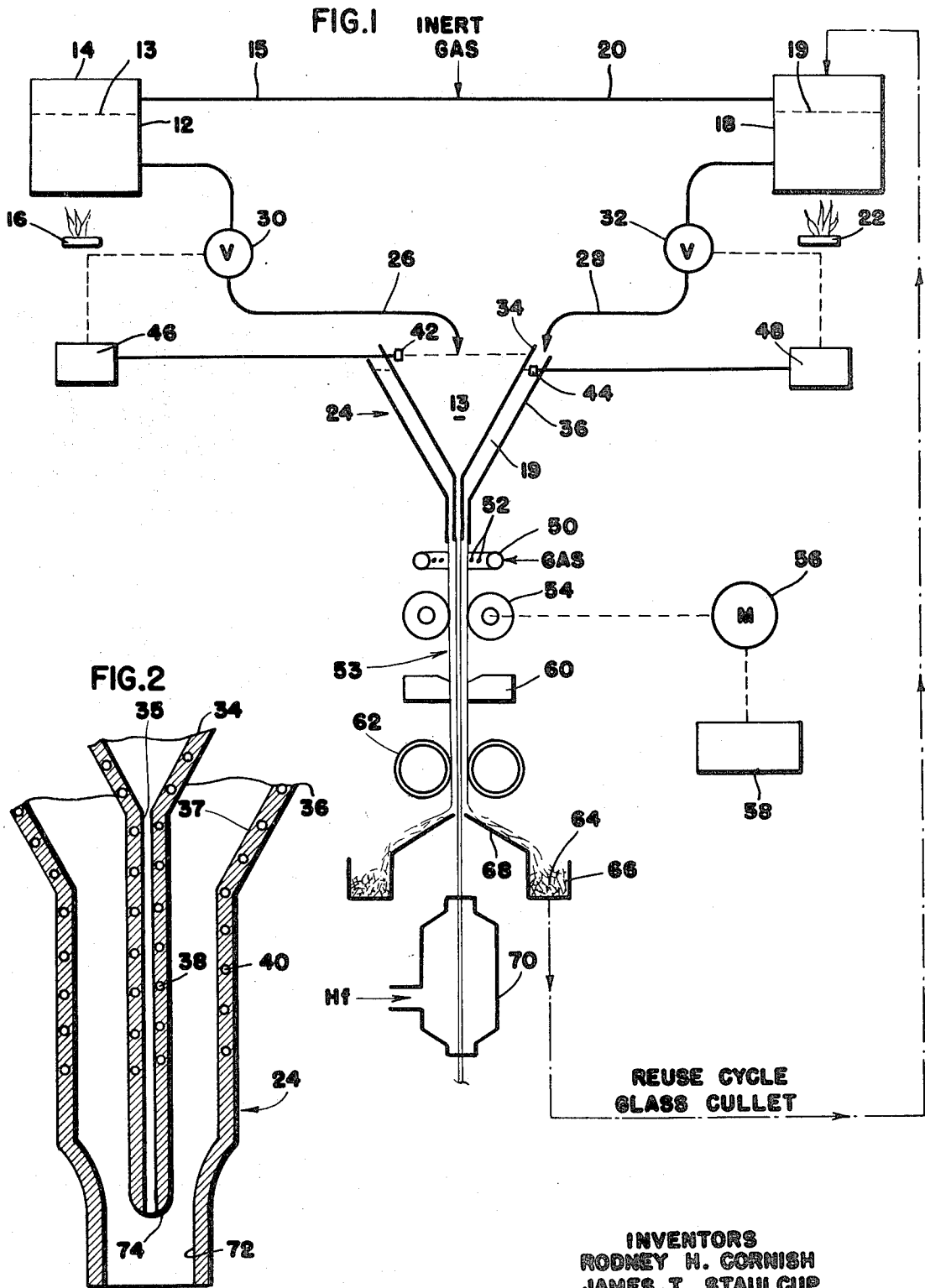
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[57] **ABSTRACT**

A process and apparatus for producing metal filament directly from the molten state employing molten glass as a movable mold. The molten glass and metal flow in the same direction through a concentric housing and exit at the same velocity. The glass surrounds the metal and both materials solidify. The apparatus includes a stripping mechanism for removing the glass from the surface of the solidified metal.

