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(54) **HIGH ZINC ALUMINUM ALLOY PRODUCTS**

(71) Applicant: **Arconic Inc.**, Pittsburgh, PA (US)

(72) Inventors: **Ali Unal**, Export, PA (US); **John Newman**, Monroeville, PA (US); **David Tomes**, San Antonio, TX (US); **Gavin Wyatt-Mair**, LaFayette, CA (US)

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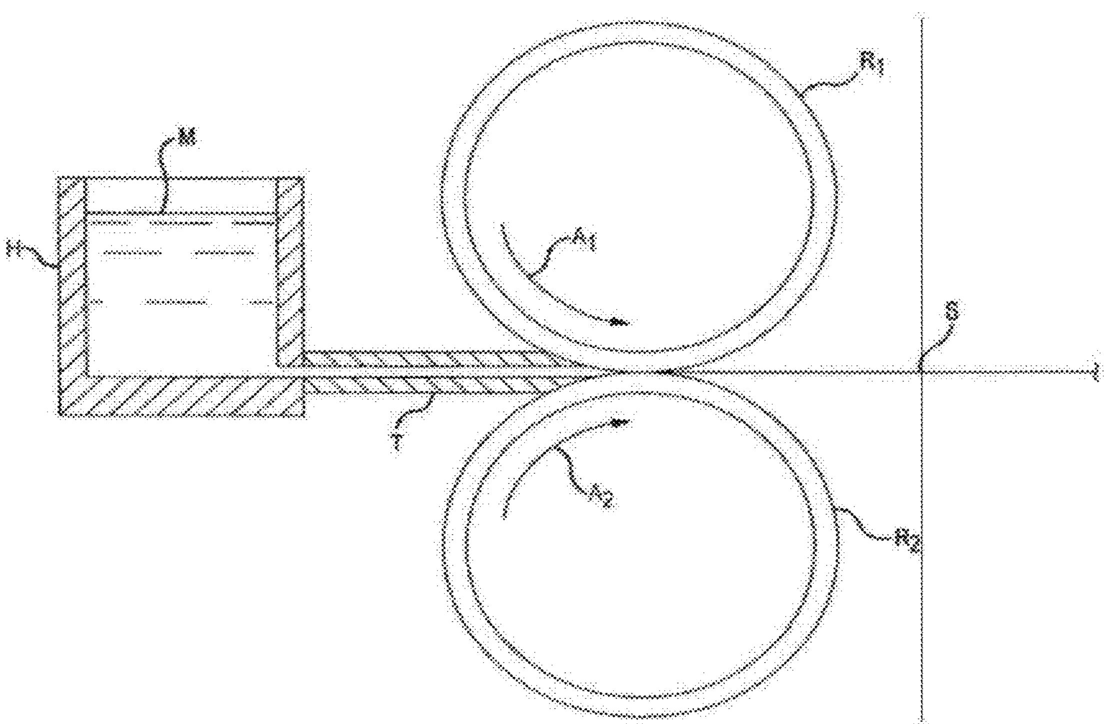
CPC *C22C 21/10* (2013.01); *B22D 21/007* (2013.01)

(57) **ABSTRACT**

The present invention, in an embodiment, is cast product in the form of an aluminum alloy strip. The aluminum alloy strip includes 4 wt. % to 28 wt. % zinc and a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.



