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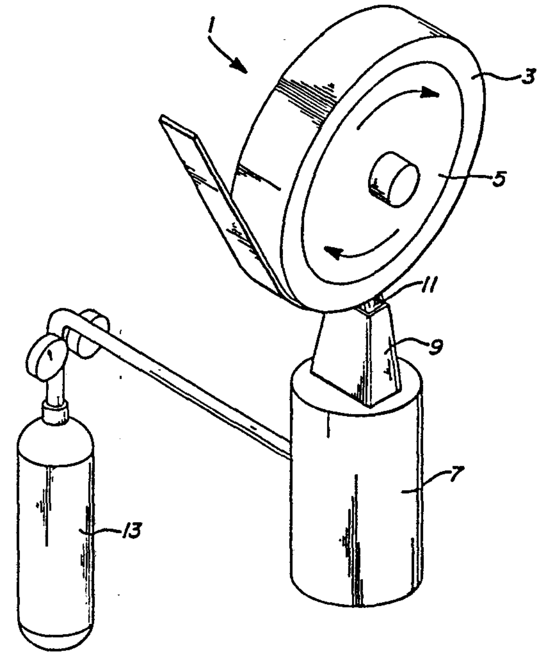
(54) **Method of producing disordered materials.**

(57) Disclosed are a method and apparatus for forming a filament of disordered material. The apparatus is a melt spinning system (1) having a chill surface means (3) and pressurizable reservoir means (7). The reservoir means (7) are spaced from and beneath the chill surface means (3) and have an effluent orifice (11) located beneath the chill surface (3) and adapted to allow upward flow of the molten reservoir means contents to the chill surface (3). The method of the invention contemplates providing molten material in the reservoir means (7) and pressurizing the reservoir means to form a negative meniscus (11) of molten material in contact with the chill surface (3). In this way there is formed an edge defined filament of disordered material.



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METHOD OF PRODUCING DISORDERED MATERIALS

FIELD OF THE INVENTION

The invention relates to the synthesis of disordered materials by rapidly quenching the molten material on a quench surface.

BACKGROUND OF THE INVENTION

Bulk disordered materials find utility because of their unique characteristics. These characteristics include the ability to tailor make the electrical, thermal, magnetic and ultimate properties of the disordered material. However, in order to obtain bulk disordered materials it is necessary to rapidly quench precursor liquids from the melt, thereby freezing in metastable and/or normally thermodynamically unstable phases, morphologies, structures, and compositions. The materials capable of forming disordered materials have a wide temperature range between the melting temperature and the glass transition temperature. In order to obtain disordered materials, it is necessary to quench the molten material from the molten state to the glass transition temperature at a rate high enough to substantially avoid formation of the thermodynamically favored crystalline states. That is, the quench rate must be high enough to kinetically block formation of the thermodynamically favored phases, structures, and morphologies while allowing formation of thermodynamically unfavored phases, states, and morphologies.

One method of quenching is melt spinning in which a jet of molten material is jetted through a pressurized orifice down onto a quenched surface, i.e., a chill surface. Melt spinning is exemplified by a moving chill surface where the chill surface moves at a velocity of 1 to 50 meters per second. In melt spinning the jet of molten material has a high degree of hydrodynamic instability. This arrises from the low surface tension and high viscosity of the molten materials, causing the molten materials to form droplets. Droplet formation introduces an undesired form of gross disorder into the filament.

An alternative method of quenching is melt dragging described in U.S. Patents 3,522,036 and 3,605,862. In the melt drag process molten metal is forced upward through an outlet, and a chill surface is drawn past the outlet, through the material. This process, characterized by the absence of jetting, fails to provide a high quench rate and is also characterized by a low throughput.

A still further method of quenching is melt extraction. In melt extraction a chill wheel rotates above and in skimming contact with the surface of the molten material. The chill wheel is wetted by and draws up the molten material. The thus by drawn molten materials solidifies, shrinks away from the chill surface and is thrown from the chill surface by centrifugal force. Melt extraction is characterized by a number of problems including extended contact between the pool of molten material and the chill wheel, resulting in turbulance, and a large exposed area of molten metal, resulting in high radiant heat flux therefrom. Additionally, melt extraction is characterized by a low quench rate.