7 Claims, 2 Drawing Figures





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PROCESS OF CASTING FILAMENT

The present invention relates to the forming of metallic filaments. More particularly it is directed to a method and apparatus for forming continuous metallic filaments of small and large diameter by casting directly from the molten state without the need for a mechanical drawing operation.

Although the method and apparatus disclosed and claimed herein also finds application in the continuous formation of what is commonly called wire, they find particular application in the field of filament forming. The dividing line between wire and filament is not a clear one; however, for purposes of the present invention a filament will be defined as wire of any diameter, including diameters smaller than can be achieved conveniently by conventional wire forming methods. In addition to circular cross sections the present invention is also adaptable to the formation of noncircular cross sections without departing from the scope of the invention.

Conventional wire forming involves the mechanical elongation and reduction of an ingot or rod. The reduction in diameter is accomplished in steps by swaging, rolling and drawing processes. The ingot or rod is initially reduced to wire size by swaging or rolling at an elevated temperature. The wire is then pulled, either heated or at ambient temperature through a sequence of successively smaller dies each of which causes plastic deformation of the metal. Because of the substantial deformation the wire becomes strain hardened and requires annealing steps between drawing steps. When it is desired to form wire of only a few thousandths of an inch or a few microns in diameter, the conventional wire forming steps of drawing and annealing are no longer satisfactory. The smaller diameter wire becomes too delicate for drawing and the strain hardening results in embrittlement of the filament.

It has long been recognized in the art that mechanical forming of small diameter filament has serious limitations. Many attempts have been made to devise methods of forming filament of uniform small diameter directly from the molten state. The methods employed include hot extrusion from nozzles such as the Pond process disclosed in U.S. Pat. No. 2,825,108; the Taylor process disclosed in U.S. Pat. No. 1,793,529, involving melting a charge of metal in a softened glass envelope and drawing the softened glass to form a finite metal fiber within the glass envelope; and processes involving the insertion of a rod into a glass tube followed by heating and drawing the rod and tube. None of the above methods has proven satisfactory for the formation of continuous filament. The Taylor process, while forming the most uniform filament is a batch process not easily adaptable to continuous formation.

Still another method of forming filament continuously and in a movable mold is disclosed in U.S. Pat. No. 3,347,959, to Engelke et al. Engelke et al. discloses the forming of filament from a molten metal with high velocity molten salt as a surface tension controller and drawing the wire to a smaller diameter before it solidifies employing the frictional drag of the high velocity salt as a drawing force. The method of Engelke requires that many critical parameters must be held constant. Otherwise the filament diameter will vary with the velocity differential causing separations or enlarged areas in the filament. Also it is neither a drawing operation nor a casting operation as it reduces the diameter of the metal after contact with the molten salt which never solidifies.

Accordingly, there remains in the industry the need for a practical, economical and efficient way of forming continuous small diameter filament.

An object of the present invention is to provide a method and apparatus suitable for the continuous formation of filament.

Other objects of the present invention will become evident in connection with the following description and the drawings in which:

FIG. 1 is a schematic of one embodiment of an apparatus of the invention; and

FIG. 2 is a partial sectional view of one embodiment of a concentric housing suitable for use in the present invention.

Briefly, the present invention involves a method and apparatus for casting metal filaments in a continuous fashion employing molten glass as a movable mold. Molten metal and molten glass are provided in separate containers which each include a heater for maintaining the respective material in the molten state. The materials are fed simultaneously through separate conduits to a concentric bore housing. They flow through the housing simultaneously and still in the molten state, the metal through a central cylindrical passage in the form of a solid cylinder and the glass through a concentric outer passage of the housing in the form of a hollow tubular cylinder. As the materials emerge from the lower ends of the concentric passages they are flowing in the same vertical direction and the velocities are controlled so that they are flowing at the same velocity. At this point the glass makes surrounding contact with the molten metal. After a controlled period of free attenuation in either ambient air or a primary cooling flow, a final cooling or quenching fluid is applied to the outer surface of the glass in order to solidify it. Solidification is followed by contact with a pair of regulator rollers or a capstan which regulates the speed of movement of the now solidified filament away from the housing. After moving through the regulator rollers the entire filament, both metal core and glass coating, has solidified.