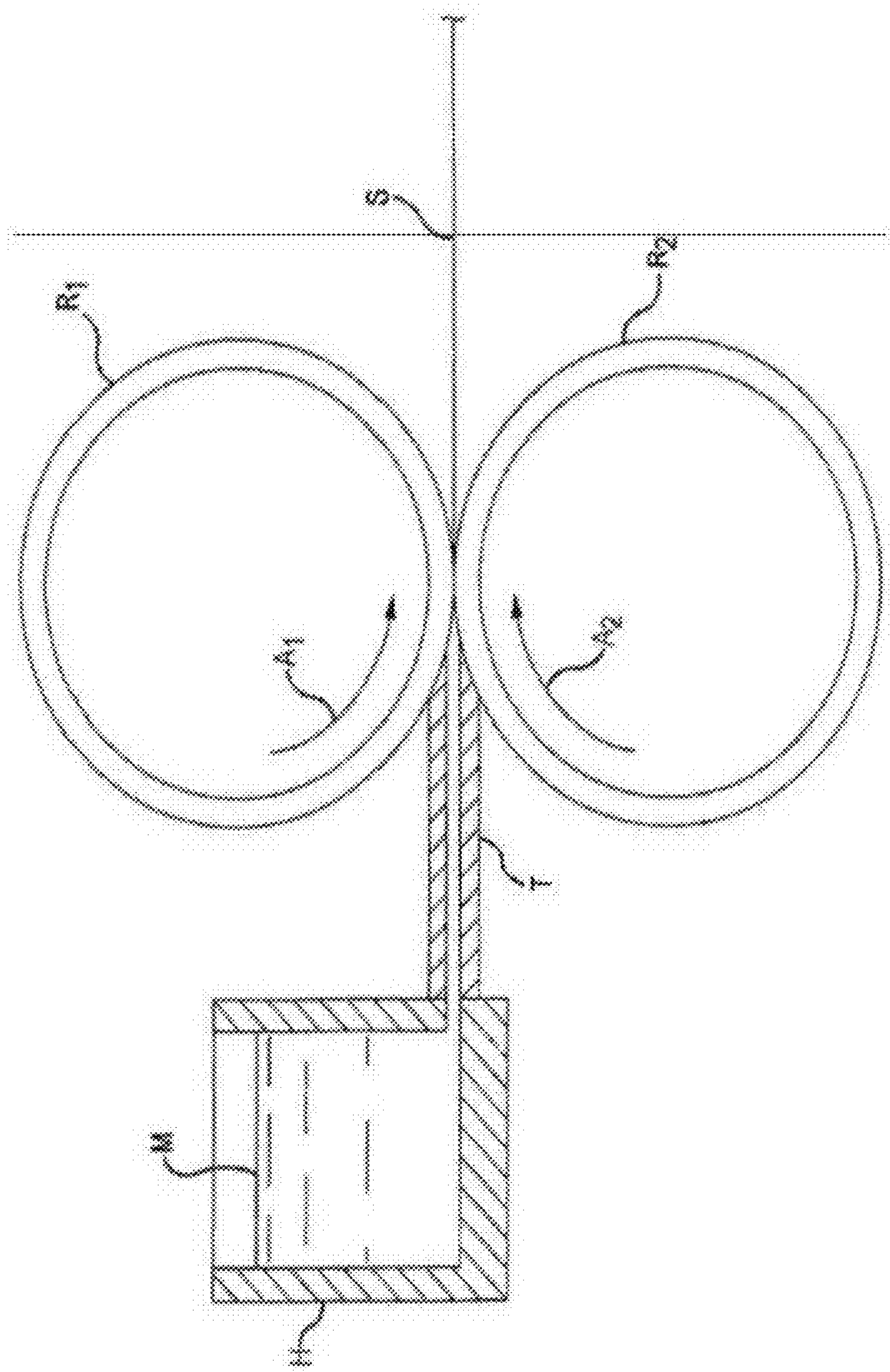


FIGURE 1

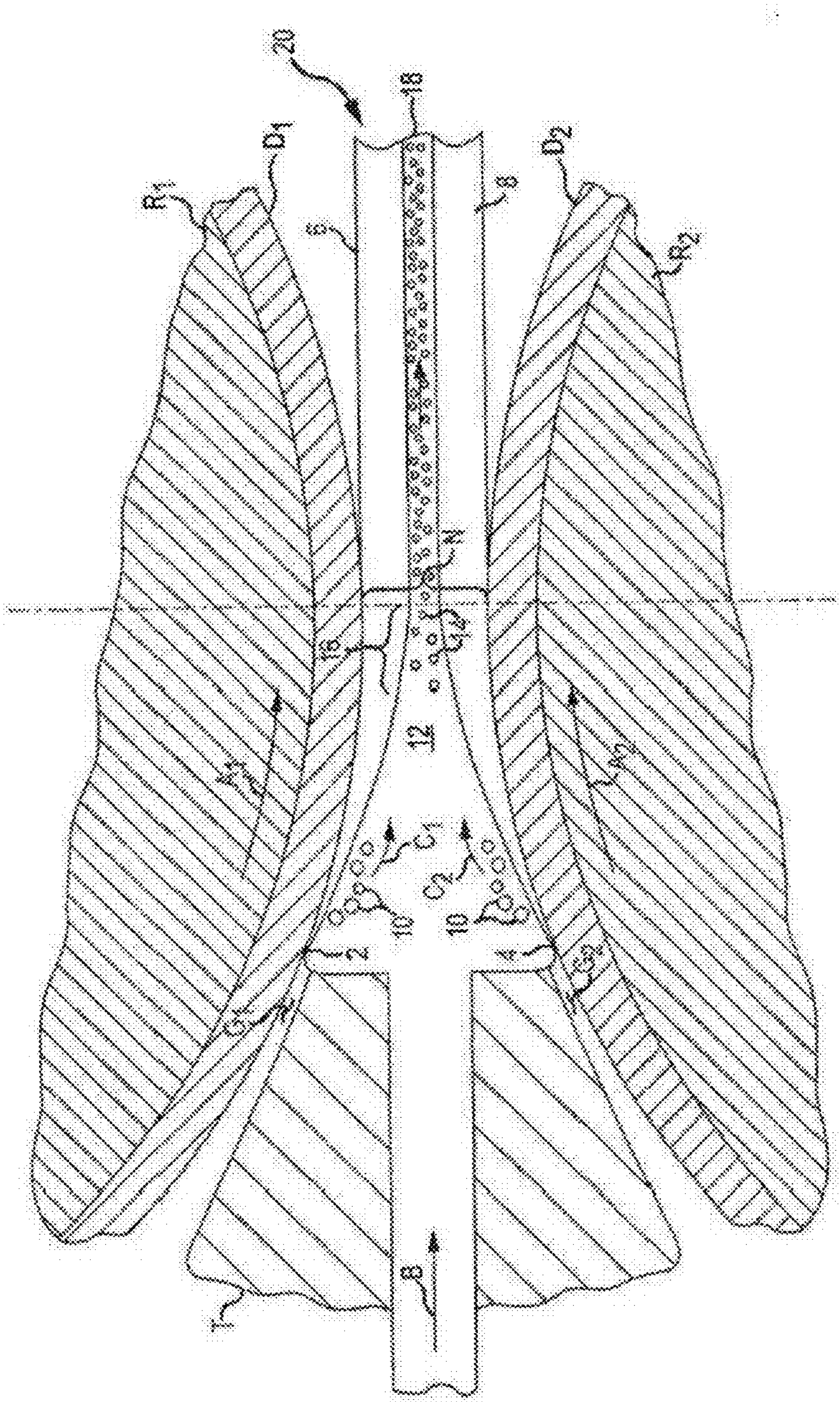


FIGURE 2

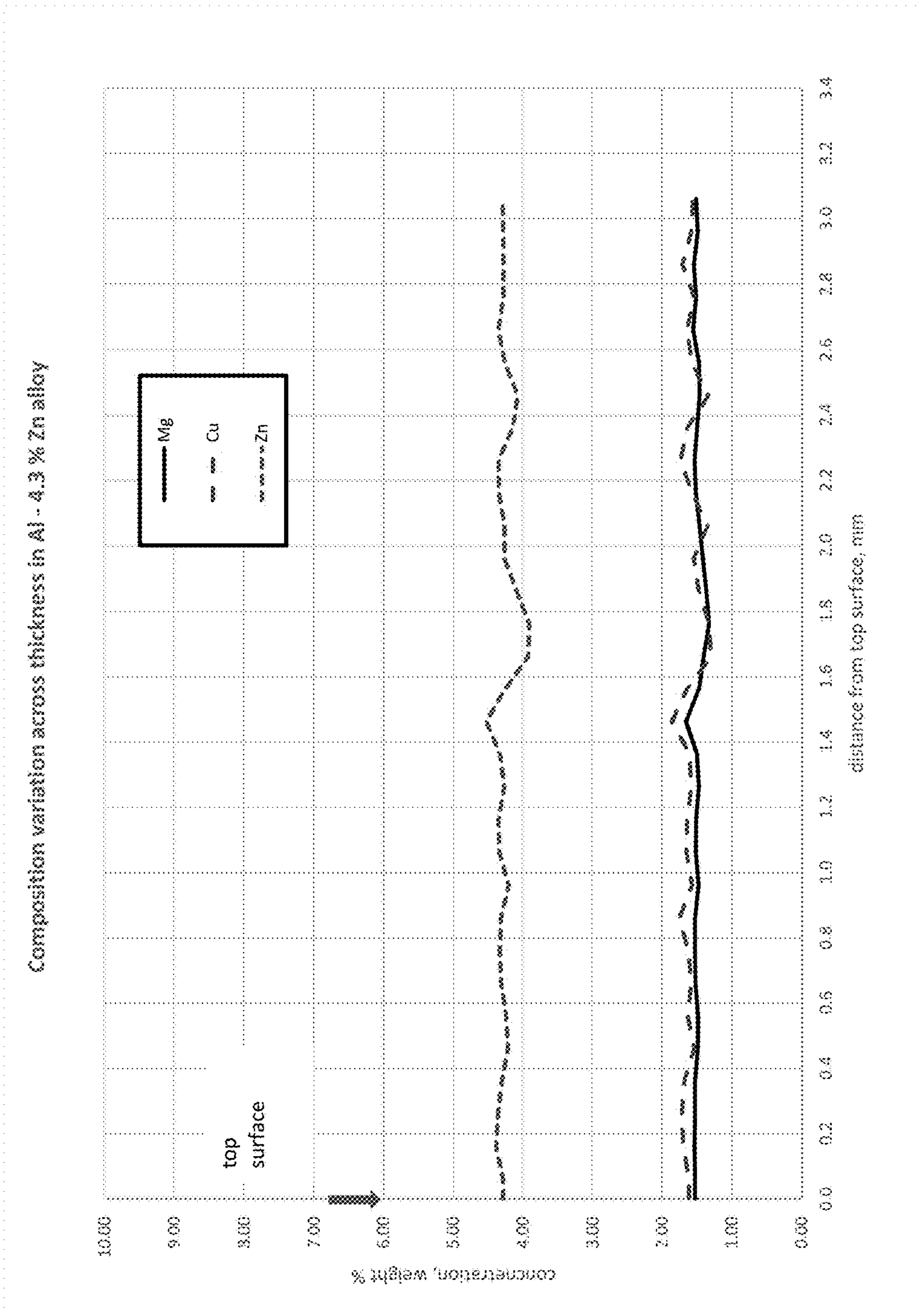

Composition variation across thickness in Al - 4.3 % Zn alloy
Mg
Cu
Zn
top surface
concentration, weight %
distance from top surface, mm
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

FIGURE 3

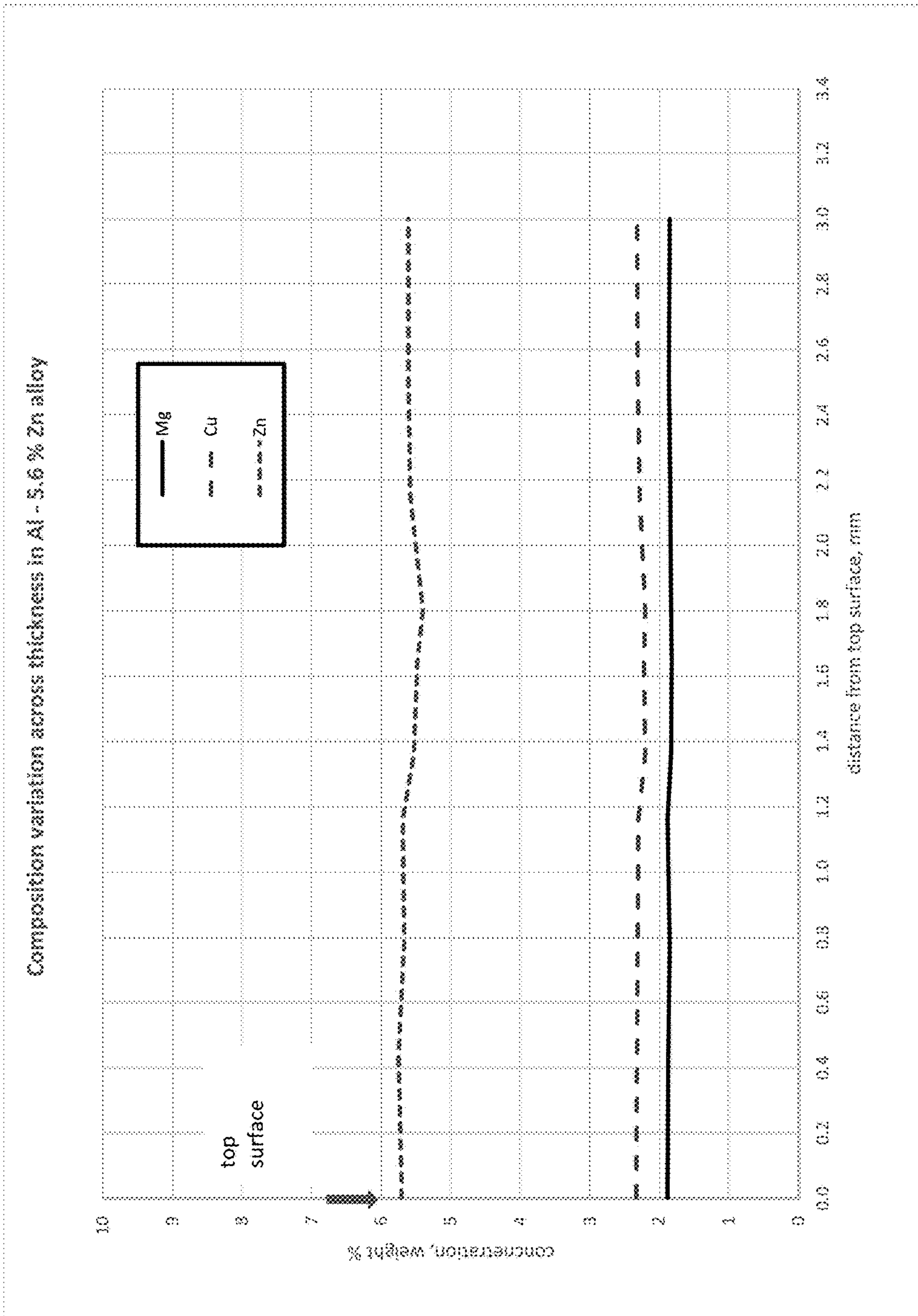

Composition variation across thickness in Al - 5.6 % Zn alloy
Mg
Cu
Zn
top surface
concentration, weight %
distance from top surface, mm

FIGURE 4

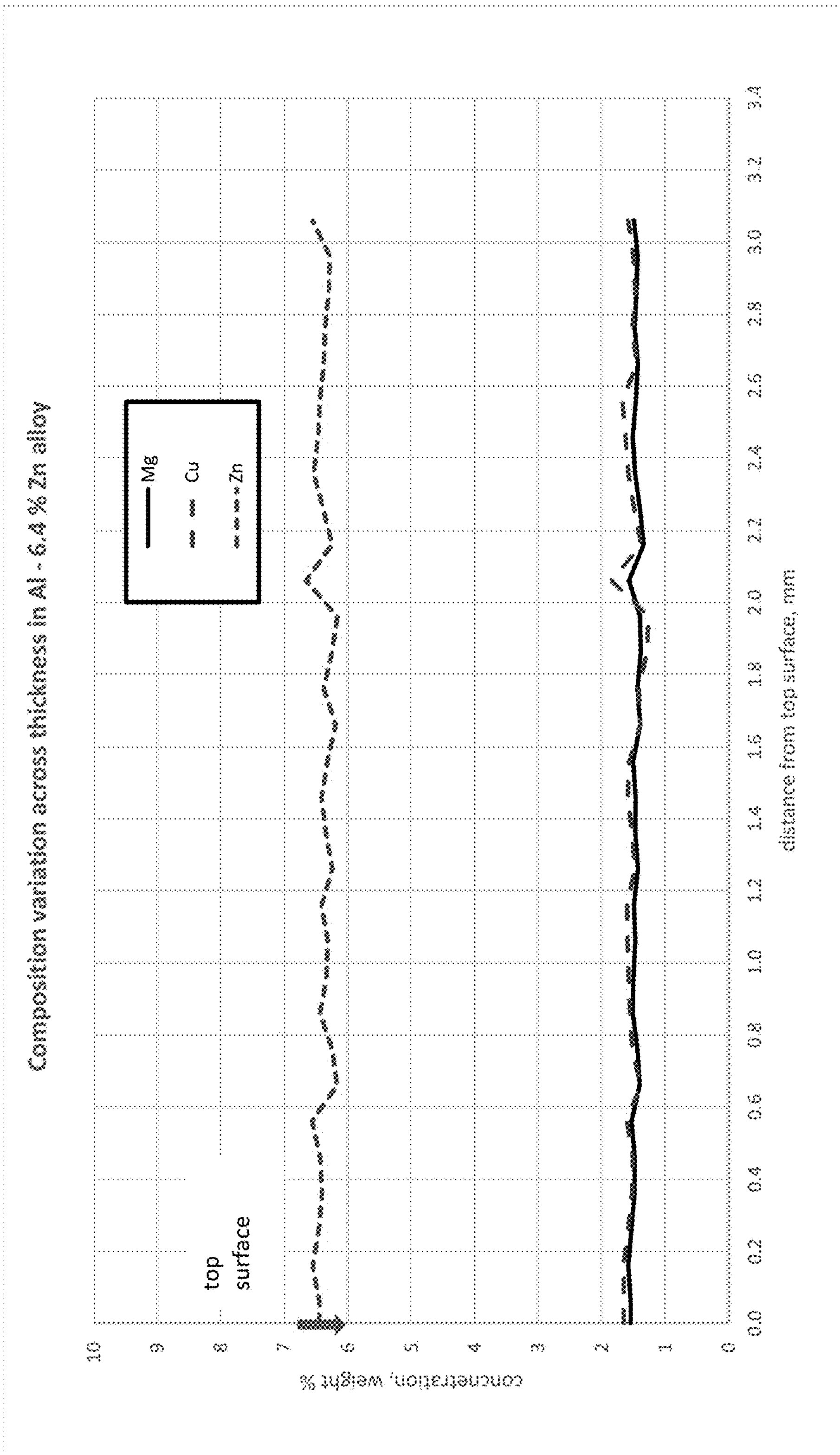

Composition variation across thickness in Al - 6.4 % Zn alloy
Mg
Cu
Zn
top surface
concentration, weight %
distance from top surface, mm
0 1 2 3 4 5 6 7 8 9 10
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4

