

[54] APPARATUS FOR THE FORMATION OF DISCONTINUOUS FILAMENTS DIRECTLY FROM MOLTEN MATERIAL

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FOREIGN PATENTS OR APPLICATIONS

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Related U.S. Application Data

[60] Division of Ser. No. 251,985, May 10, 1972, Pat. No. 3,838,185, which is a continuation-in-part of Ser. No. 147,390, May 27, 1971, abandoned.

[52] U.S. Cl. 425/472; 425/8; 164/87; 264/165

[51] Int. Cl. B01d 5/26; B22d 11/06

[58] Field of Search 164/87; 425/8, 269, 270, 425/275, 472; 264/8, 165

[56] References Cited

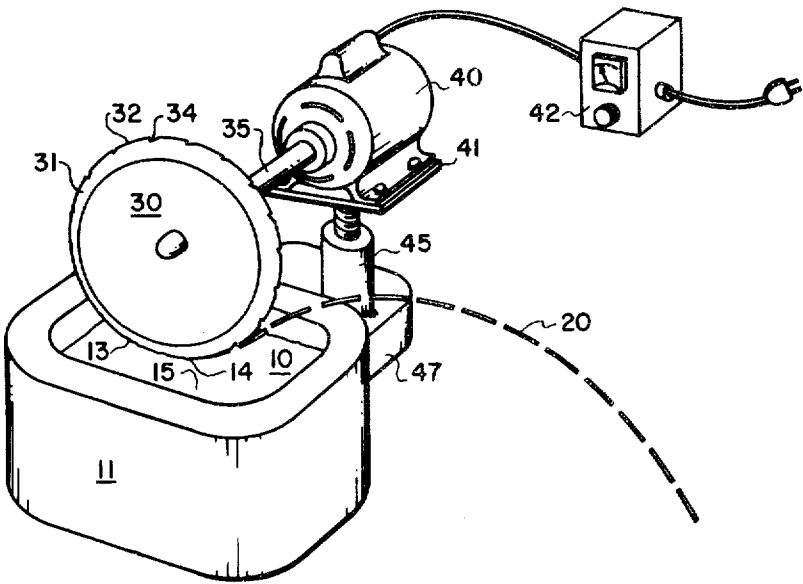
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[57] ABSTRACT

An apparatus for producing controlled length discontinuous products having a small cross-sectional area such as filaments or wire directly from a pool-like source of molten metal or a molten inorganic compound having a surface tension and viscosity similar to that of a molten metal by the application of a rotating heat-extracting member to the surface of the pool of molten material so as to form the material into the desired shape by extracting a filamentary form of material from the supply of molten material having a length equal the distance between indentations on the outer edge of the narrow circumferential edge of the heat-extracting member.