Subsequent to movement through the feeding roller the optional step of stripping the glass away from the metal filament leaving an uninsulated metal filament may be performed. Alternatively, the glass layer may be left on the filament for insulation. In the embodiment illustrated, the stripping of the glass from the metal filament is accomplished by means of a scribing die followed by a fracturing of the scribed glass by a pair of stripping rollers. Finally the metal filament is passed through an etching bath to remove any remaining particles of glass which may adhere to the filament. The scrap glass which is stripped from the surface of the filament is collected and remelted for use in the manufacture of additional filament. For the sake of convenience certain portions of the following description will refer to a portion of the apparatus as being directly above or below another. It is to be understood that such terminology is descriptive of the illustrated embodiment of the apparatus and is not to be construed by way of limitation of the invention disclosed.

Referring specifically to the schematic diagram set forth in FIG. 1 of the drawings, one embodiment of the apparatus of the present invention is illustrated. A supply container 12 is provided for melting and holding molten metal 13 prior to supplying it to the remainder of the apparatus. The container 12 may be of any suitable configuration and, as illustrated, is covered at its top 14 to limit the amount of oxidation which occurs on the surface of the molten metal. In addition to retarding the oxidation on the surface by covering the container, inert gas may be pumped in through a conduit 15 as illustrated schematically to reduce further the chance of oxidation on the surface of the molten metal. The container may be made of any suitable material which can withstand the temperature of the particular metal which is to be contained in a molten state. Examples of suitable materials are refractory metals and ceramics. Heat is supplied to the container by means of a suitable heater 16. The chief requirement of the heater is that it generate sufficient heat to melt the volume of metal which the container holds and maintain it at the desired temperature. While the heater 16 is illustrated as a flame-type heater positioned below the container, it is also possible to heat the metal by other means such as induction coils surrounding the container.

A second supply container 18 is provided for the molten glass 19. The shape of this container is also a matter of choice, and the volume should be somewhat larger than the volume of the container for the molten metal since, as will be explained more fully hereinafter, the volume of glass used in the formation of filament will normally be higher than the volume of metal used. The glass container 18 may also be made of any suitable material capable of withstanding the temperatures

required to maintain the particular glass employed in a molten state. Although the glass container is also provided with an inert gas atmosphere by means of a conduit 20 to retard oxidation, the oxidation of the glass is not as likely to be as important as the oxidation of the metal. The glass container is also provided with a suitable heater 22 positioned adjacent to the bottom wall of the container, and capable of generating sufficient heat to maintain the glass in the tank in a molten state and at the desired working temperature.

