

[54] **METHOD OF FORMING METALLIC FILAMENT CAST ON INTERIOR SURFACE OF INCLINED ANNULAR QUENCH ROLL**

[75] Inventor: **Sheldon Kavesh**, Whippany, N.J.

[73] Assignee: **Allied Chemical Corporation**, New York, N.Y.

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[52] U.S. Cl. **164/87; 164/276; 264/237; 264/311**

[51] Int. Cl. **B22d 11/06**

[58] Field of Search **164/87, 87 D, 84, 276; 264/237, 311**

[56] **References Cited**

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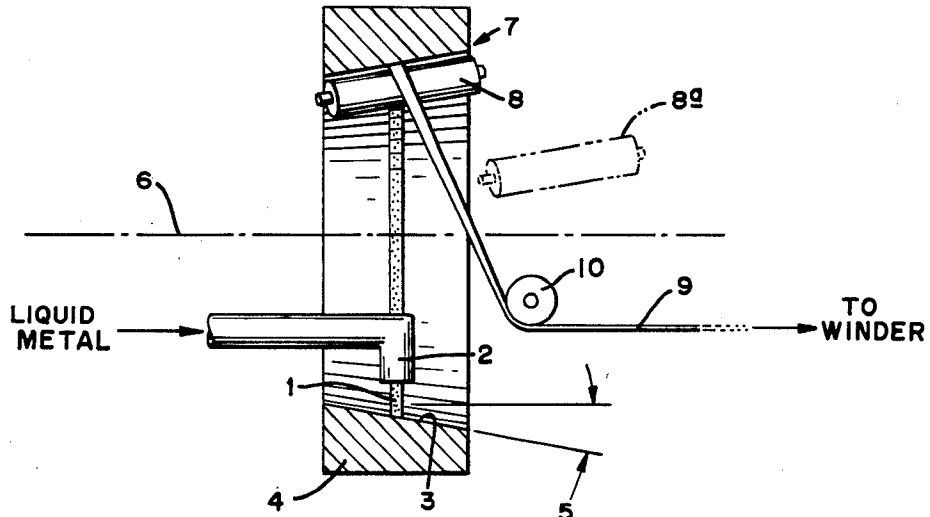
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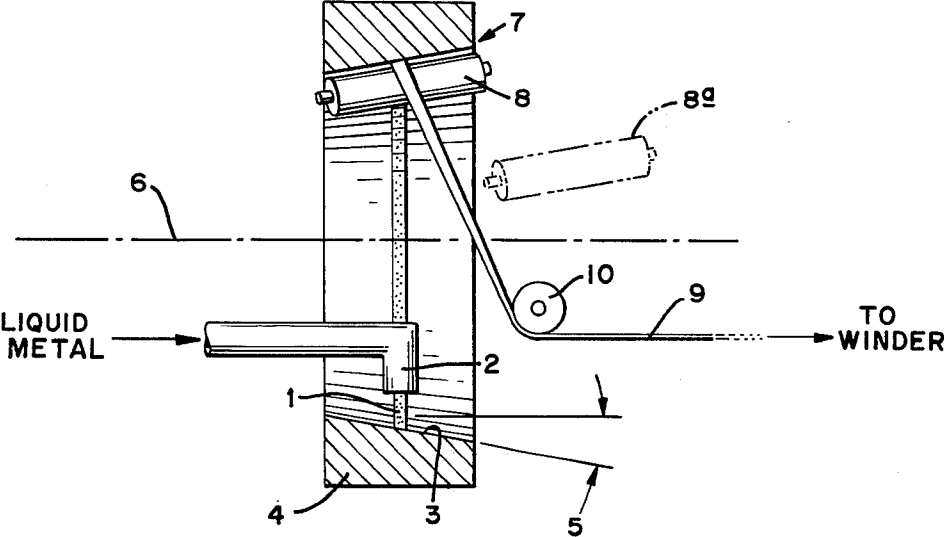
Primary Examiner—R. Spencer Annear
Attorney, Agent, or Firm—Arthur J. Plantamura;
 David W. Collins

[57] **ABSTRACT**

A process and apparatus is disclosed for the production of untwisted, continuous lengths of metal filaments from a molten stream by casting the molten stream onto the inside surface of an annular chill roll wherein the inside surface is inclined at an angle of 2–30° to the axis of rotation of the chill roll, exerting pressure on the quenched molten stream in contact with the inside surface of the chill roll after solidification and collecting the filament thus formed.