8 Claims, 7 Drawing Figures



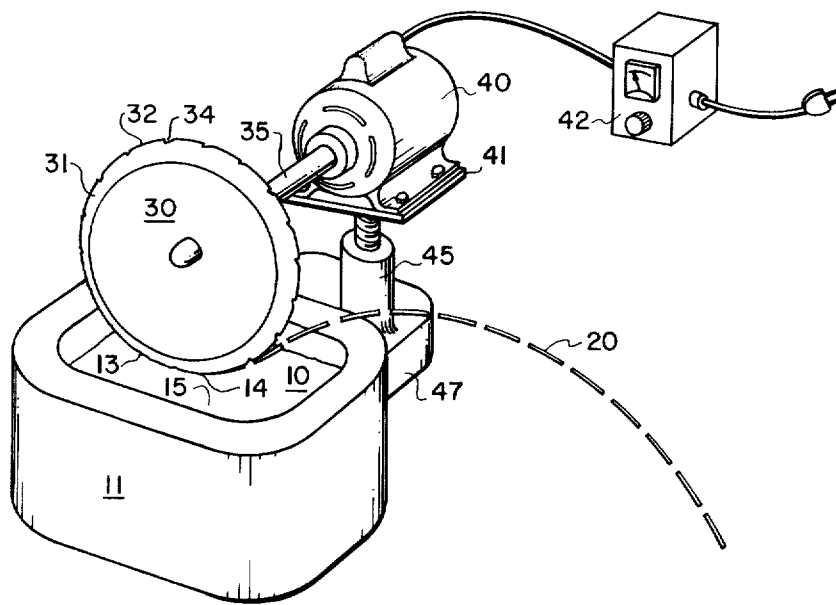


Fig. 1

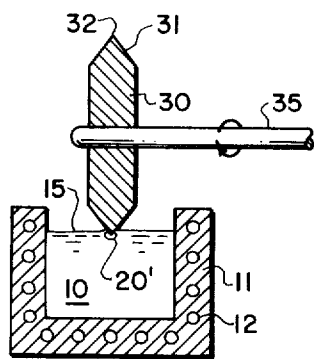


Fig. 2

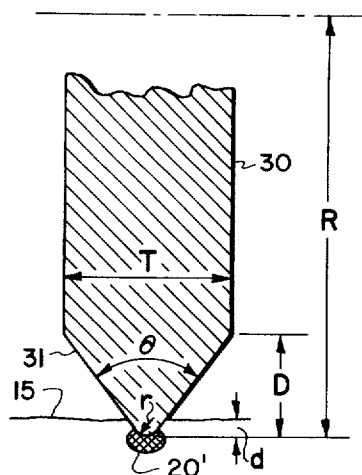


Fig. 3

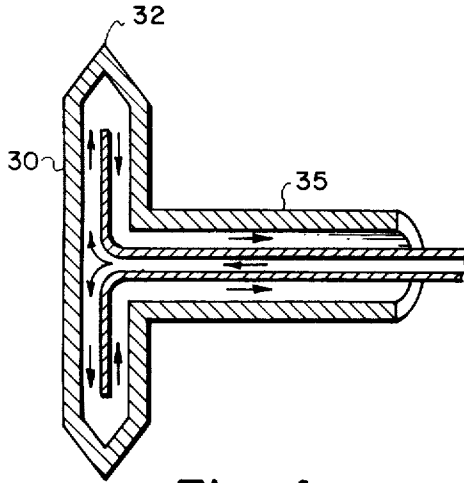


Fig. 4

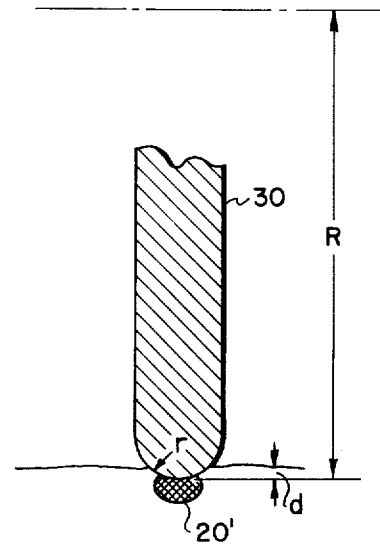


Fig. 7

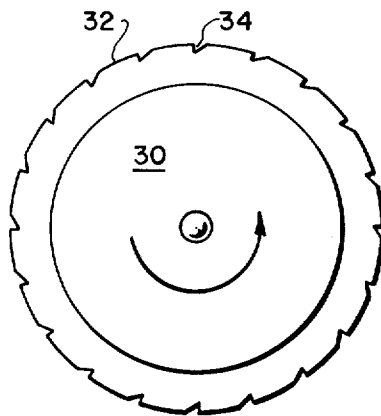


Fig. 6

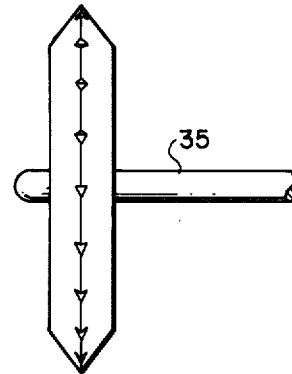


Fig. 5

APPARATUS FOR THE FORMATION OF DISCONTINUOUS FILAMENTS DIRECTLY FROM MOLTEN MATERIAL

CROSS REFERENCE TO RELATED APPLICATIONS

This is a divisional application of copending U.S. Pat. application Ser. No. 251,985, filed May 10, 1972, now U.S. Pat. No. 3,838,185 which is a continuation-in-part of U.S. patent application Ser. No. 147,390, filed May 27, 1971, now abandoned and, to the extent necessary for an adequate understanding of the present application, such patent is incorporated by reference.