The molten metal is fed from its supply container 12 to a concentric housing 24 by means of a conduit 26 which is shown attached to the lower side wall of the container 12. The conduit permits either gravity or pressure flow of the molten metal into the concentric housing. The glass is provided with a conduit 28 for guiding it to the concentric housing 24 from the glass container 18. The glass conduit is similarly affixed to the lower side wall of the glass container. Each conduit is provided with a flow control valve 30, 32 for regulating the amount of molten material flowing from the respective containers to the concentric housing 24. The concentric housing 24 itself is illustrated in the form of a concentric bushing (FIG. 2). It is provided with a first central wall 34 which is, in the illustrated embodiment, of a tapering, generally tubular configuration. The inner surface of the central wall 34 defines a funnel shaped cylindrical passage 35 of varying diameter having an inlet end and an outlet end through which the molten metal flows. Surrounding the abovementioned wall and concentric therewith is a second wall 36 which is of larger diameter and follows generally the same contours as the first wall described. The space between the outer surface of the central wall 34 and the inner surface of the second wall 36 defines a tubular passage 37 having an inlet end and an outlet end through which the glass flows during the formation of filament. The tapering from a larger diameter to a smaller, uniform diameter as illustrated in FIGS. 1 and 2 is provided so that a large volume of liquid is present in both the metal and the glass relative to the flow volumes to provide more stable conditions and a more uniform flow through the concentric housing. Both walls of the concentric housing 24 as illustrated have coils 38, 40, connected to a suitable adjustable power source, not shown, embedded in them for separately providing additional heat to the respective molten materials as they pass through the housing. The chief value of the coils lies in the fine relative temperature control which can be maintained between the molten metal and the molten glass during the formation of the filament, as will be explained more clearly in connection with the process hereinafter. The material for the concentric housing is preferably a non-reactive high-temperature material. Refractory glasses, metals or ceramic materials may be employed. The chief requirements of the material are high temperature stability and insolubility in molten glass.

As stated earlier, the walls of the concentric housing 24 taper down in the direction of the flow of molten material until the internal diameter of the central passage 35 for the metal is the diameter which is required for forming a particular filament size desired and the inner surface of the outer wall 36 and consequently the outer diameter of the tubular passage 37 through which the glass flows is reduced until it reaches the diameter necessary to produce the desired outer diameter for the glass coating. It should be pointed out, however, that the internal diameters of the two passages of the housing may well be larger than the respective diameters of the metal and glass produced. This phenomenon is due to a small amount of attenuation which occurs as the molten materials leave the housing.

The velocity of the two molten materials as they flow through the concentric housing can be controlled by means of several different control systems. In the illustrated embodiment a constant level control is provided in each passage of the concentric housing 24 to sense and maintain the level of the molten liquid in the respective passages at the desired level to promote exit velocities of the respective materials from the concentric housing which are equal. Although the constant

level might be maintained by visual inspection and manual control, it is preferred that it be accomplished automatically. The actual level sensing device may take many forms such as commercially available floats 42, 44 in each liquid which emit electrical signals upon reaching either of two preset limits on opposite sides of the desired level indicated by the dash line. The signal is relayed to a servomechanism 46, 48 which responds by automatically adjusting the control valve situated in the respective conduit coming from the supply container. All of the foregoing automation is within the skill of the art and forms no part of the present invention.

A gas-quenching mechanism is provided in the form of a ring 50 having openings 52 directed radially inwardly around its periphery so that jets of gas can be directed toward the filament 53 as it exits from the cylindrical housing 24. The ring is placed in surrounding relationship to the emerging filament and is positioned just below the exit of the concentric housing. The ring is connected to a source of pressurized air or other gas such as nitrogen which is blown onto the outer surface of the glass 19 to assist in solidification of the glass as it emerges from the concentric housing. It is also possible to provide a series of vertically aligned rings having separate gas sources to provide sequential cooling as the filament moves downwardly.

A pair of regulator rollers 54 is positioned directly below the cooling ring 50 and adapted to frictionally engage the sides of the solidified glass. In the illustrated embodiment, one of the regulator rollers is connected to a motor 56 shown schematically in FIG. 1. The motor is in turn connected to an electric power source (not shown) and to a control circuit 58. The motor causes the regulator rollers to rotate while frictionally engaging the outer surface of the solidified glass at a speed which just maintains the downward velocity of the emerging solidified filament 53 at the same velocity as the exit velocity of the metal 13 and the glass 19 from the respective passages in the concentric housing. Depending on the particular circumstances, therefore, the control circuit 58 may cause the regulating rollers 54 to exert a pulling force or alternatively a retarding action on the outer surface of the formed filament. The control circuit forms no part of the present invention and is within the skill of the art.