FIGURE 5

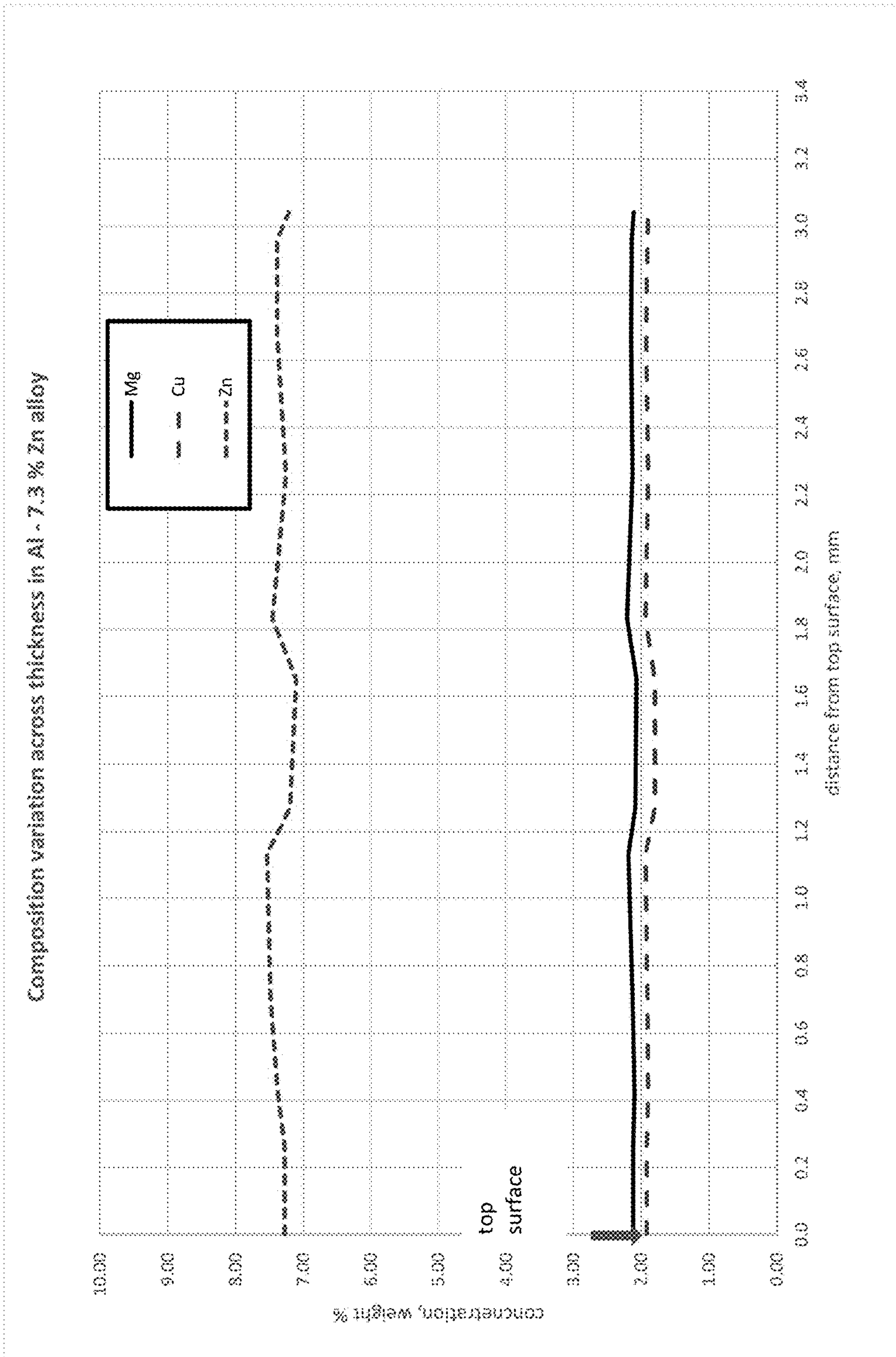

Composition variation across thickness in Al - 7.3 % Zn alloy
Mg
Cu
Zn
top surface
concnetration, weight %
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
distance from top surface, mm

FIGURE 6

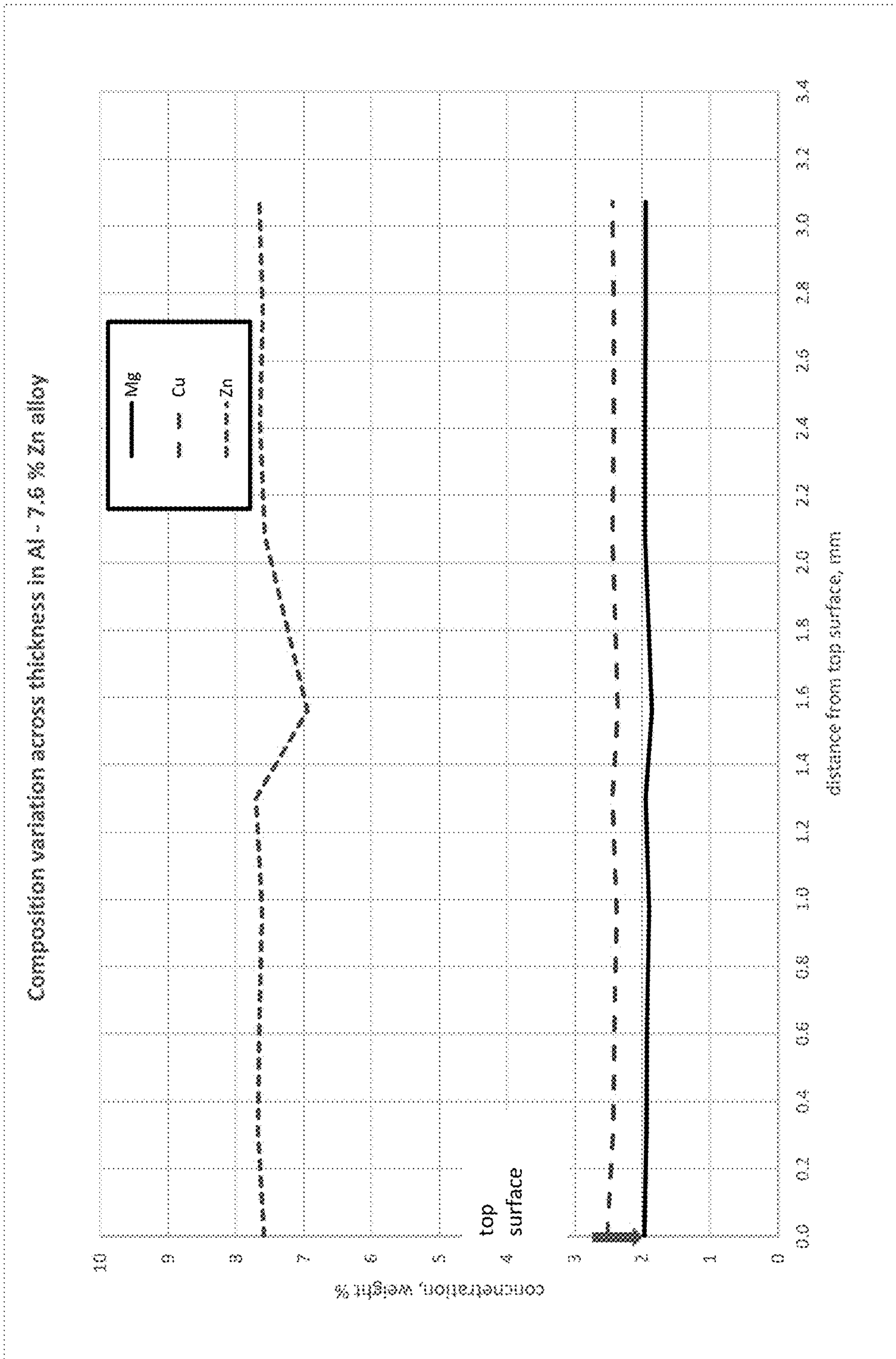

Composition variation across thickness in Al - 7.6 % Zn alloy
Mg
Cu
Zn
top surface
concnetration, weight %
distance from top surface, mm
0 1 2 3 4 5 6 7 8 9 10
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4

FIGURE 7

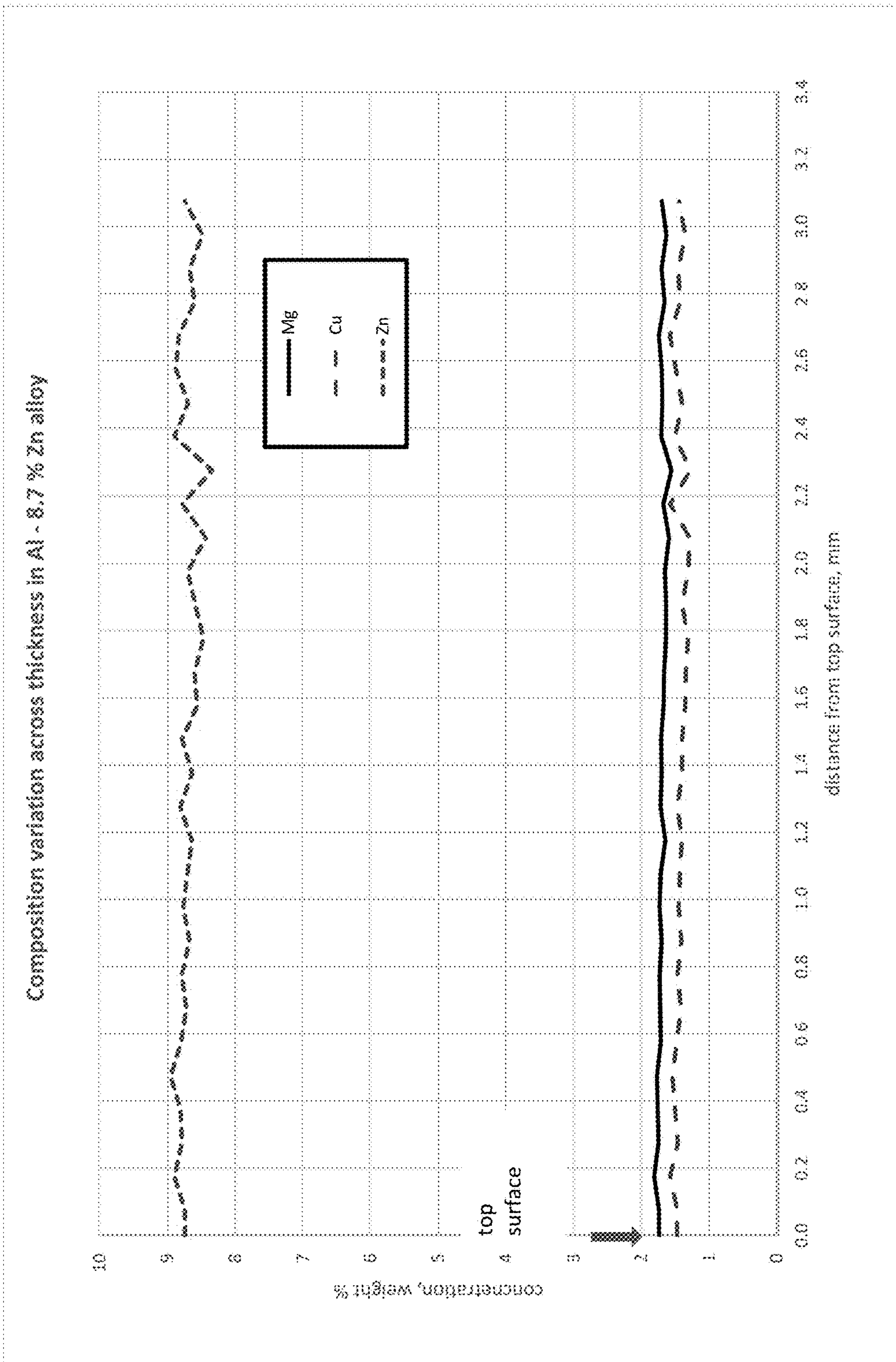

Composition variation across thickness in Al - 8.7 % Zn alloy
concentration, weight %
distance from top surface, mm
top
surface
Mg
Cu
Zn
0
1
2
3
4
5
6
7
8
9
10
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

