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(54) **ALUMINUM ALLOY WITH HIGH RECYCLED CONTENT FOR STRUCTURAL HIGH PRESSURE DIE CASTING**

(57) A recycled aluminum alloy used to form a portion of an improved aluminum alloy, which can be cast into a vehicle component, is provided. The recycled aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper; 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20

wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %. Preferably, the recycled aluminum alloy in an amount of 50 wt. % is mixed with the primary aluminum alloy in an amount of 50 wt. % to form the improved aluminum alloy.

Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Sr	Others	Total Others
Aural 2 (ingot) Primary	10 - 11.0	0.13 - 0.20	0.03 max	0.47 - 0.55	0.27 - 0.33	0.03 max	0.04 - 0.07	0.01 - 0.03	0.03 max	0.10 max
Aural 2R50 Secondary	9.5 - 11.5	0.25 - 0.5	0.20 - 0.40	0.45 - 0.65	0.20 - 0.35	0.2 - 0.4	0.01 - 0.10	0.01 - 0.1	0.05 max	0.15 max

FIG. 1

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. Non-Provisional Patent Application claims the benefit of and priority to U.S. Provisional Patent Application Serial No. 63/754,035 filed February 5, 2025, entitled "Aluminum Alloy With High Recycled Content For Structural High Pressure Die Casting," the contents of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates generally to a recycled aluminum alloy, an improved aluminum alloy formed in part from the recycled aluminum alloy, a method of manufacturing the improved aluminum alloy using the recycled aluminum alloy, and a method of manufacturing a component by casting the improved aluminum alloy.

2. Related Art

[0003] Casting of aluminum alloys is oftentimes used in the automotive industry to form lightweight components, including structural, body-in-white, suspension, and chassis components. There are many types of known casting processes, for example, high pressure die casting, low pressure casting, and squeeze casting. The die is typically formed of a hardened tool steel. Although the casting equipment is expensive, the cost per component formed is relatively low, which makes the process suitable for high volume production.

[0004] A series of aluminum alloys which include silicon and magnesium, referred to as the "Aural" aluminum alloys, have been developed to manufacture structural components by high pressure die casting. These aluminum alloys provide a good combination of castability (fluidity) and mechanical properties after a heat treatment process is applied to the alloy.

[0005] Some aluminum alloys are "primary" alloys and thus include low amounts of impurities. Alternatively, aluminum alloys could be "secondary" aluminum alloys or "recycled" aluminum alloys, which have a significantly lower carbon footprint than primary alloys. However, the secondary aluminum alloys typically include higher amounts of impurities, such as Fe, Cu, and Zn, which can make it difficult to meet desired customer specifications, such as the Aural alloy specifications. For example, the yield strength, tensile strength, elongation, corrosion resistance, rivetability, and/or castability of the recycled aluminum alloys may not be sufficient for manufacturing structural components by high pressure die casting. Advanced degassing or filtration methods can be used to remove impurities from recycled aluminum alloys and meet specifications, but these processes are costly. In

addition, the availability of recycled aluminum alloys is limited, and the amount required by production foundries may not be available. Thus, aluminum alloys made with a high content of recycled materials, and which are able to meet desired specifications are needed.

SUMMARY

[0006] One aspect of the invention provides a recycled aluminum alloy which can be mixed with a primary aluminum alloy to form an improved aluminum alloy, also referred to as an Aural 2R aluminum alloy. The recycled aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper; 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20 wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy.

[0007] Another aspect of the disclosure provides a method of manufacturing the improved aluminum alloy by mixing the recycled aluminum alloy and the primary aluminum alloy. The recycled aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper; 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20 wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy. The primary aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; up to 0.25 wt. % iron; up to 0.05 wt. % copper; 0.40 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 0.05 wt. % zinc; up to 0.12 wt. % titanium; 0.010 wt. % to 0.025 wt. % strontium; other elements each in an amount up to 0.030 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy. The improved aluminum alloy formed by mixing the recycled aluminum alloy and the primary aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.20 wt. % to 0.60 wt. % iron; 0.10 wt. % to 0.60 wt. % copper; 0.20 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 1.5 wt. % zinc; up to 0.15 wt. % titanium; 0.010 wt. % to 0.070 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the improved aluminum alloy.