In the illustrated embodiment, the apparatus further includes a scribing die 60 positioned just below the regulator rollers to score the glass coating to facilitate removal of the glass, yielding a finished metal filament in uninsulated form. The scribing die takes the form of a metal ring having a central annular opening just larger than the size of the coated filament. The inner edge of the periphery of the central opening of the scribing die is provided with one or more projections made of carbide or diamond sharpened to score the outer surface of the glass as it passes. After the glass has been scored, a pair of stripping rollers 62 is provided which contact the sides of the scored glass in a squeezing action. The stripping rollers are provided with a roughened surface to facilitate the crushing of the scored glass into small pieces 64. The small pieces of glass are broken away from the outer surface of the metal filament and fall into a glass cullet collector 66. The cullet collector 66 is in the form of a pan surrounding the path of the filament and includes deflecting vanes 68 which cause the glass from the filament to fall into the cullet collector. The cullet collector is provided with a reuse cycle so that the same glass may be employed in the formation of additional filament. This reuse cycle may take many forms and is illustrated only schematically in the drawing. One embodiment of a reuse cycling means is in the form of a conveyor which receives the glass cullet 64 from the cullet collector 66 and conveys it back with an exit dumping the glass cullet into the top of the glass container 18 described earlier. The glass is then remelted by the heat from the heater 22 described earlier and is reused.

The apparatus further includes an etching bath in the form of a hollow tank 70 through which the metal filament passes after having been cleaned of the majority of the glass coating. The etching bath is provided by circulation of a hydrofluoric acid spray within the hollow tank which attacks the glass

remaining on the surface of the filament. After leaving the etching bath, additional operations may be performed such as size control and a coiling operation. These, however, form no part of the present invention and are not illustrated.

In addition, it should be obvious that if it is desired to retain an insulating coating on the metallic filament as formed, the apparatus described above beginning with the scribing die and concluding with the etching bath can be eliminated and the resulting filament coated with glass can be coiled directly from the regulators rollers. If desired the etching step may be retained to enhance the strength of the glass coating.

A greater understanding of the specific parameters and functions of the various pieces of apparatus described hereinabove will be facilitated by the following description of the process of the present invention. The molten metal 13, which may be of any desired composition, is placed in the molten metal container 12 and is heated until it exceeds its melting point and becomes liquid. The heat is then adjusted to maintain the molten metal at a constant temperature substantially above the melting point. At the same time, glass cullet is placed in the glass container 18 referred to above and is heated above its softening point. When the molten metal 12 and the molten glass 19 have reached an equilibrium state at the desired temperatures the control valves 30, 32 from the respective containers to the concentric housing 24 are opened. The glass and the molten metal flow through gravity feed or pressure feed to the concentric housing.

There is some heat loss involved during this flow resulting in a lower temperature of both materials at the time they reach the inlet of the concentric housing 24. It is in part due to this heat loss that both the glass and metal are maintained in the containers at temperatures above their respective softening and melting points. The heat losses can, of course, be reduced by insulating the conduits 26, 28 properly and may be eliminated by heating the conduits. In this connection it should be noted that one of the primary advantages of the present system over the prior art methods is the ability to introduce the molten metal 13 and the molten glass 19 into the concentric bushing 24 at different temperatures due to the fact that they are separately heated and melted rather than in the form of a tube and rod or tube and pieces of metal wherein the heat is of necessity applied equally to both materials in order to effect melting. An advantage derived from the separate melting lies in the ability of the present invention to utilize a low temperature melting, and therefore less expensive, glass such as pyrex for the coating material.

As stated above the two materials are introduced into the inlet end of the concentric housing simultaneously. The metal employed may be of any composition, including but not limited to, typical electrical conducting metals such as copper and aluminum. The molten metal is received in the funnel shaped portion which constitutes part of the cylindrical passage described earlier. The flow of the metal is controlled by the constant level control referred to earlier so that the desired head of metal is present at all times. The physical control of the flow of metal into the center of the concentric housing is accomplished by means of the control valve in the conduit from the metal container. Because the passageway is funnel shaped and is of substantially larger diameter at the upper end, it is relatively easy to maintain the metal flowing at a constant speed and easier to maintain the head of the metal at the desired level since only a small volume of metal is permitted to pass in a cylindrical stream through the cylindrical opening at the bottom of the cylindrical passage. Since metal is a sharp melting point type of material rather than softening and gradually becoming less viscous, the viscosity of the molten metal remains relatively constant for wide variations in temperature. Therefore the only requirements for the metal flow in the manner desired are that it be above its melting point so that it will not solidify within the concentric housing and that it is not so hot that it causes bulging of the glass prior to solidification. Whenever the cooling has progressed to the point of danger that the metal might solidify within the hous-