A further attempt to solve certain of the problems of rapid quenching and melt spinning is elevated melt extraction described in U.S. Patent 3,863,700 to Bedell, et al for Elevation Of Melt In The Melt Extraction Of Metal Filaments. Bedell, et al attempt to overcome problems of melt extraction by spacing the chill surface from the melt and elevating the melt to the chill surface. This may be accomplished by capillary action, by the use of submerged wheels to propel the molten material to the chill surface, or by the use of gas jets impinging on the surface of the melt and causing a rise in the melt surface to drive the melt onto the chill wheel. Elevated melt extraction has not found wide commercial exceptance.

None of the above described processes provide a high quench rate, high throughput means for forming bulk disordered materials.

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SUMMARY OF THE INVENTION

According to the invention herein contemplated there is provided method and apparatus for forming disordered material, e.g., filamentary disordered material. As herein contemplated there is provided a chill surface and a reservoir, the reservoir having an effluent for discharging molten material. The reservoir is located beneath and close to the chill surface, with the chill surface moving relative to the reservoir effluent outlet. The effluent nozzle is adapted to allow upward flow of molten material, i.e., the reservoir contents, to the chill surface. The spacing, pressure, viscosity, surface tension, and chill surface velocity are such to allow a negative meniscus of molten material to form and be drawn by the chill surface, thereby resulting in edge defined growth of the filament.

According to the contemplated invention there is provided a pool of molten material in the reservoir. The reservoir is pressurized to form a meniscus of molten material extending substantially vertically upward from the effluent nozzle to the chill surface under conditions to form a negative meniscus in the molten material. The chill surface moves with respect to the effluent nozzle to draw along and rapidly solidify and quench the molten material, thereby forming an edge defined filament of disordered material. The filament is withdrawn from the chill surface.

As herein used the term "disordered materials" means materials characterized by the substantial absence of long range order although they may have short range local order. Disordered materials include amorphous materials, microcrystalline materials, polycrystalline materials and mixtures thereof. While the disordered materials may have zones, regions, and/or inclusions of crystalline materials, this does not detract from their characteristion as disordered materials. Disordered materials may be characterized by thermodynamically unstable and/or metastable phases, regions and morphologies.

As used herein a "filament" is a slender metallic body having a quenched transverse dimension less than its length. Filaments include ribbons, sheets, wires, and flakes, as well as materials of irregular cross-section.

THE FIGURES

The invention may be understood by reference to the Figures.

Figure 1 is an isometric view of a system for forming disordered materials with the chill wheel, the reservoir, and orifice.

Figure 2 is a plan view of the system of Figure 1 showing the piston and the negative meniscus of the molten material.

Figure 3 is an isometric view of an alternative exemplification where the means for forming the meniscus is a head of molten material.

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DETAILED DESCRIPTION OF THE INVENTION

The melt spinning system 1 herein contemplated has a chill surface means including a high heat transfer surface 3 on a chill wheel 5. The chill surface means may further include means for maintaining the heat transfer surface 3 of the chill wheel 5 at a relatively constant temperature whereby to maintain a high quench rate. Exemplary materials for formation of the heat transfer surface 3 include copper, steel, stainless steel and the like. The quench surface is further characterized by the presence of means to provide relative motion thereto, for example, rotational means whereby the high heat transfer surface 3 is a peripheral surface of a chill wheel 5.

The reservoir 7 is spaced from and beneath the chill surface 3 and has a effluent orifice 9. The effluent orifice 9 is located beneath the chill surface 3 and is adapted to allow upward of molten material from reservoir contents under conditions where the molten material forms a negative meniscus, which negative meniscus is contacted by the chill surface 3 and drawn along thereby to form a filament.

The meniscus of molten material is formed by driving molten material upward from the reservoir 7 by pressure means, a distance sufficient to form the meniscus 11. This may be accomplished, for example, by pressurized gas from pressurized gas tank 13 under conditions to avoid introduction of gas into the molten material, i.e., by driving piston 14 upward, or by a hydrostatic head of molten metal 15, or by a piston.