2 Claims, 1 Drawing Figure





METHOD OF FORMING METALLIC FILAMENT CAST ON INTERIOR SURFACE OF INCLINED ANNULAR QUENCH ROLL

BACKGROUND OF THE INVENTION

I. Field of the Invention:

This invention relates to a method and apparatus for the production of continuous metal filaments, particularly amorphous metal filaments, by casting a molten stream on the inside surface of a rotating drum and withdrawing an untwisted filament.

For the purposes of the invention, filament is herein used to represent a slender body whose transverse dimensions are much less than its length. In the present context, the filaments may be ribbons, sheets, wires or irregular cross-sections.

II. Brief Description of the Prior Art:

Methods for the formation of metal filaments have been developed which avoid the inherent difficulties of previous casting, die drawing and rolling techniques. One of these methods involves chill roll casting in which a free jet of molten metal is impinged upon a moving chilled quenching surface whereon it is solidified and flung away by centrifugal action.

Chill roll casting techniques as first described by Strange and Pim in U.S. Pat. No. 905,758 involve casting the molten metal stream onto the outside of a rotating chill roll thus permitting ready pickup and winding of continuous filaments by using a nipping means as disclosed in my co-pending U.S. Ser. No. 348,814 filed 4/6/73. The procedure described by Strange et al. may be readily employed to form filaments of many of the polycrystalline metals which possess sharp melting points, i.e. have a solidus-liquidus transition range of less than 5°C; however, the nature of amorphous or glassy metals is such that there is a transition range often well in excess of 400°C through which the viscosity of the metal gradually increases until the critical glass transition temperature is reached and it is necessary for the filament to be quenched to below its glass transition temperature before departure from the quench roll.

Pond and Maddin in Trans. Met. Soc. AIME, 245 (1969) pgs. 2475-6 describe a method for casting onto the inside surface of an annular chill roll where the inside surface is parallel to the axis of rotation. The radial acceleration of the roll acts to insure a good thermal contact of the melt with the roll due to the relative motion of the roll and the molten stream which spreads the liquid over a larger area resulting in a thinner layer of solidified material and hence a larger overall thermal transfer rate.

When the inside surface of the roll is parallel to the axis of rotation as in the apparatus of Pond and Maddin, the rotation of the casting roll twists the filament as it is continuously withdrawn from the casting surface thereby greatly complicating the preparation and winding of continuous filaments. Since these twists are geometric in structure, their occurrence in the production of ribbons or sheets prevents winding of the formed product into smooth rolls. Even, in the case of equiaxial round wire, the presence of twists creates undue torsional stress which makes incorporation of the wire product into multifilament bundles very difficult.

SUMMARY OF THE INVENTION

This invention is directed to an apparatus for the production of continuous lengths of metal filaments, particularly amorphous metal by casting onto the inside surface of an annular chill roll where the inside surface is inclined at an acute angle to its axis of rotation. A nipping means is positioned at a point in contact with the quench (inside) surface of the chill roll beyond the point of solidification of the filament. Optionally, a guide means whose axis is skewed to the axis of the nip roll may be provided to direct the filament for recovery.

The invention is also directed to a process for the production of continuous length, untwisted metal filaments from a molten stream by casting the molten stream on the inside surface of a rotating annular chill roll wherein the inside surface is inclined at an angle of 2°-30° to the axis of rotation of the chill roll, exerting a pressure on the quenched molten stream in contact with the inside surface of the chill roll after solidification of the filament and collecting the filament thus formed.