FIGURE 8

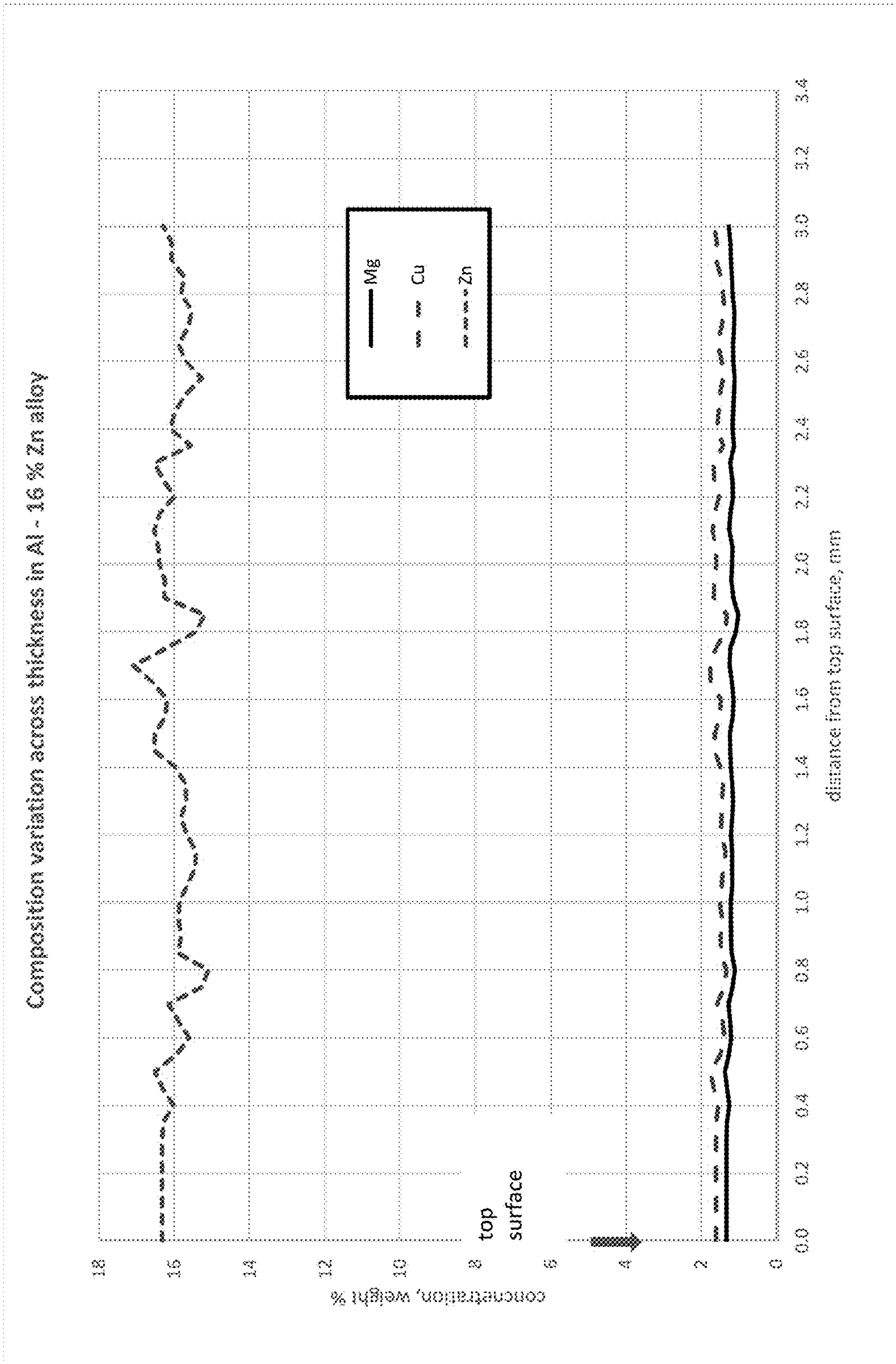

Composition variation across thickness in Al - 16 % Zn alloy
concentration, weight %
18
16
14
12
10
8
6
4
2
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
distance from top surface, mm
top surface
Mg
Cu
Zn

FIGURE 9

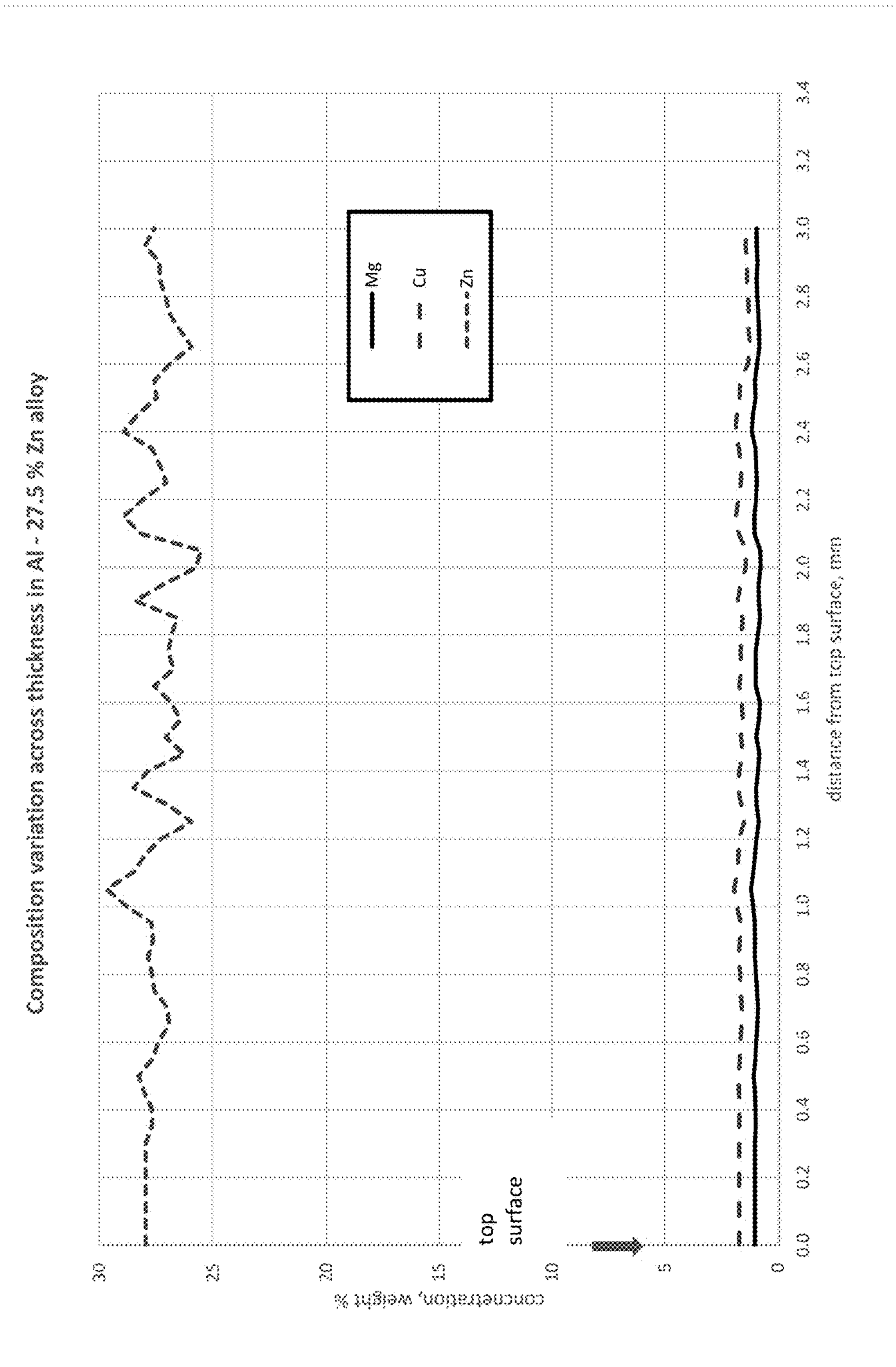
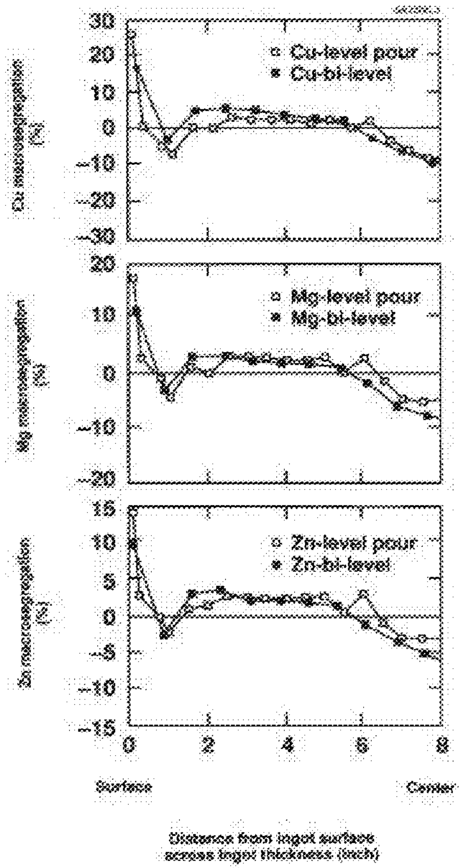

Composition variation across thickness in Al - 27.5 % Zn alloy
Mg
Cu
Zn
top surface
concnetration, weight %
distance from top surface, mm
0
5
10
15
20
25
30
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

FIGURE 10



Macrosegregation Profiles of 16"× 50" Al-Zn-Mg-Cu Ingot Cast by the Bi-level and Level Pour Methods. The y Axis Represents the Deviation of Each Major Alloy Elements from the Melt Chemistry
Figure 3

Prior Art

From M. G. Chu and J. E. Jacoby: **Macrosegregation characteristics of commercial size aluminum alloy ingot cast by the direct chill method, Light Metals 1990, ed. C. M. Bickert, The Minerals, Metals and Materials Society, 1990., pp. 925-930.**