BACKGROUND OF THE INVENTION

This invention relates to an apparatus capable of production of discontinuous controlled length filament directly from a pool-like supply of molten material by the use of an indented rotating disk in contact with that molten material and without the use of a forming orifice.

The conventional method of producing metal products of small cross section such as wire involves the casting of billets and their subsequent formation into the final product by mechanical working that may include extrusion, drawing, rolling, and other normal mechanical-forming techniques. In addition to these numerous post-casting mechanical operations there may be the necessity of intermittent heat treatment before the intermediate product can be further mechanically worked. The cost of these subsequent operations has created a long standing search for a means to form small cross-section discontinuous products directly from the molten metal.

The prior art methods used to make such products as filament or wire from inorganic compounds are substantially different since inorganic compounds do not have the mechanical properties to withstand forming processes as used on metallic materials. The formation of compounds into final shapes is usually carried out while the material is molten such as casting directly into a forming mold. The subject invention forms the desired product directly from the molten state, and therefore, inorganic compounds having properties in the molten state similar to that of molten metals and metal alloys may be formed in substantially the same manner. The properties that must be similar to that of molten metal are the viscosity and surface tension in the molten state as well as the compound having a substantially discrete melting point rather than a broad continuous range of viscosities characteristic of molten glasses.

Materials conforming to the class having such properties will have a viscosity in the molten state when at a temperature less than 125 percent of their melting point in degrees Kelvin in the range from 10^{-3} to 1 poise as well as having surface tension values in that same temperature range in the order of from 10 to 2500 dynes/cm.

Prior art patents and publications show various means for producing metallic wire using a rotating disk-like surface. The processes typically have molten metal flowing out an orifice determining the size of the final product. U.S. Pat. No. 745,786, Cole, is typical of the prior art devices where the disk-like surface is a rotating metallic wheel upon which molten metal is impinged by way of an orifice. The prior art methods of

producing wire products use flow conditions varying from the removal of the metal from a stable meniscus disclosed in U.S. Pat. No. 3,522,836, King, to the forcing of molten metal in a free-standing stream through the orifice directly on a rotating heat-extracting surface as disclosed by U.S. Pat. No. 2,825,108, Pond. The prior art means of direct formation of a filament or wire-like product all have one feature in common—the use of an orifice to control the size and flow of the molten metal.

The use of an orifice has several attendant difficulties in that it must function in the severe environment of flowing molten metal. Where the metal product desired is composed of low melting point alloys such as lead, tin, zinc, etc., the problems with the orifice are not severe. However, due to the commercial demand to make a continuous product out of materials having relatively high melting points, processes using orifices are plagued with several difficult problems.

At higher temperatures, orifice materials begin to react with the molten metal or the surrounding atmosphere degrading the properties of the orifice material as well as its physical dimensions. Consequently, the orifice tends to erode and "wash," becoming larger, and providing "out of gage" products. Further, insoluble materials such as silicates or refractory particles from the refractory container tend to clog orifices particularly where fine gage products are involved. As a consequence, the usual materials for orifices which resist erosion are expensive and difficult to form into the shape needed for the application; and, once formed, the erosion due to the flowing metal makes the size of the final product difficult to control.

The use of an orifice usually requires additional heating to insure that metal does not solidify in the orifice and thereby change the shape of the product formed. The use of small orifices requires extremely clean melts to prevent intermittent plugging or restriction of the orifice.

The present invention forms a filamentary product without the use of any type of orifice and, therefore, is free of all problems attendant the flow of molten metal through an orifice. The size of the final product is controllable and is primarily affected by the shape and properties of the rotating disk applied to the surface of a molten pool, its heat-extracting properties, its depth of entry into the melt, its velocity in contact with the melt, the melt superheat, and the melt material.

BRIEF SUMMARY OF THE INVENTION

The invention as herein disclosed is a means for producing controlled length discontinuous filaments directly from a pool-like supply of molten material. The invention consists of a rotating disk-shaped member having an axis of rotation substantially parallel to the surface of a molten pool of the material and having indentations on the circumferential edge of the disk.