This novel method and apparatus is particularly useful in achieving the critical glass transition temperature necessary for the production of amorphous metal filaments since it permits increased retention of the filament in contact with the quench surface. Moreover this method and apparatus is advantageous in that it provides for the production and collection of a smooth, uniform and untwisted product.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE represents a cross section of the annular chill roll of the invention showing the inside surface inclined in an acute angle to the axis of the rotation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the FIGURE which is representative of the novel aspects of the invention, the molten stream 1 is ejected through a nozzle 2 onto the inner surface 3 of a rotating annular chill roll 4 whose inside surface 3 is inclined at an acute angle 5 to its axis of rotation. The molten stream is solidified and the resulting filament is carried by the rotation of the roll into the nip area 7 where it is contacted by nipping means 8 and the filament 9 is withdrawn in a direction perpendicular to the inside surface of the quench roll 4 so as to make a single twist of approximately 90° in traversing the distance to an optional guide roll 10 from which the filament 9 may be recovered.

During start-up of the operation, the nipping means 8 may be swivelled to a remote position 8a. Rotation of the chill roll 4 is initiated and the molten metal 1 is ejected onto the chill surface 3 thereby commencing formation of the metal filament. The filament is carried by rotation of the roll 4 into the nip area 7 and the nipping means 8 is then converged toward the quenching surface 3 so that the filament 9 can be withdrawn from the apparatus.

It is intrinsic to the present invention that the inside surface of the chill roll form an angle with the axis of rotation. While angles of 2° to 30° are practical, best results are obtained when the inside surface is inclined at an angle of about 5°-15° to the axis of rotation.

By increasing the angle of inclination, it becomes easier to place the required equipment within the geometric confines of the chill roll; however, this increased angle also causes the filament produced to be heavier on one side than on the other so that for angles greater than about 30°, the production of a relatively uniform filament is rendered difficult. It is possible to regulate the centrifugal pressures on the filament so that uniform filaments may be produced for angles of about 15°–29° by increasing the diameter of the roll or by decreasing the rotational velocity or rpm.

The chill roll 4 may comprise any of the conventionally used quenching materials as for example oxygen-free high conducting copper, beryllium copper or stainless steel. The thickness of the roll will depend on the other dimensions, the cooling means and the manner in which the roll is driven. In general this thickness will vary from 1/8 to 1 inch. The chill roll shown in the FIGURE is externally driven but it is obvious that the system could be easily adapted to any internal or other drive means. The chill roll may be cooled externally, as by passing the roll in contact with a bath or by spraying cooling gas or liquid on the outside of the roll. Alternatively, the roll could be adapted with an internal chamber through which a cooling fluid would be transported. The chill roll may be open on opposite ends or one end may be closed.

The nipping means employed may be any device having freedom of movement and capable of exerting a degree of pressure on the solidifying filament. If a winder is used to collect the filament, it is necessary that the pressure exerted by the nipping means be sufficient to counteract the stress transmitted by the winder thereby establishing a tension free zone as discussed in the hereinabove noted co-pending application Ser. No. 348,814. The nipping device may comprise any suitable arrangement, e.g., it may be in the form of a bar, a blunt blade or, preferably, a cold roll freely rotating or driven at the same velocity as the quench roll. The position of the nipping means, and the pressure which it exerts on the filament, are controlled by means of a pressure exerting mechanism such as an air-cylinder operating through a conventional connecting link between the nipping device and the quench roll. The nip roll may be located at any point on the inner surface of the roll at or beyond the point of solidification of the filament. It is preferred, largely for convenience, to locate the roll at a position about 180° opposed to the point of impingement of the molten stream on the quench surface.