FIGURE 11

Prior Art

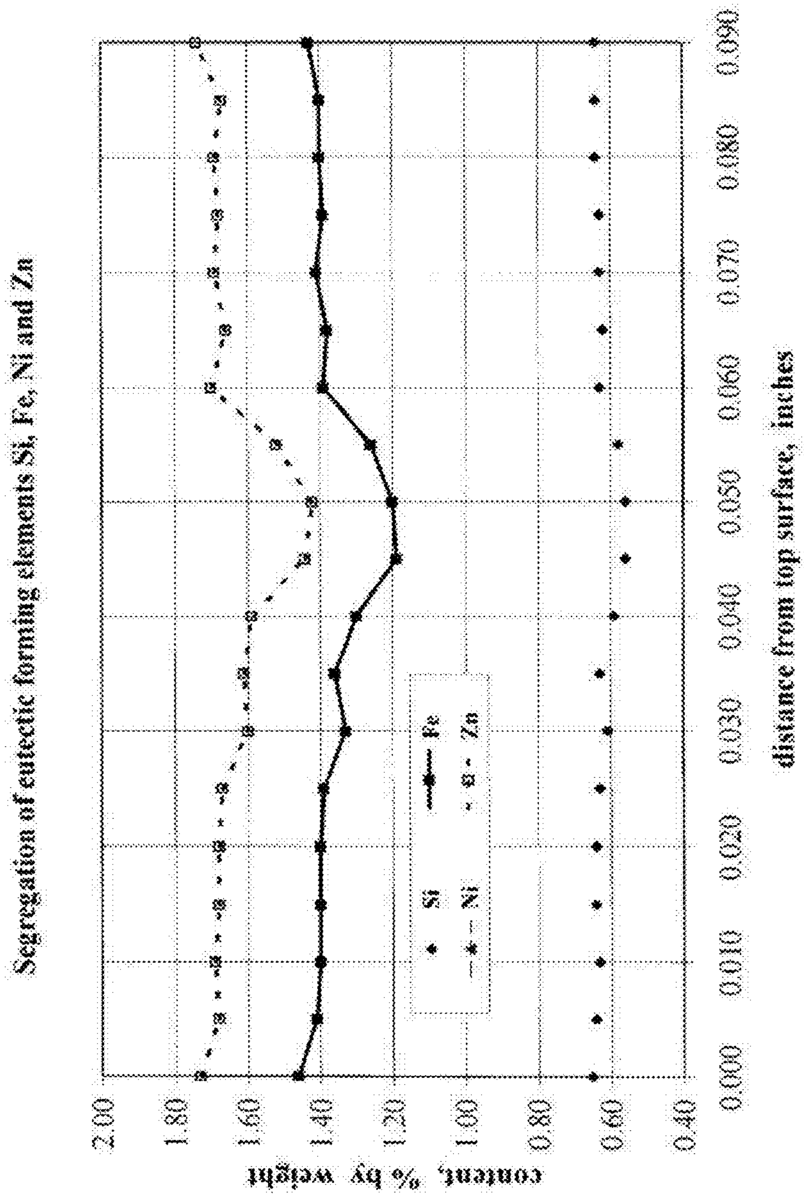


FIGURE 12

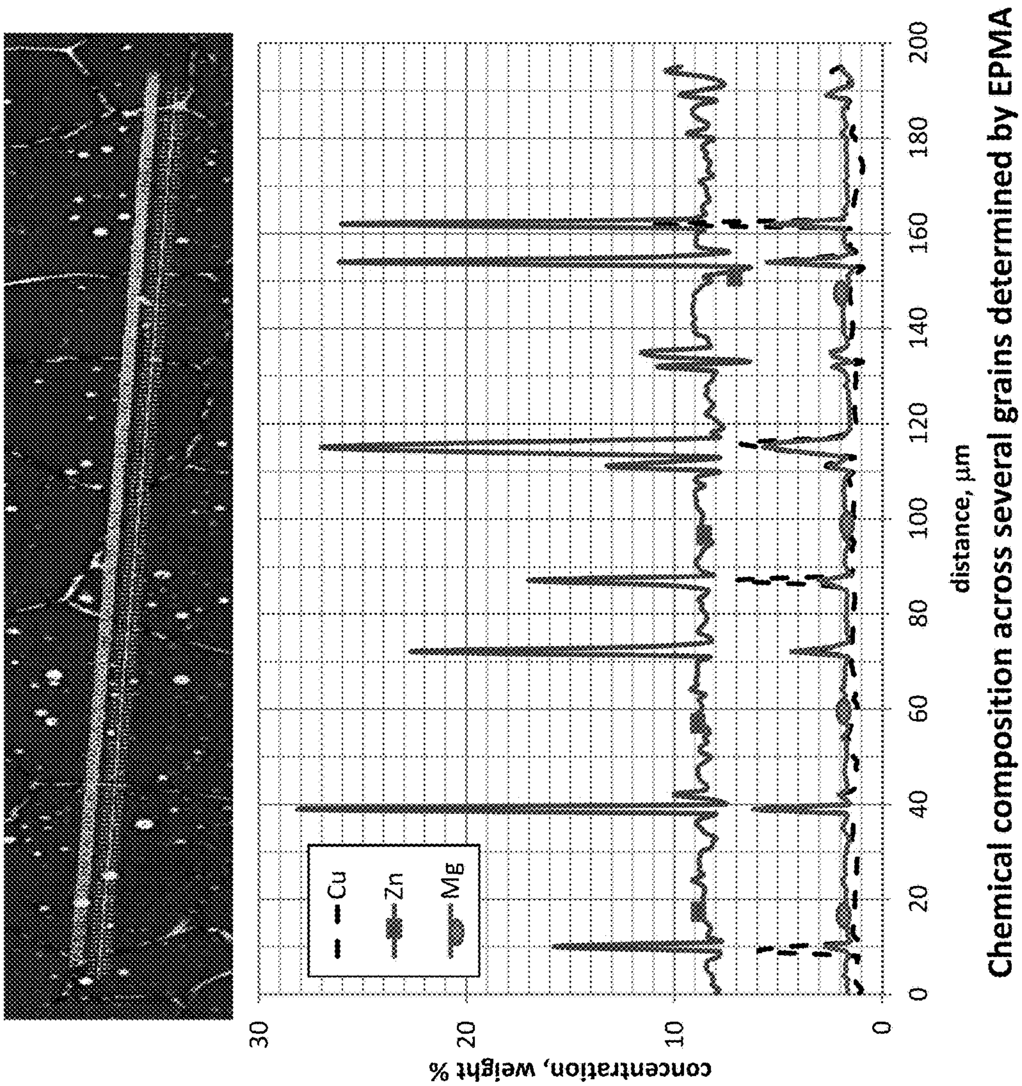

Cu
Zn
Mg
concentration, weight %
distance, μm
Chemical composition across several grains determined by EPMA