ing the controlled heating coils 38 embedded in the central wall of the concentric housing can be activated to assist in maintaining the metal at a temperature above the melting point.

The glasses suitable for use in the present invention include most common glasses such as pyrex and E-glass. A particular advantage is realized by the use of pyrex for the glass coating due to its low thermal coefficient of expansion which facilitates dimensional stability of the filament as formed. The glass is simultaneously introduced into the funnel shaped upper section of the concentric tubular passage 37, which in the illustrated embodiment conforms generally to the shape of the central wall 34. The funnel shaped central wall holding the metal defines the inner wall of the tubular passage through which the glass passes in a tubular stream. The glass is also maintained in the concentric housing at a desired level by means of the second constant level control which activates the adjustment of the control valve 32 in the glass conduit 28. It should be noted that due to differences in opening size and viscosity the respective heads of the metal and the glass may not be of the same height.

As stated earlier, the most important parameter of the method of the present invention is the controlling of the exit velocity of the glass and the metal from the concentric housing. This may be accomplished in several different ways, which will become apparent in connection with the description hereinafter. In the illustrated embodiment the head of glass maintained by the constant level control in the concentric housing is one of the factors in determining the velocity of the glass at the exit of the tubular passage. Since glass is not a sharp melting substance and has a softening temperature combined with a gradual decrease in viscosity as temperature increases, the glass flow is controlled and matched to the exit velocity of the metal by controlling the temperature while maintaining the constant head at the desired depth. The precise temperature control is accomplished by means of the second set of coils 40 in the outer wall 36 of the concentric housing 24. The temperature of the glass is raised until the viscosity of the glass is low enough that the exit velocity of the glass from the lower end of the concentric bushing is equated to the exit velocity of the molten metal. Alternate means of control are constant temperature and variable head or artificially varying the head by pressurizing the glass in the tubular passage. Because the properties of glasses are known the particular head and temperature can be calculated to provide a given flow through the tubular opening in the housing employed. This calculation is within the skill of the art and obviously provides a wide range of temperatures and pressures within which the invention may be practiced.

As the molten metal exits from the lower end of the cylindrical passage in the concentric housing it remains in the molten state at somewhat higher temperature than the melting point of the metal. At this point the glass is permitted to come into contact with the molten metal in surrounding relationship and moving in the same direction at the same velocity. One reason for maintaining the velocities as nearly equal as possible is to minimize the drawing down of the metal causing variances or discontinuities in the filament formed or alternatively, if the velocity of the glass should be slower, causing bunching of the filament in portions producing larger diameter than desired. Another reason that the velocities are equal is that the Reynolds number which is a friction factor causing turbulence as fluids flow is a relative thing. Therefore, if there are no shear forces and no relative velocity between the molten metal and the molten glass prior to solidification there will be no disruption of the filament due to turbulence at the liquid interface between the metal and the glass. The need for no relative velocities and no turbulence is one reason for the short period of free attenuation mentioned earlier. The free attenuation just below the housing, or bushing exit also permits the end of the cylindrical passage to be larger than the final filament diameter so that laminar flow may be maintained within the cylindrical passage before contact with the glass.

In the illustrated embodiment the cylindrical passage containing the molten metal terminates just above the termination of the tubular passage containing the molten glass. Therefore, the glass remains in the confines of the outer wall of the tubular passage when the metal is contacted for a short time.