Broadly stated, the invention provides an apparatus for producing a solid discontinuous filament from molten material normally solid at ambient temperature having properties in the molten state at their conventional casting temperatures substantially similar to molten metals by introducing the indented outer edge of a rotating disk-shaped member to the surface of a pool of molten material, removing heat at the circumferential extremity of said member to cause solidification of said material in filament form on said member between

the indentations and allowing said final filamentary product to spontaneously release from said member.

For the purposes of this invention a pool or poollike source of molten material is one that is not confined by a limiting orifice and has a free surface relatively free of turbulence. Turbulence does not prevent operation but makes the quality of the product somewhat irregular. As the invention is practiced, flow induced by induction heating of the melt does not detrimentally affect operation. In fact, the productivity of the process may be enhanced by flowing molten material parallel to the direction of rotation of the rotating member and increasing the speed of rotation of the member. Generally, flow directed across the member will disturb the filament formation if the magnitude of the flow is sufficiently large.

When the periphery of the rotating disk is introduced to the surface of the melt, a portion of the melt solidifies on the member and is carried through the melt by the rotation. This rotation also initiates a buildup of molten material above the equilibrium level of the melt immediately adjacent the point where the member exits the melt. Molten material from this buildup is at a slightly lower temperature than the melt and adheres to the previously formed material on the edge of the rotating member and exiting the melt through this buildup. The form of the final product is determined by the portion of material initially solidified on the member as well as the liquid portion deposited on the solidified portion as it passes through the buildup of material upon exiting from the pool of molten material and the distance between indentations on the edge.

The essence of the present invention resides in the extracting of molten material from the surface of a molten pool by contacting such surface with the edge of a rotating disk. Although the disk may act at least in part as a heat-extracting member or chill block, its essential function is extracting the molten material from the molten in pool semicontinuous fashion into the surrounding atmosphere or controlled gaseous environment where quenching occurs. It is our belief that a film of molten material initially wets the surface of the rotating disk and thus clings to such surface as it passes from contact with the molten metal. As cooling progresses the thin filament contracts, separates from the disk surface, and is ejected into the surrounding gaseous environment by the uninhibited centrifugal force of the rotating disk where solidification of any liquid portion with the film is completed. Since the disk presents a limited contact area and rotates at relatively high speed, the product is thin gage wire or filament rather than heavy gage material attained in prior art processes.

The shape of the final product is dependent in part on the shape of the rotating disk introduced to the melt surface. In the production of discontinuous filaments the periphery of the shell is preferably V-shaped or radiused with only the tip of the member being introduced to the surface of the molten material.

For the purpose of this invention, filament shall be defined as an elongated member having a cross-sectional area less than 0.020 in.² and a width measurement less than 0.20 inch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of the apparatus producing a discontinuous filamentary product.

FIG. 2 is a vertical cross section of the apparatus of FIG. 1 showing the shape of the disk-like member used to produce fiber or filament.

FIG. 3 shows an enlarged cross section of the tip of a disk-like member in a melt illustrating the physical dimensions that effect the properties of filamentary products.

FIG. 4 is a cross-sectional view of a disk-like member that is kept at substantially constant temperature by the internal circulation of a liquid coolant.

FIG. 5 shows a side view of a disk-like member that produces filaments having a controlled length.

FIG. 6 shows the disk-like member of FIG. 5 turned 90°.

FIG. 7 shows a cross section of a radiused disk-like member in a melt showing such a member as used for the production of filament.