The invention further contemplates providing a molten material in the reservoir 7 and forcing the molten material from the reservoir 7, through the orifice 9. The molten material may be forced through the orifice 9 by pressurization. Pressurization may be by pressurized gas 13 separated from the molten material by a membrane, or a hydrostatic head 15 of molten material, or a piston. Pressurization of the reservoir 7 forces the molten material substantially vertically upward through the effluent orifice 9 to form a meniscus contacting the chill surface 3. The molten material is driven through the orifice under conditions to form a negative meniscus in the molten material. The orifice 9 dimension parallel to the chill surface 3 movement is from 1 to 5 millimeters. The orifice dimension perpendicular to the chill surface 3 movement is set by the chill surface, and may be from 1 to 10 or more centimeters.

The chill surface 3 moves relative to the effluent orifice 9, whereby to receive and draw the molten metal along the chill surface 3, whereby to result in rapid solidification and a high quench rate, and the formation of a filament 15 on the chill surface 3.

The transition range between the melting point of the material and the glass transition temperature thereof, the velocity of the chill surface 3, and the temperature of the chill surface 3 are such as to provide a quench rate of at least above about 10^5 degrees centrigrade per second and frequently above about 10^6 degrees centrigrade per second in order to result in the contemplated disordered materials.

The filament 15 is an edge defined filament of disordered material and is withdrawn from the chill surface.

The meniscus 11 of molten material is formed at from the orifice 9, with the vertical distance between the chill surface 3 and orifice 9, the driving pressure, and the physical properties of the molten materials i.e., viscosity and surface tension thereof, being such as to allow a negative meniscus 11 to form so as to allow formation of an edge defined filament 15.

While the invention has been described with respect to certain preferred exemplifications and embodiments thereof it is not intended to limit the scope of the invention thereby but solely by the claims appended hereto.

Claims

1. A method of forming a filament of disordered material in a melt spinning system (1) having chill surface means (3) and pressurizable reservoir means (7), the reservoir means (7) being spaced from and beneath the chill surface means (3), the reservoir (7) having an effluent orifice (9) located beneath the chill surface (3) and adapted to allow upward flow of reservoir means contents to the chill surface (3), which method comprises:

(a) providing molten material in the reservoir means;

(b) pressurizing the reservoir means (7) whereby to force molten material substantially vertically upward from the effluent orifice (9) to form a negative meniscus (11) of the molten material in contact with the chill surface (3);

(c) moving the chill surface (3) relative to the effluent orifice (9) to rapidly quench the material; and

(d) withdrawing an edge defined filament of disordered material from the chill surface (3).

2. The method of Claim 1 comprising pressurizing the reservoir means (7) by inert gas (13).

3. The method of Claim 1 comprising pressurizing the reservoir means (7) by hydrostatic pressure of molten material.

4. The method of Claim 1 comprising pressurizing the reservoir (7) by means of a piston (14).

5. The method of Claim 1 comprising quenching the molten material at a quench rate above about 10^5 degrees centrigrade per second.

6. In a melt spinning system (1) having a moving chill surface (3) and a reservoir (7) with an effluent orifice (9) for contacting molten material to be solidified into a filament of disordered material onto the chill surface (3), characterized in that the effluent orifice (9) is below and spaced from the chill surface (3) a distance adapted to allow formation of a negative meniscus (11) in the molten material.