FIGURE 13

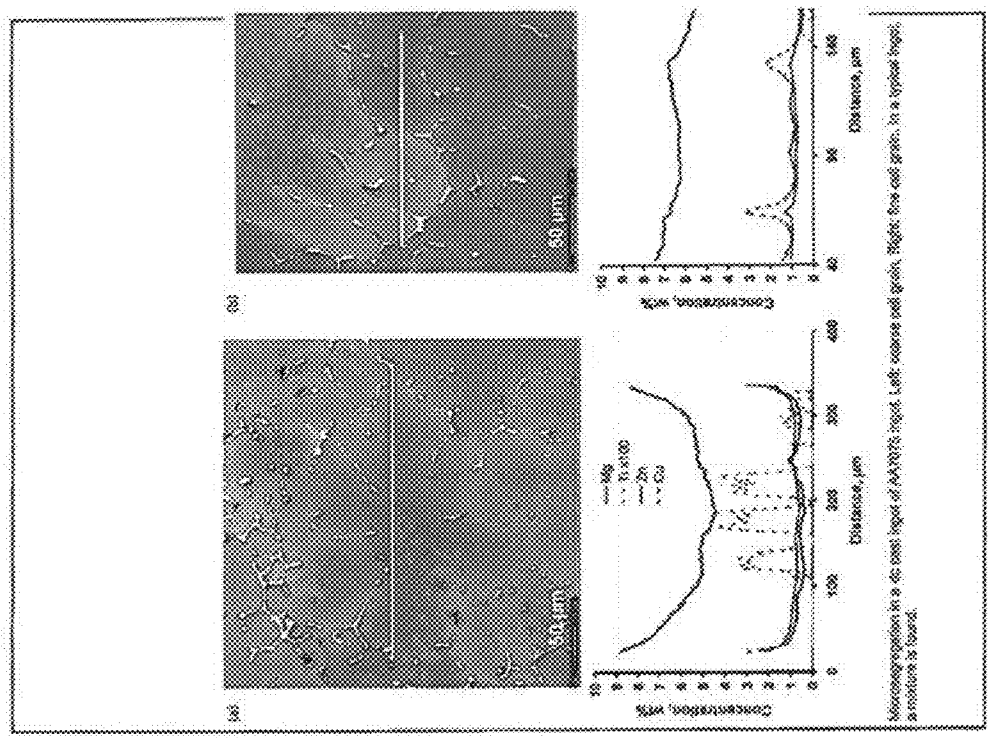


FIGURE 14

Prior Art

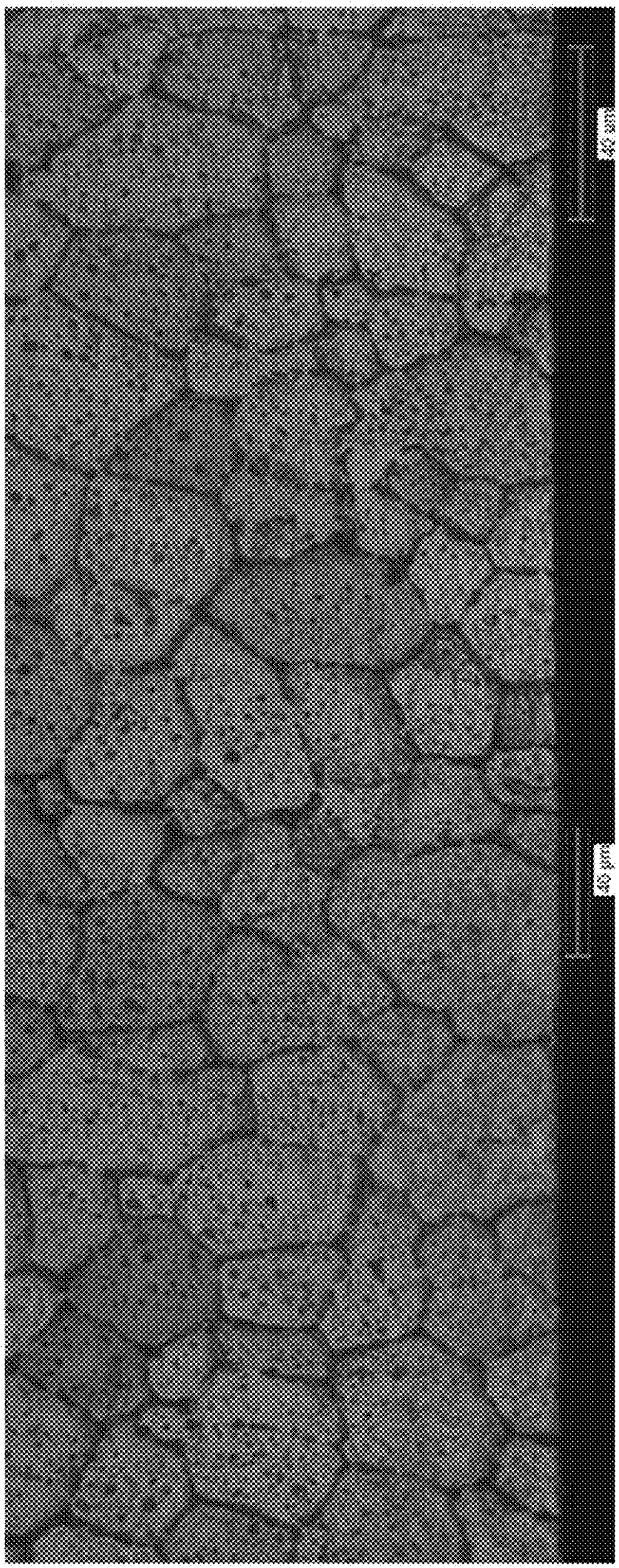


FIGURE 15

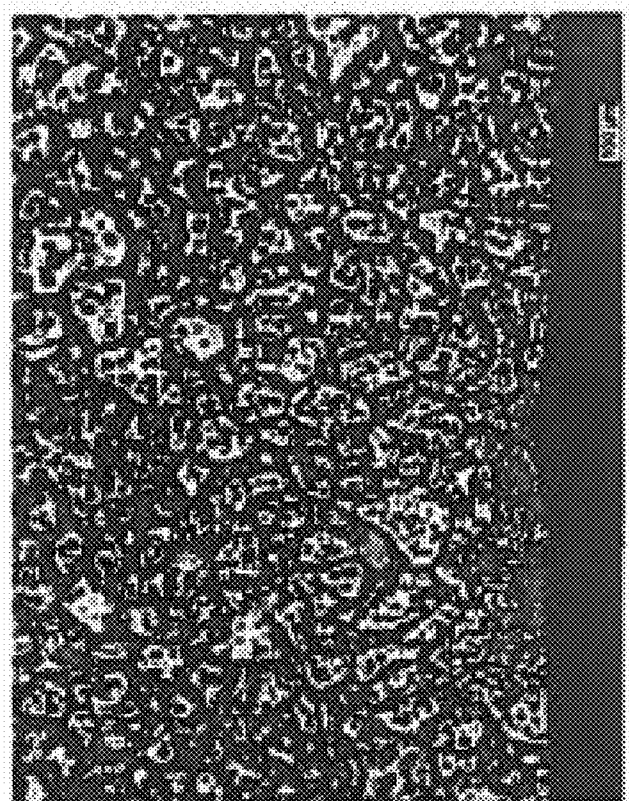


FIGURE 17

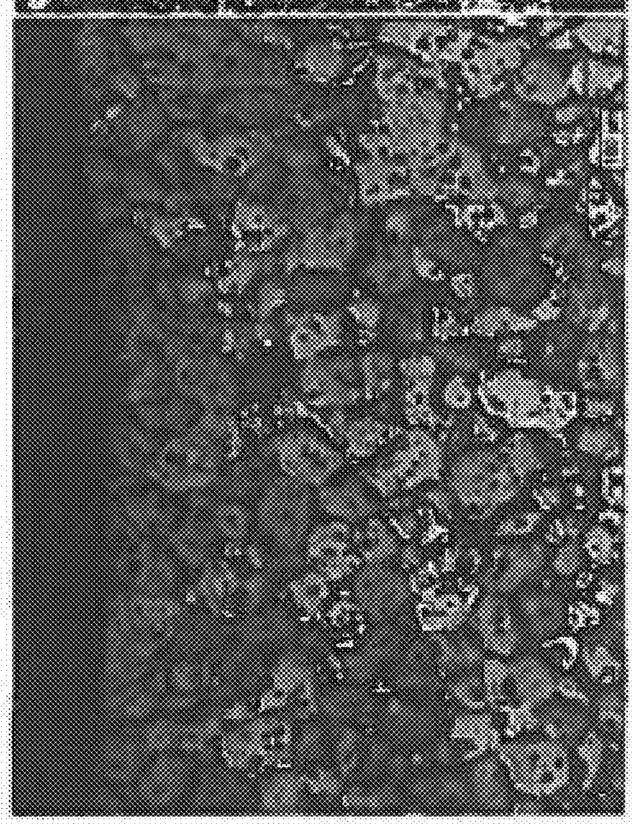


FIGURE 16

HIGH ZINC ALUMINUM ALLOY PRODUCTS

RELATED APPLICATION

[0001] This application claims the priority of U.S. provisional application Ser. No. U.S. Ser. No. 62/437,489, entitled "High Zinc Aluminum Alloy Products" filed Dec. 21, 2016, which is incorporated herein by reference in its entirety for all purposes.

BACKGROUND OF INVENTION

[0002] Casting aluminum alloys to form cast aluminum alloy products is known.

TECHNICAL FIELD

[0003] The present invention relates to cast aluminum alloy products, and products derived therefrom.

BRIEF SUMMARY OF INVENTION

[0004] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: 4 wt. % to 28 wt. % zinc; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

[0005] In one or more embodiments detailed herein, the aluminum alloy strip comprises 6 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 8 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 10 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 6 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 8 wt. % zinc.

[0006] In one or more embodiments detailed herein, the variation of the zinc weight percent is 12% or less between the surface and the thickness center of the aluminum alloy strip.

[0007] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: (i) 4 wt. % to 28 wt. % zinc; (ii) 1 wt. % to 3 wt. % copper; and (iii) 1 wt. % to 3 wt. % magnesium; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

[0008] In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc.

[0009] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % copper.

[0010] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % magnesium.

[0011] In one or more embodiments detailed herein, the cast product comprises an aluminum alloy strip; wherein the aluminum alloy strip comprises: 4 wt. % to 28 wt. % zinc and 1 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a schematic of a non-limiting method of making the cast product;

[0013] FIG. **2** is an enlarged cross-sectional schematic of the molten metal delivery tip and rolls shown in FIG. **1**;

[0014] FIG. **3** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0015] FIG. **4** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0016] FIG. **5** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0017] FIG. **6** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0018] FIG. **7** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0019] FIG. **8** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0020] FIG. **9** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0021] FIG. **10** shows the variation in zinc weight percentage from surface to a thickness depth of 3,000 micrometers in a cast product;

[0022] FIG. **11** shows the variation in zinc weight percentage through depth of a prior art ingot cast by direct chill casting;

[0023] FIG. **12** shows the variation in zinc weight percentage through depth of a prior art cast product;

[0024] FIG. **13** shows the weight percentages of zinc, magnesium and copper across grains from the surface to 200 micrometers thickness depth in a cast product according to an embodiment of the present invention.

[0025] FIG. **14** shows the weight percentages of the zinc, magnesium and copper across grains through thickness depth for a direct chill cast prior art product;

[0026] FIG. **15** shows the structure of a cast product according to an embodiment of the present invention;

[0027] FIG. **16** shows the structure of a cast product according to an embodiment of the present invention; and

[0028] FIG. **17** shows the structure of a cast product according to an embodiment of the present invention.

[0029] The figures constitute a part of this specification and include illustrative embodiments of the present invention and illustrate various objects and features thereof. Further, the figures are not necessarily to scale, some features may be exaggerated to show details of particular components. In addition, any measurements, specifications and the like shown in the figures are intended to be illustrative, and not restrictive. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

[0030] The present invention will be further explained with reference to the attached drawings, wherein like structures are referred to by like numerals throughout the several views. The drawings shown are not necessarily to scale, with emphasis instead generally being placed upon illustrating the principles of the present invention. Further, some features may be exaggerated to show details of particular components.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Among those benefits and improvements that have been disclosed, other objects and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying figures. Detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely illustrative of the invention that may be embodied in various forms. In addition, each of the examples given in connection with the various embodiments of the invention which are intended to be illustrative, and not restrictive.

[0032] Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The phrases "in one embodiment" and "in some embodiments" as used herein do not necessarily refer to the same embodiment(s), though they may. Furthermore, the phrases "in another embodiment" and "in some other embodiments" as used herein do not necessarily refer to a different embodiment, although they may. Thus, as described below, various embodiments of the invention may be readily combined, without departing from the scope or spirit of the invention.

[0033] In addition, as used herein, the term "or" is an inclusive "or" operator, and is equivalent to the term "and/or," unless the context clearly dictates otherwise. The term "based on" is not exclusive and allows for being based on additional factors not described, unless the context clearly dictates otherwise. In addition, throughout the specification, the meaning of "a," "an," and "the" include plural references. The meaning of "in" includes "in" and "on."

[0034] As used herein, the term "at least one of A, B, or C" and the like, means "only A", "only B", "only C", or "any combination of A, B, and C."

[0035] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: 4 wt. % to 28 wt. % zinc; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

[0036] In one or more embodiments detailed herein, the aluminum alloy strip comprises 6 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 8 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 10 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 6 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 8 wt. % zinc.

[0037] In one or more embodiments detailed herein, the variation of the zinc weight percent is 12% or less between the surface and the thickness center of the aluminum alloy strip.

[0038] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: (i) 4 wt. % to 28 wt. % zinc; (ii) 1 wt. % to 3 wt. % copper; and (iii) 1 wt. % to 3 wt. % magnesium; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

[0039] In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc.

[0040] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % copper.

[0041] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % magnesium.

[0042] In one or more embodiments detailed herein, the cast product comprises an aluminum alloy strip; wherein the aluminum alloy strip comprises: 4 wt. % to 28 wt. % zinc and 1 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

[0043] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: 4 wt. % to 25 wt. % zinc; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip.

[0044] In one or more embodiments detailed herein, the aluminum alloy strip comprises 6 wt. % to 25 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 8 wt. % to 25 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 10 wt. % to 25 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 8 wt. % zinc.

[0045] In one or more embodiments detailed herein, the variation of the zinc weight percent is 12% or less between the surface and the thickness depth of 3,000 micrometers in the aluminum alloy strip.

[0046] In one or more embodiments detailed herein, the present invention is a cast product comprising an aluminum alloy strip; wherein the aluminum alloy strip comprises: (i) 4 wt. % to 25 wt. % zinc; (ii) 1 wt. % to 3 wt. % copper; and (iii) 1 wt. % to 3 wt. % magnesium; and wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip.

[0047] In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 12 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc.

[0048] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % copper.

[0049] In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % magnesium.

[0050] As used herein, the term "aluminum alloy" means an aluminum metal with soluble elements either in the aluminum lattice or in a phase within aluminum. Elements may include aluminum, copper, iron, magnesium, nickel, silicon, zinc, chromium, manganese, titanium, vanadium, zirconium, tin, scandium, lithium. Elements are added to influence physical properties of the aluminum alloy and performance characteristics.

[0051] As used herein, the phrase "7xxx aluminum alloys" and the like means an aluminum alloy selected from 7xxx aluminum alloys registered with the Aluminum Association and unregistered variants of the same.

[0052] As used herein, the term "cast product" means a product that has been produced by a casting method such as continuous casting as detailed in U.S. Pat. Nos. 6,672,368 and 7,125,612. In one or more embodiments detailed herein, the term "cast product" includes a product produced from the "cast product". In one or more embodiments, the term "cast product" includes a rolled product produced from the "cast product".

[0053] As used herein, the term "variation" of the weight percent of an alloying element in a specified thickness depth has units of "%" and is calculated according to the following equation:

(maximum weight percent of alloying element in the specified thickness depth−minimum weight percent of the alloying element in the specified thickness depth)/(average weight percent of the alloying element in the specified thickness depth)*100.

[0054] As used herein, the term "centerline segregation" means the enrichment or depletion of alloying elements in a central portion of an aluminum alloy strip. In embodiments, centerline segregation is determined based on a variation of the weight percent of an alloying element in a specified thickness depth of an aluminum alloy strip. In one or more embodiments detailed herein, centerline segregation is determined based on a variation of weight percent of an alloying element of greater than 15% between a surface and a thickness depth of 3,000 micrometers. In one or more embodiments detailed herein, centerline segregation is determined based on a variation of weight percent of an alloying element of greater than 15% between a surface and a thickness center of the aluminum alloy strip.

[0055] As used herein, the "weight percent of an alloying element" in a specified thickness depth is determined using the "macro-segregation procedure" detailed herein.

[0056] As used herein, the term "strip" may be of any suitable thickness, and is generally of sheet gauge (0.006 inch to 0.249 inch) or thin-plate gauge (0.250 inch to 0.400 inch), i.e., has a thickness in the range of from 0.006 inch to 0.400 inch. In one embodiment, the strip has a thickness of at least 0.040 inch. In one embodiment, the strip has a thickness of less than 0.320 inch. In one or more embodiments detailed herein, the strip has a thickness of from 0.0070 to 0.18 inches. In one or more embodiments detailed herein, the strip has a thickness of from 0.08 to 0.2 inches.

[0057] As used herein, "surface" means a top surface or a bottom surface of the cast product.

[0058] As used herein, "thickness center" means a depth of half the total thickness of the cast product or half thickness (t/2).

[0059] In one or more embodiments detailed herein, the aluminum alloy strip may include any aluminum alloy having 4 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip may include at least one of 1 wt. % to 3 wt. % copper and 1 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy may include 7xxx (zinc based) aluminum alloys.

[0060] In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 27 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 25 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 22 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 20 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 18 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 15 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 13 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 11 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 10 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 9 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 8 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 7 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 6 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 4 wt. % to 5 wt. % zinc.

[0061] In one or more embodiments detailed herein, the aluminum alloy strip has 5 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 6 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 7 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 8 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 9 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 10 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 11 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 13 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 15 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 18 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 20 wt. % to 28 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 22 wt. % to 28 wt. % zinc.