Immediately after exit a gaseous quenching or cooling step is provided to solidify the skin of the glass. Depending on the dimensions of the particular glass coating and the dimension of the filament being cast, either the glass or the metal filament may solidify first. The order of solidification in a particular case is not critical to the invention. The only requirement being that the skin of the glass be solidified below its softening point before it is contacted by the regulator rollers described earlier. After the quenching step the sheathed filament is contacted by the regulating rollers. The metal may or may not be solidified at this point, but the outer portion of the glass is solidified so that it will not deform when in contact with the regulator rollers. As mentioned earlier the function of the regulator rollers is to maintain the movement of the solidified filament from the concentric housing at a constant rate so as to avoid discontinuities and irregularities in the filament as it is formed.

After passing through the regulator rollers the entire filament and the glass are solidified. If the glass is to be removed, the filament is cooled further and moved downward until it passes through the center opening of the scribing die. The scribing die scores the outer surface of the glass at three or more points to assist in breaking glass away from the metal filament. The scribed glass coating and filament proceed to the stripping rollers which receive the coated filament in the bight between the two rollers and crush the glass to cause it to fracture and fall into the cullet collector bin. In order to assure that the metal filament is completely free from glass the etching bath of hydrofluoric acid is provided to dissolve the small particles of glass which might remain on the surface of the filament.

The glass which is broken away by the stripping rollers is returned to the glass container and melted for reuse as a mold for additional filament.

There may be some diffusion of the metal into the glass. This diffusion results in scrap cullet after the stripping operation which may contain some minor content of the metal employed in the filament. While after a certain point it would be inadvisable to continue reusing the same glass for coating new filament the problem does not appear critical and a substantial number of cycles of reuse of the glass cullet can be achieved without substantially affecting the properties of the glass.

Referring specifically to FIG. 2 it can be seen that the concentric housing illustrated is provided with a contoured tip made up of an inwardly curved portion 72 of the outer wall 36 and a blunted portion 74 of the inner wall 34. These contours are provided to assist the transition of the glass to free attenuation as it exits from the housing, or bushing. The blunted portion 74 causes the glass to cling to the central wall and to contact the metal immediately after it leaves the central opening. The curved portion 72 causes the glass to reach the precise diameter for which its flow velocity is equal to that of the exiting metal.

It should further be pointed out that the vertical position of the ends of the central wall and the outer wall relative to each other can be varied depending on the particular design of the concentric housing and the diameter of the filament to be formed. Although the reason is not entirely clear it appears that for very fine diameters of filament it is desirable to terminate the central wall above the termination point of the outer wall so that the metal contacts the glass while the glass is still confined within the outer wall of the housing. For large diameters of filament it has been found that it is advantageous to terminate the outer wall of the housing prior to the termination of the central wall so that the glass exits from the housing while the metal is still contained in the central passage. One possible reason for the observed differences noted above lies in the different modes of cooling for the two materials. The

metal cools by radiation and conduction through contact with the glass while the glass cools primarily by convection. Therefore, the larger the mass of metal the more tendency there is for the cooling of the metal to maintain the glass in a molten state for a longer period thus presenting more opportunity for the forces of gravity, the hydrostatic pressure of the metal, and vibrations to affect uniformity of the filament formed. Accordingly, in the larger diameter filament the outer surface of the glass may be permitted to cool after exiting from the outer wall and before contacting the metal to avoid remelting of the entire glass coating due to heat transmission from the metal. This phenomenon further points out, as was stated earlier in the specification, the need for a larger volume of glass than of metal in most applications so that the wall thickness of the coating is sufficiently thick that the metal does not prevent solidification of the outer surface of the glass prior to contact with the regulator rollers.

The operation of the method of the present invention is further illustrated by the following example.