DETAILED DESCRIPTION OF THE INVENTION

The means by which the discontinuous filamentary product is produced is illustrated in one configuration in FIG. 1. For the forming of a filamentary discontinuous product, a disk 30 is rotated by its attachment through some type of power transmission device such as the shaft 35 to a rotating motor herein disclosed as an electric motor 40. The motor 40 is mounted on a platform 41 that is capable of being adjusted vertically through the use of a jack 45. This vertical adjustment should not be accomplished by any substantial rotation around the axis of the jack 45 since this would affect the direction of the emission of the filaments 20. The placement of the jack base 47 is not critical and the process is not adversely affected by minor misalignments or deviations from the true vertical. While minor natural vibrations from the rotation of the apparatus do not seem to adversely affect the formation process, and the process has been successfully employed without using damping materials under the base 47, the quality of the filament is enhanced by the elimination of vibration. The electric motor 40 should have some method of controlling its rotational speed and, as illustrated, the apparatus is equipped with a rheostat-type control 42. The motor support plate 41 may be extended toward the disk 30 to provide a support for a shaft bearing (not shown) if the length of the shaft 35 and the size of the disk 30 pose alignment or vibrational problems. It would also be possible to extend the shaft 35 through the disk 30 to the other side to another support bearing (not shown). For most applications the shaft 35 is substantially parallel to the surface 15 of the melt 10; however, this angle may be acute with no substantial detriment to the formation process. For the formation of discontinuous fiber, it may be advantageous since centrifugal force would then eject the fibers away from the melt rather than straight up above the melt only to fall back in and possibly disturb the process. The disk 30 must introduce a relatively narrow surface to the melt 10 to form a filamentary product 20, but the exact shape of the surface will be discussed with other parameters; however, in general nonreplicating filaments 20 will emanate from a disk 30 that rotationally introduces a small area 32 of its circumference having substantially line contact between the indentations 34 with the surface of the melt 10 or to a buildup of molten material above the surface. When the disk-shaped member introduces only a small chord length of its peripheral edge its contact with the melt is narrow and elongated

in the direction of the filament length and is best described as a line contact. This line contact promotes solidification on a narrow area 32 on the member 30 and the direction of heat removal solidifies filamentary form that is not simply a female replica of the peripheral edge introduced to the surface of the melt 10. The process will become unstable when the melt 10 raises the temperature of the area 32 to a degree where the solidification rate is significantly retarded and the area 32 is removed from the melt 10 before any significant solidification can form a filament 20' on the area 32 as shown in FIGS. 2, 3, and 4. We have found that surprisingly the rotating member can pass through the melt at speeds up to 200 ft/sec and still promote solidification. It has been found that the preferred range of operating speeds is from 5 to 100 ft/sec.

Normally filament is formed in the melt by controlling the area of contact of the rotating member as well as its contact time with the molten material so that the typical cross-sectional dimension of the filamentary product is less than 0.060 inch but greater than the width of the cross section of the edge introduced to the molten material as measured parallel to the axis of rotation of the member at the average depth of immersion of the edge of the rotating member. Referring to FIG. 3, the width of 20', and subsequently 20, will be greater than the width of the radiused portion of the member 30 at r .

The supply of molten material referred to as the melt 10 may be composed of an elemental metal, metal alloy, or an inorganic compound heated and contained by a vessel 11 having elements 12 to heat the material contained to a temperature above its melting point. While the amount of superheat (number of degrees in excess of the material's equilibrium melting point) will affect the size or gage of the filament 20, we have found that substantially constant diameter filaments 20 can be produced with a melt at a temperature less than 125 percent of the equilibrium melting point (in °K) of the material used with no need for the precise control of the melt temperature during operations. While this quantitative definition of the preferred temperature will normally encompass the desired melt temperature, it should be understood that the formation process does not require unusual melt temperatures. Therefore, the present invention is known to be operable with metals and metal alloys at conventional casting temperatures that represent a compromise between the cost of heating versus fluidity of the molten material. The melt 10 may have a thin protective flux coating to prevent excessive reaction with the surrounding atmosphere without substantially disturbing the formation of the filament 20. The filament is initially formed, as illustrated in FIG. 3, below a surface of the melt 10 and will pass through most surface fluxes without any adverse effects. Where it is desired or necessary, the simplicity of the apparatus lends itself to the use of a simple container (not shown) for the process where the atmosphere surrounding the melt 10 and the filament 20 while it is still at high temperatures can be kept inert.