[0062] In one or more embodiments detailed herein, the aluminum alloy strip has 5 wt. % to 27 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 7 wt. % to 25 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 8 wt. % to 23 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 9 wt. % to 20 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 10 wt. % to 18 wt. % zinc. In one or more embodiments detailed herein, the aluminum alloy strip has 12 wt. % to 15 wt. % zinc.

[0063] In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.8 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.6 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.4 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.2 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.0 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.8 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.6 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.4 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.2 wt. % copper.

[0064] In one or more embodiments detailed herein, the aluminum alloy strip has 1.2 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.4 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.6 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.8 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 2.0 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 2.2 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 2.4 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 2.6 wt. % to 3 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 2.8 wt. % to 3 wt. % copper.

[0065] In one or more embodiments detailed herein, the aluminum alloy strip has 1.2 wt. % to 2.8 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.4 wt. % to 2.6 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.6 wt. % to 2.4 wt. % copper. In one or more embodiments detailed herein, the aluminum alloy strip has 1.8 wt. % to 2.2 wt. % copper.

[0066] In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.8 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.6 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.4 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.2 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 2.0 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.8 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.6 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.4 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1 wt. % to 1.2 wt. % magnesium.

[0067] In one or more embodiments detailed herein, the aluminum alloy strip has 1.2 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.4 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.6 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.8 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 2.0 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 2.2 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 2.4 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 2.6 wt. % to 3 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 2.8 wt. % to 3 wt. % magnesium.

[0068] In one or more embodiments detailed herein, the aluminum alloy strip has 1.2 wt. % to 2.8 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.4 wt. % to 2.6 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.6 wt. % to 2.4 wt. % magnesium. In one or more embodiments detailed herein, the aluminum alloy strip has 1.8 wt. % to 2.2 wt. % magnesium.

[0069] In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 1.0 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.2 wt. % to 1.0 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.4 wt. % to 1.0 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.6 wt. % to 1.0 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.8 wt. % to 1.0 wt. % manganese.

[0070] In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.8 wt. % manganese.

In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.9 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.7 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.5 wt. % manganese. In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.3 wt. % manganese.

[0071] In one or more embodiments detailed herein, the aluminum alloy strip has 0.05 wt. % to 0.3 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.3 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.15 wt. % to 0.3 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.2 wt. % to 0.3 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.25 wt. % to 0.3 wt. % chromium.

[0072] In one or more embodiments detailed herein, the aluminum alloy strip has 0.05 wt. % to 0.25 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.05 wt. % to 0.2 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.05 wt. % to 0.15 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.05 wt. % to 0.1 wt. % chromium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.15 wt. % to 0.25 wt. % chromium.

[0073] In one or more embodiments detailed herein, the aluminum alloy strip has 0.04 wt. % to 0.25 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.04 wt. % to 0.2 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.04 wt. % to 0.18 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.04 wt. % to 0.15 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.04 wt. % to 0.1 wt. % zirconium.

[0074] In one or more embodiments detailed herein, the aluminum alloy strip has 0.1 wt. % to 0.25 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.15 wt. % to 0.25 wt. % zirconium. In one or more embodiments detailed herein, the aluminum alloy strip has 0.2 wt. % to 0.25 wt. % zirconium.

[0075] In one or more embodiments detailed herein, the aluminum alloy strip has 0.07 wt. % to 0.14 wt. % zirconium.

[0076] In one or more embodiments detailed herein, the aluminum alloy strip includes at least one of zinc, copper, magnesium, manganese, chromium, or zirconium. In one or more embodiments detailed herein, the aluminum alloy strip is free of at least one of copper, magnesium, manganese, chromium, or zirconium.

[0077] In one or more embodiments detailed herein, the aluminum alloy strip may contain secondary elements and/or other elements. As used herein, "secondary elements" are Fe, Si, and/or Ti. As used herein, "other elements" includes any elements of the periodic table other than aluminum (Al), Zn, Cu, Mn, Cr, Zr, Mg, Fe, Si, and/or Ti.

[0078] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 15% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 14% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 13% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 12% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 11% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 10% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 9% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 8% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 7% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 6% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 5% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 4% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 3% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 2% or less.

[0079] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 14%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 13%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 12%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 11%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 10%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 9%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 8%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 7%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 6%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 0.1% to 5%. In one or more embodiments detailed herein, a variation of the zinc weight percent is 0.1% to 4% between a surface and a thickness center of the aluminum alloy strip.

[0080] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 1% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 2% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 3% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 4% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 5% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 6% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 7% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 8% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 9% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 10% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 11% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness center of the aluminum alloy strip is 12% to 15%.

[0081] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 15% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 14% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 13% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 12% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 11% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 10% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 9% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 8% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 7% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 6% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 5% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 4% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 3% or less. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 2% or less.

[0082] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 14%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 13%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 12%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 11%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 10%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 9%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 8%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 7%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 6%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 0.1% to 5%. In one or more embodiments detailed herein, a variation of the zinc weight percent is 0.1% to 4% between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip.

[0083] In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 1% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 2% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 3% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 4% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 5% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 6% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 7% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 8% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 9% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 10% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 11% to 15%. In one or more embodiments detailed herein, a variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the aluminum alloy strip is 12% to 15%.

[0084] In one or more embodiments detailed herein, the aluminum alloy has a zinc weight percent of 4% to 28% or any other weight percent range detailed herein and does not exhibit centerline segregation.

[0085] Non-Limiting Method for Producing Aluminum Alloy Strip

[0086] In embodiments, the casting of the aluminum alloy strip detailed herein may be accomplished via a continuous casting apparatus capable of producing continuously cast products that are solidified at high solidification rates. One example of a continuous casting apparatus capable of achieving the above-described solidification rates is the apparatus described in U.S. Pat. Nos. 6,672,368 and 7,125,612, incorporated by reference in their entirety. In one or more embodiments detailed herein, the aluminum alloy strip is continuously cast using the Micromill™ process described in U.S. Pat. Nos. 6,672,368 and 7,125,612.

[0087] In embodiments, as illustrated in FIGS. **1-2**, a molten aluminum alloy metal M may be stored in a hopper H (or tundish) and delivered through a feed tip T, in a direction B, to a pair of rolls R_1 and R_2, having respective roll surfaces D_1 and D_2, which are each rotated in respective directions A_1 and A_2, to produce a solid cast product S. In one or more embodiments detailed herein, gaps G_1 and G_2 may be maintained between the feed tip T and respective rolls R_1 and R_2 as small as possible to prevent molten metal from leaking out, and to minimize the exposure of the molten metal to the atmosphere, while maintaining a separation between the feed tip T and rolls R_1 and R_2. A plane L through the centerline of the rolls R_1 and R_2 passes through a region of minimum clearance between the rolls R_1 and R_2 referred to as the roll nip N.

[0088] In one or more embodiments detailed herein, during casting, the molten metal M directly contacts the cooled rolls R_1 and R_2 at regions **2** and **4**, respectively. Upon contact with the rolls R_1 and R_2, the metal M begins to cool and solidify. The cooling metal produces an upper shell **6** of solidified metal adjacent the roll R_1 and a lower shell **8** of solidified metal adjacent to the roll R_2. The thickness of the shells **6** and **8** increases as the metal M advances towards the nip N. Large dendrites **10** of solidified metal (not shown to scale) may be produced at the interfaces between each of the upper and lower shells **6** and **8** and the molten metal M. The large dendrites **10** may be broken and dragged into a center portion **12** of the slower moving flow of the molten metal M and may be carried in the direction of arrows C_1 and C_2. The dragging action of the flow can cause the large dendrites **10** to be broken further into smaller dendrites **14** (not shown to scale). In the central portion **12** upstream of the nip N referred to as a region **16**, the metal M is semi-solid and may include a solid component (the solidified small dendrites **14**) and a molten metal component. The metal M in the region **16** may have a mushy consistency due in part to the dispersion of the small dendrites **14** therein. At the location of the nip N, some of the molten metal may be squeezed backwards in a direction opposite to the arrows C_1 and C_2. The forward rotation of the rolls R_1 and R_2 at the nip N advances substantially only the solid portion of the metal (the upper and lower shells **6** and **8** and the small dendrites **14** in the central portion **12**) while forcing molten metal in the central portion **12** upstream from the nip N such that the metal may be completely solid as it leaves the point of the nip N. In this manner and in one or more embodiments detailed herein, a freeze front of metal may be formed at the nip N. Downstream of the nip N, the central portion **12** may be a solid central portion, **18** containing the small dendrites **14** sandwiched between the upper shell **6** and the lower shell **8**. In the central portion, **18**, the small dendrites **14** may be 20 microns to 50 microns in size and have a generally globular shape. The three portions, of the upper and lower shells **6** and **8** and the solidified central portion **18**, constitute a single, solid cast product (S in FIG. **1** and element **20** in FIG. **2**). Thus, the aluminum alloy cast product **20** may include a first portion of an aluminum alloy and a second portion of the aluminum alloy (corresponding to the shells **6** and **8**) with an intermediate portion (the solidified central portion **18**) therebetween. The solid central portion **18** may constitute 20 percent to 30 percent of the total thickness of the cast product **20**.

[0089] The rolls R_1 and R_2 may serve as heat sinks for the heat of the molten metal M. In one embodiment, heat may be transferred from the molten metal M to the rolls R_1 and R_2 in a uniform manner to ensure uniformity in the surface of the cast product **20**. Surfaces D_1 and D_2 of the respective rolls R_1 and R_2 may be made from steel, copper, nickel, or other suitable material and may be textured and may include surface irregularities (not shown) which may contact the molten metal M.

[0090] The control, maintenance and selection of the appropriate speed of the rolls R_1 and R_2 may impact the ability to continuously cast products. The roll speed determines the speed that the molten metal M advances towards the nip N. If the speed is too slow, the large dendrites **10** will not experience sufficient forces to become entrained in the central portion **12** and break into the small dendrites **14**. In one or more embodiments detailed herein, the roll speed may be selected such that a freeze front, or point of complete solidification, of the molten metal M may form at the nip N. Accordingly, the present casting apparatus and methods may be suited for operation at high speeds such as those ranging from 25 to 500 feet per minute; alternatively from 40 to 500 feet per minute; alternatively from 40 to 400 feet per minute; alternatively from 100 to 400 feet per minute; and alternatively from 150 to 300 feet per minute. The linear rate per unit area that molten aluminum is delivered to the rolls R_1 and R_2 may be less than the speed of the rolls R_1 and R_2 or about one quarter of the roll speed.

[0091] Continuous casting of aluminum alloys according to the present disclosure may be achieved by initially selecting the desired dimension of the nip N corresponding to the desired gauge of the cast product S. The speed of the rolls R_1 and R_2 may be increased to a desired production rate or to a speed which is less than the speed which causes the roll separating force increases to a level which indicates that rolling is occurring between the rolls R_1 and R_2. Casting at the rates contemplated by an embodiment of the present invention (i.e. 25 to 400 feet per minute) solidifies the aluminum alloy cast product about 1000 times faster than aluminum alloy cast as an ingot cast and improves the properties of the cast product over aluminum alloys cast as an ingot. The rate at which the molten metal is cooled may be selected to achieve rapid solidification of the outer regions of the metal. Indeed, the cooling of the outer regions of metal may occur at a rate of at least 1000 degrees Celsius per second.

[0092] The continuous cast strip may be of any suitable thickness, and is generally of sheet gauge (0.006 inch to 0.249 inch) or thin-plate gauge (0.250 inch to 0.400 inch), i.e., has a thickness in the range of from 0.006 inch to 0.400 inch. In one embodiment, the strip has a thickness of at least 0.040 inch. In one embodiment, the strip has a thickness of less than 0.320 inch.