EXAMPLE

Molten copper was introduced into the central passage of a concentric Vycor housing having the tip configuration shown in FIG. 2. The temperature of the copper at introduction to the housing was 2,300° F. Molten pyrex glass was introduced into the tubular passage of the concentric housing at a temperature of 2,100° F. Filament was cast at a rate of 500 feet per minute having a copper diameter of 0.005 inches and an outer diameter of the glass coating of 0.050 inches. Immediately upon exiting from the lower end of the housing the glass coating was quenched with nitrogen to cause solidification. The outer surface of the glass was then engaged by the regulator rollers to maintain the velocity at 500 feet per minute. The glass was then scored with a scribing die and was engaged by the stripping rollers causing the major portion of the glass coating to be broken away. Finally the filament was sprayed with hydrofluoric acid to remove the remaining fragments of glass and was rinsed and coiled. Because of the dynamics of the forming operation it was not possible to determine whether the copper was solidified at the point of contact of the glass coating with the regulator rollers nor to determine temperatures at the exit of the housing.

While the present invention is applicable to a relatively wide range of filament or wire sizes, it is particularly adapted to filament diameters ranging from one-eighth inch down to a fraction of a mil. The thickness of the glass coating can be as large as desired. The lower limit of glass coating appears to be of the order of five times the cross sectional area of the metal filament. Lower volumes of glass tend to rupture on contact with the metal.

The present invention as described herein has provided a method and apparatus capable of forming continuous filament directly from the molten state. Because of the variables which can be controlled in the performance of the process as described, such as the viscosity of the glass and the pressure applied to the surface of one or both of the molten materials, it is believed that the particular geometry of the concentric housing can be of a very wide variety of designs and configurations. No attempt has been made herein to describe all of the possible variations in the housing configuration as these variations will be apparent to one skilled in the art having the principles of operation of the present invention before him. It should be obvious from the above description that it is possible without departing from the teachings of the invention to employ multiple concentric housings from common feeds thereby simultaneously producing a plurality of filaments.

What is claimed is:

1. A method for the continuous casting of metallic filaments comprising the steps of forming a cylindrical stream of molten metal, forming a tubular stream of molten glass concentric with and flowing in the same direction as said stream of molten metal,

separately controlling the flow rate and pressure on said stream of molten metal and said stream of molten glass while each is flowing separately,
 causing said molten streams to join at equal velocities with the molten glass surrounding and contacting said molten metal with laminar flow and allowing a free attenuation of the filament,
 cooling said molten glass and said molten metal sufficiently to solidify both of them to form a filament having a glass coating and a metallic core, and
 regulating the movement of the glass coating and the metallic core by exerting a force on the filament in the longitudinal direction thereof to regulate the velocity of movement of the filament subsequent to surrounding and contacting of the molten metal with the molten glass and subsequent to the free attenuation of the filament to prevent discontinuities or variations in diameter of the metallic core.

2. The method defined in claim 1 further comprising the step of stripping said glass coating from said metallic core to form a metallic filament.

3. The method defined in claim 2 wherein said stripping further comprises successive mechanical stripping and acid etching for complete removal of said glass coating.

4. The method defined in claim 2 further comprising the steps of recycling said glass after stripping, and remelting said glass for reuse as a coating on additional filament being formed.

5. The method defined in claim 1 further comprising the

step of maintaining said molten metal and said molten glass in an inert atmosphere to prevent oxidation.

6. A method in accordance with claim 1 in which the step of separately controlling the flow rate and pressure on said stream of molten metal and said stream of molten glass further comprises the steps of sensing and maintaining a constant head of molten metal and of molten glass and separately controlling the respective temperatures of the molten glass and molten metal to control the viscosities thereof.

7. A method for the continuous casting of metallic filaments comprising the steps of forming a cylindrical stream of molten metal,

forming a tubular stream of molten glass concentric with and flowing in the same direction as said stream of molten metal,

separately controlling the respective temperatures of said stream of molten metal and said stream of molten glass while each is flowing separately,

causing said molten streams to join at equal velocities so that said molten glass surrounds and contacts said molten metal,

cooling said molten glass and said molten metal sufficiently to solidify both of them to form a filament having a glass coating and a metallic core, and

regulating the movement of the glass coating and the metallic core together as a solidified filament to avoid discontinuities and irregularities as the filament is formed.

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