7. The melt spinning system of Claim 6 comprising reservoir gas pressurizing means (13).

8. The melt spinning system of Claim 6 comprising hydrostatic reservoir pressurizing means.

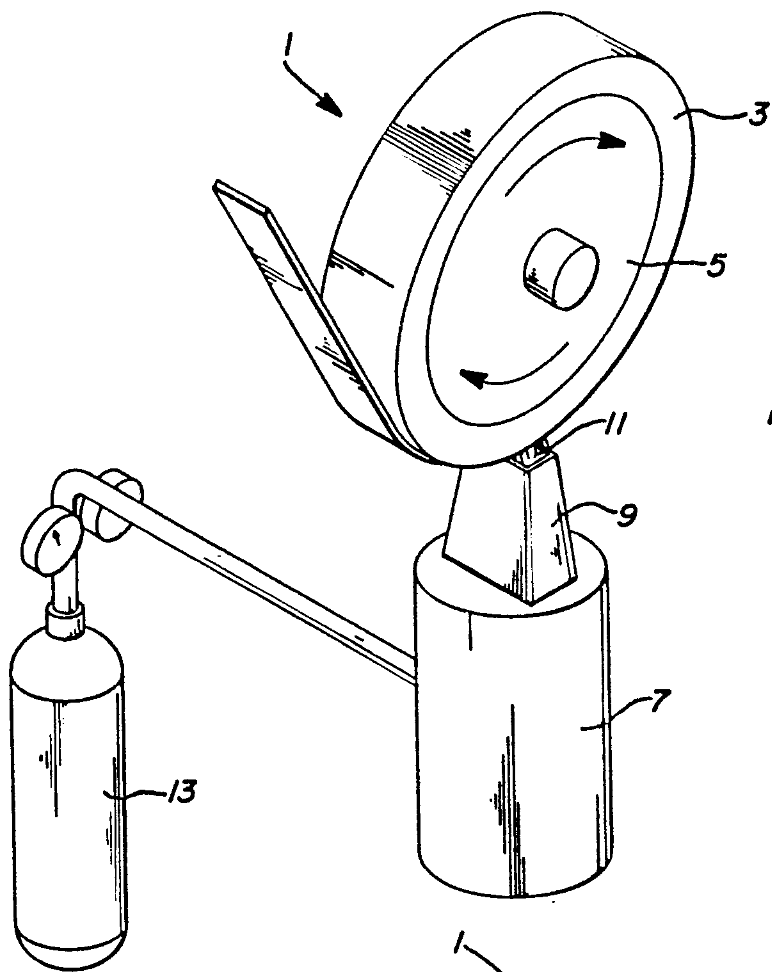

FIG 1

FIG 2

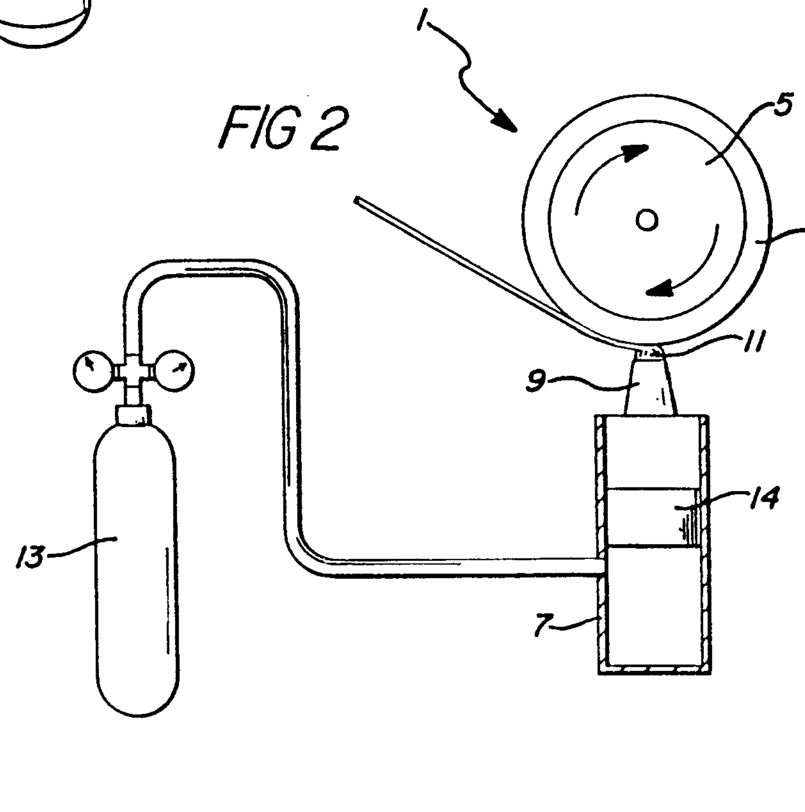

FIG 3