Filamentary material has been successfully produced from several metals and metal alloys including tin, zinc, copper, nickel, aluminum, aluminum alloys, aluminum bronze, cast iron, ductile iron, high and low carbon steel, 18-8 stainless steel, and Hadfield steel. While these materials are known to be readily formed into filaments by the subject invention, the present invention

is obviously applicable to a wider range of molten materials. The present invention may be used with any material having several specific properties similar to those of a molten metal, i.e., having a low viscosity in the range of from 10^{-3} to 1 poise, a high surface tension in the range of from 10 to 2,500 dynes/cm, a reasonably discrete melting point, and being at least momentarily compatible with a solid material having sufficient heat capacity of thermal conductivity to initiate solidification on the outer edge 32 of the disk 30 made of that solid material. For the purposes of this invention, a reasonably discrete melting point shall be defined as one exhibited by materials changing state from liquid to solid, changing state of one alloy component passing through a liquidus line on a temperature-composition phase diagram, or any change in state exhibiting a discontinuous viscosity increase upon reduction of melt temperature. Filamentary products have been produced from a molten alkali nitrate heattreating salt known commercially as Houghton's Draw Temp 430 available from E. F. Houghton & Company, Philadelphia, Pa., which is typical of inorganic compounds having the aforementioned properties in the molten state.

The disk 30 as shown in the Figures has a configuration that produces discontinuous metallic filaments 20 from the melt 10. FIG. 2 shows a different orientation of the disk 30 with relation to the melt 10 while FIG. 3 illustrates the dimensions of the outer portions 31 of the disk 30. Referring now to FIGS. 1 and 2, the disk 30 is rotated within the melt 10 just below its surface 15, and subsequent to its entry into the melt 10 at 13 the disk 30 nucleates solid metal on the edge 32 of the disk 30 not necessarily at point 13 by removing the superheat and the heat of fusion of the melt 10. During the rotation of the disk 30 the melt 10 continues to solidify on the disk edge 32 forming the filament 20'. The size of the final filament 20' is determined by the size and shape of the imposed disk surface 32 and the amount of heat removed by the disk 30. The amount of heat removed, therefore, depends on several controlled variables, one of which is the residence time of a point of the disk edge 32 within the melt 10 which is a function of the distance along the disk edge 32 from point 13 to 14 and the speed of rotation of the disk 30. The size of the final filament 20 is determined by the amount of molten material 10 that is deposited on 20' when it passes through the buildup of molten material 16.

Another variable affecting heat removal is the shape of the disk edge 32. It must nucleate and grow a filamentary product yet dissipate enough heat to maintain it at a temperature below that of the melt 10. The amount of this temperature differential will be discussed in a subsequent portion of the disclosure. The shape of the disk 30 as illustrated in FIG. 3 shows the physical dimensions that affect the rate of heat removal. The disk 30 is inserted into the melt 10 at a depth shown in the figure as d . Filamentary products are most efficiently produced when the value of d is less than 0.060 inch and yields a filamentary product less than 0.010 in² in cross-sectional areas.

The radius of curvature r at the disk edge 32 will affect the final form of the filament 20 since it is essentially a mold for one side of the filament 20' as well as providing the site for initial nucleation of 20'. Filaments have successfully been produced with r ranging from 0.015 inch to ∞ (i.e., a narrow, flat projection into

the melt 10). A preferred embodiment would have r within the range of from 0.001 to 0.10 inch. In addition to the V-shaped configuration, a member 30 having a radiused peripheral edge may also be used. A filamentary product is formed with such a member if the depth of insertion is less than 0.020 and the radius of curvature is less than 0.50 inch. All of edges 32 of the member 30 have a common characteristic in that they are all rounded or in some way relieved and a change in cross-sectional direction so as to freely release any product solidified thereon. The variables θ , T , and D as shown in FIG. 3 affect the conductivity of the heat emanating from 32 to the cooler portions of the disk 30. These variables are controlled by the chill material and any form of external cooling of the disk 30. The manipulation of these variables is not critical and one skilled in the art can successfully arrive at a workable configuration without excessive trial and error. The value of R affects the process in two ways, one of which is affecting the mass of the member 30 and hence its thermal capacity. The thermal capacity of the disk 30 can be controlled by material selection, external cooling, and the manipulation of the variables θ , T , and D ; therefore, variation of R is not primarily used to control the total thermal capacity of the disk 30. R does, however, directly affect several important variables; namely, the aforementioned residence time of a point on the disk edge 32 within the melt 10 and the generation of centrifugal forces that affect the spontaneous removal of the filament 20 from the disk 30 at point 25.