[0093] Macro-Segregation Procedure

[0094] Samples are first mounted and polished in Lucite using standard metallographic preparation techniques for aluminum. An Electron Probe Micro Analyzer ("EPMA") is used to profile the distribution of the alloying elements across a thickness to show the macro-segregation of the alloying elements.

[0095] EPMA line scans are set with an initial spot of 100 micrometers diameter about 50 micrometers from the sample surface moving in the thickness direction until the other surface is reached. The defocused beam spots are calculated to maintain a 50 micrometer separation to provide 50% overlap between points.

[0096] A JEOL JXA 8530F Field Emission Electron Probe Microanalyzer Hyperprobe with 4 Wave dispersive spectrometers and JEOL SDD-EDS are used to gather the data. The operating conditions are:

[0097] Accelerating Voltage: 15 kV

[0098] Beam Intensity: 100 nA

[0099] Defocus electron beam: 100 μm

[0100] Line scan profile step 50 μm

[0101] Analyzed elements may include: Ti, Zr, Mg, Si, Mn, Fe, Cu, Zn and Al

[0102] The wave dispersive spectrometer (WDS) crystal and spectrometers are used as detailed in the Table 1.

TABLE 1

Spectrometer	Diffracting Crystal	Counter	Element
1	PETJ	Gas Flow (P-10)	Ti, Zr
2	TAP	Gas Flow (P-10)	Mg, Si
3	LIFH	Sealed Xe gas	Mn, Fe
4	LIFL	Sealed Xe gas	Cu, Zn
5		SDD-EDS	Al

The counting time is 10 seconds for all elements

[0103] A background measurement is collected every 50 spots for 5 seconds on positive and negative background locations. Elements measured are quantitatively analyzed using the JEOL quant ZAF analysis package for metals with atomic number correction by Philibert-Tixier method and flourescence excitation correction by Reed method.

[0104] Alternately, the concentration of alloying elements through depth of a sample was determined using a quantometer consistent with the method used to analyze the samples from U.S. Pat. No. 6,672,368.

[0105] Micro-Segregation Procedure

[0106] Samples are first mounted and polished in Lucite using standard metallographic preparation techniques for aluminum. An EPMA is used to profile the distribution of the alloying elements across a thickness to show the micro-segregation of the alloying elements.

[0107] EPMA line scans are set with a focused spot moving with a 1 micrometer step across several grains to provide overlapping points through multiple grains.

[0108] A JEOL JXA 8530F Field Emission Electron Probe Microanalyzer Hyperprobe with 4 Wave dispersive spectrometers and JEOL SDD-EDS are used to gather the data. The operating conditions are:

[0109] Accelerating Voltage: 15 kV

[0110] Beam Intensity: 100 nA

[0111] Focused electron beam

[0112] Line scan profile step 1 μm

[0113] Analyzed elements may include: Ti, Zr, Mg, Si, Mn, Fe, Cu, Zn and Al

[0114] The WDS crystal and spectrometers are used as detailed in Table 1.

[0115] A background measurement is collected every 50 spots for 5 seconds on positive and negative background locations. Elements measured are quantitatively analyzed using the JEOL quant ZAF analysis package for metals with atomic number correction by Philibert-Tixier method and flourescence excitation correction by Reed method.

[0116] Non-Limiting Examples

[0117] Aluminum alloy samples were cast using the apparatus detailed in U.S. Pat. No. 6,672,368 at a speed of 55 feet per minute to 85 feet per minute and had a final thickness detailed in the tables below. The average weight percentages of the zinc, magnesium and copper from the surface to 3,000 micrometers thickness depth in each sample was determined using either the "macro-segregation" procedure detailed herein or via quantometer. Table 2 below shows the average weight percentages of zinc, copper and magnesium from surface to a thickness depth of 3,000 micrometers in each of the cast samples and the method used to determine the weight percentages in each sample:

TABLE 2

Sample	Thickness (mm)	Avg. Zn wt. %	Avg. Mg wt. %	Avg. Cu wt. %	Method
1	3.5	4.26	1.50	1.59	macro-segregation procedure
2	3.3	5.60	1.85	2.28	quantometer
3	3.9	6.38	1.47	1.53	macro-segregation procedure
4	3.4	7.34	2.13	1.90	quantometer
5	3.4	7.56	1.94	2.42	quantometer
6	4.1	8.71	1.68	1.43	macro-segregation procedure
7	3.9	15.98	1.21	1.53	macro-segregation procedure
8	3.6	27.46	0.97	1.64	macro-segregation procedure

[0118] Table 3 below shows the variation of zinc weight percentages in each of the samples from surface to a thickness depth of 3,000 micrometers:

TABLE 3

Sample	Min. Zn wt. %	Max. Zn wt. %	Avg. Zn wt. %	Variation (%)
1	3.91	4.52	4.26	14.40
2	5.40	5.75	5.60	6.25
3	6.17	6.66	6.38	7.68
4	7.11	7.54	7.34	5.86
5	6.95	7.71	7.56	10.05
6	8.34	8.96	8.71	7.12
7	15.10	17.09	15.98	12.45
8	25.53	29.70	27.46	15.19

[0119] The average weight percentages of the zinc, magnesium and copper from the surface to the thickness center in each sample were determined using either the "macro-segregation" procedure detailed herein or via quantometer. Table 4 below shows the average weight percentages of zinc, copper and magnesium from surface to a thickness center in each of the cast samples and the method used to determine the weight percentages in each sample:

TABLE 4

Sample	Thickness (mm)	Avg. Zn wt. %	Avg. Mg wt. %	Avg. Cu wt. %	Method
1	3.5	4.27	1.50	1.61	macro-segregation procedure
2	3.3	5.64	1.86	2.28	quantometer
3	3.9	6.36	1.47	1.52	macro-segregation procedure
4	3.4	7.33	2.12	1.88	quantometer
5	3.4	7.54	1.93	2.42	quantometer
6	4.1	8.71	1.70	1.42	macro-segregation procedure
7	3.9	15.97	1.21	1.52	macro-segregation procedure

TABLE 4-continued

Sample	Thickness (mm)	Avg. Zn wt. %	Avg. Mg wt. %	Avg. Cu wt. %	Method
8	3.6	27.54	0.99	1.70	macro-segregation procedure

[0120] Table 5 below shows the variation of zinc weight percentages in each of the samples from surface to a thickness center in each sample:

TABLE 5

Sample	Min. Zn wt. %	Max. Zn wt. %	Avg. Zn wt. %	Variation (%)
1	3.91	4.52	4.27	14.29
2	5.48	5.75	5.64	4.79
3	6.17	6.57	6.36	6.29
4	7.11	7.54	7.33	5.87
5	6.95	7.71	7.54	10.08
6	8.44	8.96	8.71	5.97
7	15.10	17.09	15.97	12.46
8	25.96	29.70	27.54	13.58

[0121] The data generated for each sample is plotted in FIGS. **3-10**. A comparison the weight percentages of the zinc, magnesium and copper through thickness of a direct chill cast prior art product and a continuously cast prior art product of U.S. Pat. No. 6,672,368 are also included as FIGS. **11-12** for comparison.

[0122] As shown in FIGS. **3-10** and the tables above, the inventors surprisingly found that the variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in samples 1-7 according to the present invention is less than 15%. Moreover, the variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers of sample 8 is greater than 15%. Similarly, based on visual inspection of FIGS. **11-12**, the variation of the zinc weight percent between a surface and a thickness depth of 3,000 micrometers in the direct chill cast prior art product and the continuously cast prior art product is greater than 15%.

[0123] As shown in FIGS. **3-10** and the tables above, the inventors surprisingly found that the variation of the zinc weight percent between a surface and a thickness center in samples 1-8 according to the present invention is less than 15%. Moreover, based on visual inspection of FIGS. **11-12**, the variation of the zinc weight percent between a surface and a thickness center of the direct chill cast prior art product and the continuously cast prior art product is greater than 15%.

[0124] The weight percentages of the zinc, magnesium and copper across grains from the surface to 200 micrometers thickness depth in sample 6 was determined using the "micro-segregation" procedure detailed herein. The data is presented in FIG. **13**. For comparison, the weight percentages of the zinc, magnesium and copper across grains through thickness for a direct chill cast prior art product are shown in FIG. **14**. As shown in FIG. **13**, the inventors surprisingly found that the weight percent of the primary alloying elements Zn, Cu and Mg were substantially uniform across the grains within the matrix with an increase in the weight percent of the alloying elements at the positions of second phase particles at grain boundaries and within the grains.

[0125] FIG. **15** shows the structure of sample 6. The structure of samples of aluminum alloys having average zinc contents of 16% and 25% cast using the apparatus detailed in U.S. Pat. No. 6,672,368 at a speed of 55 feet per minute are shown in FIGS. **16** and **17**, respectively. FIGS. **15-17** show products of the present invention have a globular grain structure and are substantially free of micro-segregation. Moreover, as illustrated in FIGS. **15-17**, the products of the present invention may be substantially free of dendrites and consist primarily of globular non-dendritic grains—i.e., a globular grain structure. Also, as shown by the absence of shading within the grains of FIGS. **15-17** when the samples are observed in polarized light, the products are substantially free of micro-segregation effects.

[0126] While a number of embodiments of the present invention have been described, it is understood that these embodiments are illustrative only, and not restrictive, and that many modifications may become apparent to those of ordinary skill in the art. Further still, the various steps may be carried out in any desired order (and any desired steps may be added and/or any desired steps may be eliminated).

We claim:

1. A cast product comprising:
an aluminum alloy strip;
wherein the aluminum alloy strip comprises:
4 wt. % to 28 wt. % zinc; and
wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

2. The cast product of claim **1**, wherein the aluminum alloy strip comprises 6 wt. % to 28 wt. % zinc.

3. The cast product of claim **1**, wherein the aluminum alloy strip comprises 8 wt. % to 28 wt. % zinc.

4. The cast product of claim **1**, wherein the aluminum alloy strip comprises 10 wt. % to 28 wt. % zinc.

5. The cast product of claim **1**, wherein the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc

6. The cast product of claim **1**, wherein the aluminum alloy strip comprises 6 wt. % to 12 wt. % zinc.

7. The cast product of claim **1**, wherein the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc.

8. The cast product of claim **1**, wherein the aluminum alloy strip comprises 4 wt. % to 8 wt. % zinc.

9. The cast product of claim **6**, wherein the variation of the zinc weight percent is 12% or less between the surface and the thickness center of the aluminum alloy strip.

10. A cast product comprising:
an aluminum alloy strip;
wherein the aluminum alloy strip comprises:
(i) 4 wt. % to 28 wt. % zinc;
(ii) 1 wt. % to 3 wt. % copper; and
(iii) 1 wt. % to 3 wt. % magnesium;
wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

11. The cast product of claim **10**, wherein the aluminum alloy strip comprises 4 wt. % to 15 wt. % zinc

12. The cast product of claim **10**, wherein the aluminum alloy strip comprises 4 wt. % to 12 wt. % zinc.

13. The cast product of claim **10**, wherein the aluminum alloy strip comprises 4 wt. % to 10 wt. % zinc.

14. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % copper.

15. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % copper.

16. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % copper.

17. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 2.5 wt. % magnesium.

18. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 2.0 wt. % magnesium.

19. The cast product of claim **10**, wherein the aluminum alloy strip comprises 1 wt. % to 1.5 wt. % magnesium.

20. A cast product comprising:
an aluminum alloy strip;
wherein the aluminum alloy strip comprises:
(i) 4 wt. % to 28 wt. % zinc; and
(ii) 1 wt. % to 3 wt. % copper;
wherein a variation of a weight percent of the zinc is 15% or less between a surface and a thickness center of the aluminum alloy strip.

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