The optional guide means employed may be in the form of a bar, blade or preferably a freely rotating or driven roll. The guide means illustrated by roll 10 in the drawing may be by-passed if a winder or other collecting device is located in close proximity to the quenching apparatus. However, it is intrinsic to the production of continuous, uniform filaments that the guide means or winder be positioned so that its axis is skewed to the axis of the nipping means so as to direct the filament from the quench roll with only a single half-twist of approximately 90°. The filament is collected from the guide means in any suitable manner. A preferred collecting apparatus may comprise a wind-up mechanism (not shown) used alone or in conjunction with a separate tension regulating device of the kind conventionally utilized in the fiber spinning art.

This novel apparatus may be readily employed to produce metal filaments in the form of ribbon or sheets. Moreover, by machining a groove into the inner surface of the chill roll 4 and directing the flow of molten metal into this groove, it is readily apparent that filaments having circular or irregular cross-sections can be produced.

It is to be noted that the filaments, when produced in accordance with the present invention, contain no twists and consequent torsional stress in their collected form.

Thus the use of the novel method and apparatus of the present invention facilitates the production of continuous, uniform, untwisted metal ribbons, sheets and wires and enables the collection of the filaments thus formed into smooth wound rolls.

The invention will be further described by the following illustrative examples.

EXAMPLE 1

An alloy formulated to be amorphous upon quenching was cast into filamentary form using an apparatus similar to that depicted schematically in the attached FIGURE.

The apparatus employed herein consisted of an annular chill roll cooled by an external water spray (not shown). The chill roll was composed of oxygen-free high conductivity copper and had dimensions of 2 feet outer diameter and one-fourth inch in thickness with its inside surface inclined at an angle of 5° to the axis of rotation.

The alloy to be spun consisted of 38 at.% Fe, 39 at.% Ni, 14 at.% P, 6 at. wt% B and 3 at. wt% Al. The alloy was melted in an argon atmosphere at 1000°C. and ejected through a zirconia nozzle of 0.0355 inch interior diameter onto the inner surface of the chill roll which was rotating at 922 rpm. A solidified filament of 0.0747 inch width and 0.0016 thickness was formed and carried by centrifugal force to the nip area located 180° from the point of impingement where a rubber nip roller was actuated to a "closed" or converged position by means of an air cylinder which exerted a pressure of about 5 psi on the filament. The filament was then directed to a hard steel ball bearing guide roll positioned so that its axis was skewed to that of the axis of the nipping roller and wound continuously on a tension controlled winder at 1 lb. tension. The resulting untwisted amorphous ribbon filament was collected in tight uniform packages.

EXAMPLE 2

An apparatus and procedure similar to that employed in Example 1 were used to produce wound packages of polycrystalline wire.

A half-circular groove of 0.020 inch width was machined into the apparatus of Example 1. A grey iron alloy containing 3.4 wt.% C, 2.2 wt.% Si, 0.6 wt.% Mn, 0.2 wt.% P and 0.01 wt.% S was melted at 1300°C and extruded directly into the groove of the rotating chill roll through a nozzle of 0.010 inch interior diameter. A D-shaped filament of approximate cross-sectional diameter of 0.020 inch was solidified and collected as in Example 1.

I claim:

1. A process for the production of continuous length untwisted metal filaments from a molten stream comprising the steps of:

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- a. casting the molten stream on the inside surface of a rotating annular chill roll wherein the inside surface is inclined at an angle of 2°-30° to the axis of rotation of the chill roll;
- b. after solidification of the filament exerting pressure on the quenched molten stream in contact with the inside surface of the chill roll; to increase retention of the filament in contact with the quenching surface by nipping means applied on the

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- inside surface of the chill roll; and
 - c. collecting the filament thus formed.
2. The method of claim 1 wherein the filament after solidification is oriented to remove twist by guide means whose axis is skewed to the axis of the nipping means and thereby direct the untwisted filament for collection.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,881,540

Dated May 6, 1975

Inventor(s) Sheldon Kavesh

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Abstract - Line 6, "2 -30" should read -- 2°-30° --.

Signed and Sealed this

eighteenth Day of *November* 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

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Commissioner of Patents and Trademarks