It is felt that the process is not inherently limited as to the maximum size of the disk, but a practical limit would seem to be a disk having a radius greater than 20 inches. With disks having a radius greater than this value, the residence time in the melt becomes excessive as well as reducing the centrifugal force critical for spontaneous product removal. The temperature difference between the disk edge 32 and the melt 10 affects the formation process; however, substantial variations in that temperature difference may be tolerated before the effect is noticeable. During operation the disk 30 may start initially at room temperature and after several minutes of operation immersed in molten iron still produce continuous filaments of substantially the same diameter. Eventually the limited thermal capacity of the disk 30 allows the temperature at the disk edge 32 to increase to the point the process is no longer forming a continuous fiber. FIG. 4 shows a disk 30 having the means to circulate a coolant within the disk 30 thereby keeping the disk 30 and the disk edge 32 at a constant temperature once thermal equilibrium is established. The means by which the coolant flow rate is determined is readily discernible to one skilled in the art since the invention is operable within a broad range of disk temperatures.

The product as it leaves the disk 30 in some cases will not be completely solid and will consist of a solid film that was formerly adjacent to the disk 30 and a liquid portion that is carried out of the source of molten material by this solid portion. Depending on the thermal capacity of the disk 30 and the point where the filament leaves contact with the disk, the product may continue to solidify or if its liquid portion possesses enough mass and superheat, it may remelt the entire filament after it leaves the thermal influence of the disk 30. Proper adjustment of parameters may result in this fully molten condition long enough to reform the filament into

a circular cross section by the effect of the material's high surface tension. The gaseous environment of the filament 20 is important to this type of process since the filament cannot be completely molten for a significant period of time without breaking down into globules. Gaseous coolants such as air or non-oxidizing gases such as nitrogen or argon may be used either solely or in conjunction with a fog or mist of liquid coolant.

FIGS. 5 and 6 illustrate a disk 30 having a plurality of indentations 34 along the disk edge 32. The function of these indentations is to disturb the formation of the filament 20' on the disk edge 32 sufficiently to produce a discontinuous product of a length equal to the distance along the disk edge 32 between successive indentations 34. The shape of the indentations 34 that has successfully produced a discontinuous filament is essentially in the form of a slanted V as shown in FIGS. 5 and 6. Undoubtedly other indentation shapes would also work. The slanted V-shape has proved to limit effectively the length of the filament while not accumulating solidified metal in the indentations 34 that would eventually affect the intended function of the indentations 34. Since the distance along the disk edge 32 between successive indentations 34 controls the length of the filaments produced, the spacing of these indentations can be controlled to produce short filaments of equal length, a controlled distribution of filament lengths, or a series of longer filaments with a length limited to the circumference of the disk 30 by the use of a single indentation 34. The presence of the indentations 34 enables the disk to be rotated at higher speeds and at a smaller insertion into the melt.

The parameters that are herein disclosed to affect the filament production need not be controlled precisely and the production of a discontinuous filamentary metal product 20 will result from the introduction of a relatively small area 32 on the periphery of a rotating disk 30 with indentations thereon to a pool of molten metal 10 when the disk 30 has a peripheral speed in the range of 3 ft/sec to 200 ft/sec and has sufficient temperature difference to solidify at least a rudimentary filament 20' on the disk edge 32. To start the formation of filament, the disk 30 is rotated above the melt 10 at the desired speed to give a peripheral speed within the desired range. The jack 45 is adjusted to lower the disk 30 into the melt 10 where initially a fragmented filament is formed upon contact with the surface 15. The disk 30 is lowered into the melt 10 and upon the disk 30 reaching sufficient depth within the melt 10 a discontinuous product 20 will emanate from the melt 10 in substantially the manner illustrated in FIG. 1.

FIG. 7 illustrates another embodiment of the present invention where the disk edge 32 is radiused and inserted into the molten material at a depth less than 0.020 inch so as to form a filamentary product. If the product to be formed by this embodiment is to be filamentary, then the radius of curvature at the edge 32 should be less than 0.50 inch.

The present invention was used in several configurations to form discontinuous filamentary products from various materials. In the following examples the surface of the disk that contacts the melt consistently has a 16 to 20 micro-inch CLA (center line average) surface finish produced by 600 grit paper, and, except where noted, the depth of insertion of the disk within the melt was approximately 10 mils.

EXAMPLE 1

The present invention was used to produce a discontinuous filament of controlled length by using a copper disk having indentations on its V-shaped peripheral edge. The disk has the following physical dimensions:

Diameter of the disk	=	4 inches
Thickness	=	.47 inch
Radius at the tip of the V	=	.015 inch
Angle of the V, θ	=	90°

The disk also had indentations on its peripheral edge substantially the same as those shown in FIG. 6 with the depth of the indentations being approximately 0.03 inch and having a length along the circumference of the disk of 0.15 inch. The disk was rotated at 700 rpm yielding a peripheral speed of 12.1 ft/sec. It was introduced to the surface of a pool of molten zinc at 890°F and the disk operated within a temperature range of 120° to 200°F. A filamentary product having a cross section 8 mils by 16 mils and consistent lengths of approximately 1 inch was formed.

EXAMPLE 2

The same disk and melt material were used with the melt temperature and disk temperature substantially the same as Example 1. The rotational speed of the disk was increased to 1,190 rpm giving a peripheral velocity of 20.6 ft/sec and the depth of insertion into the melt was reduced to 2 mils. The filament produced had a cross section of approximately 2 mils $\times$ 12 mils and a length of 0.9 inch.

EXAMPLE 3

The same disk was used as in Example 1 and 2 to produce filament of nodular cast iron. The disk was rotated at 3,200 rpm yielding a peripheral surface velocity of 55.5 ft/sec 2 mils below the surface of a molten pool of nodular cast iron at 2,700°F. The disk operated at a temperature initially of 75°F and still produced filament at a temperature of 600°F. The filament had the dimensions of 10 mils by 35 mils and was approximately 1 inch in length.

EXAMPLE 4

Discontinuous fibers have also been produced using a disk of different dimensions. A copper disk having the following dimensions was used to produce discontinuous fiber of Manganese Steel (12.4 Mn, 1.3 C, balance Fe):

Diameter of the disk	=	8 inches
Thickness	=	1 inch
Radius at the tip of the V	=	.0325 inch
Angle of the V	=	90°

The disk's V-shaped peripheral edge had the same type of indentations as Examples 1, 2, and 3 placed every inch along the circumference of the disk. It was rotated at 550 rpm yielding a peripheral velocity of 19.2 ft/sec and operated in the temperature range from 150° to 440°F. The manganese steel melt was at approximately 2,900°F and the filaments produced had a V-shaped cross section with a 10 mil height and a 40 mil width with a length of 1 inch.

It is herein understood that although the present invention has been specifically disclosed with preferred embodiments and examples, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art and such modifications and variations are considered to be within the spirit and scope of the invention and the appended claims.

We claim:

1. An apparatus for the production of solid filaments from molten material which is at a temperature within 25 percent of its equilibrium melting point in °K, said molten material having a viscosity of 0.001 to 1.0 poise and a surface tension of 10 to 2,500 dynes/cm at said temperature, which apparatus comprises:
 - a. a pool-like source of said molten material;
 - b. a heat-extracting disk having at least one circumferentially extending peripheral edge upon which said filaments at least partially solidify, with said edge tapering to a narrow peripheral surface;
 - c. at least one indentation on said edge disposed to limit the length of said filaments to the distance between said indentations;
 - d. means of rotating said disk about its axis of rotation; and
 - e. means of raising and lowering said disk relative to said pool of molten material.
2. The apparatus of claim 1 wherein said peripheral edge is substantially V-shaped in cross-section with the apex of said V being the outermost circumference of said disk.
3. The apparatus of claim 2 wherein the angle between the legs of said V-shape is in the range of 60° to 120° and the radius of curvature at the tip of said V is in the range from 0.001 to 0.10 inch.
4. The apparatus of claim 1 wherein the taper of said peripheral edge results solely from its having a radius of curvature.
5. The apparatus of claim 1 wherein said radius of curvature of said peripheral edge is less than 0.50 inch.
6. The apparatus of claim 3 wherein said heat-extracting member is comprised of copper.
7. The apparatus of claim 6 wherein said edge has a surface finish in the range of from 16 to 20 microinch CLA.
8. The apparatus of claim 1 including means for cooling the disk during the filament forming process.

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