[0008] Yet another aspect of the disclosure provides a method of manufacturing a component, for example a structural component for a vehicle, by mixing the recycled aluminum alloy with the primary aluminum alloy to form the improved aluminum alloy, and then casting the improved aluminum alloy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a table listing compositions of a recycled aluminum alloy (Aural 2R50) and a primary aluminum alloy (Aural 2), which are used to form an improved aluminum alloy (Aural 2R), according to example embodiments;

Figure 2 is a table listing a composition of the primary aluminum alloy (Aural 2) in the form of an ingot, an approximate composition of the primary aluminum alloy (Aural 2) during production, a composition of the recycled aluminum alloy (Aural 2R50), and a composition of the improved aluminum alloy (Aural 2R) according to example embodiments;

Figure 3 includes an example composition of the primary aluminum alloy (Aural 2) in the form of an incoming ingot for use in production of the improved aluminum alloy (Aural 2R) according to an example embodiment;

Figure 4 illustrates a method of manufacturing the improved aluminum alloy according to a first example embodiment;

Figure 5 includes the compositions of the recycled aluminum alloy (Aural 2R50), the primary aluminum alloy (Aural 2), and the improved aluminum alloy (Aural 2R) formed according to the method of Figure 4;

Figure 6 illustrates a method of manufacturing the improved aluminum alloy (Aural 2R) according to a second example embodiment;

Figure 7 includes the compositions of the recycled aluminum alloy (Aural 2R50), the primary aluminum alloy (Aural 2), and the improved aluminum alloy (Aural 2R) formed according to the method of Figure 6;

Figure 8 illustrates mechanical properties of the primary aluminum alloy (Aural 2) and the improved aluminum alloy (Aural 2R) after F tempering, after annealing, and after the T7 process, according to example embodiments;

Figure 9 illustrates a microstructure of the improved aluminum alloy (Aural 2R) after F tempering, after annealing, and after the T7 process, according to example embodiments; and

Figures 10 and 11 compare processes of producing a cast component from the primary aluminum alloy to processes of producing a cast component from the improved aluminum alloy according to an example embodiment.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0010] One aspect of the disclosure provides a recycled aluminum alloy which can be mixed with a primary aluminum alloy, and optionally at least one other aluminum alloy, to form an improved aluminum alloy. The new recycled aluminum alloy can be referred to as a secondary alloy, and specifically "Aural 2R50". The primary aluminum alloy can be referred to as "Aural 2". The improved aluminum alloy can also be referred to as a recycled or secondary alloy, and specifically "Aural 2R". The improved aluminum alloy can be used to form components by high pressure die casting, which may be under a vacuum. The improved aluminum alloy formed in part of the recycled aluminum alloy is also capable of achieving acceptable yield strength, tensile strength, elongation, corrosion resistance, rivetability, and/or castability. For example, the improved aluminum alloy can meet Aural 2 alloy specifications.

[0011] At least a portion of the recycled aluminum alloy is made from recycled materials, and preferably at least 90% or at least 95% or at 100% of the recycled aluminum alloy is made from recycled materials. According to example embodiments, the recycled aluminum alloy (Aural 2R50) includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper; 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20 wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy.

[0012] According to a preferred embodiment, the recycled aluminum alloy (Aural 2R50) includes at least 80 weight percent (wt. %) aluminum; 10.2 wt. % silicon; 0.32 wt. % iron; 0.30 wt. % copper; 0.59 wt. % manganese; 0.28 wt. % magnesium; 0.30 wt. % zinc; 0.06 wt. % titanium; 0.015 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy. Example compositions of the recycled aluminum alloy (Aural 2R50) are disclosed in Figures 1 and 2.

[0013] The recycled aluminum alloy is mixed with the primary aluminum alloy to form the improved aluminum alloy. The primary aluminum alloy has a lower level of impurities than the recycled aluminum alloy and is typically more expensive to produce or obtain than the recycled aluminum alloy. For example, the amount of other elements present in the primary aluminum alloy is limited to 0.03 wt. % for each element and in a total amount of no more than 0.10 wt. %, based on the total weight of the primary aluminum alloy. Costly processes such as degassing and filtration systems may be used to form the primary aluminum alloy with limited impurities. The primary aluminum alloy is typically provided in the form of an

ingot, and then melted, but may be provided in other forms.

[0014] According to the example embodiment, the primary aluminum alloy (Aural 2) includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; up to 0.25 wt. % iron; up to 0.05 wt. % copper; 0.40 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 0.05 wt. % zinc; up to 0.12 wt. % titanium; 0.010 wt. % to 0.025 wt. % strontium; other elements each in an amount up to 0.030 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy.

[0015] According to a preferred embodiment, the primary aluminum alloy (Aural 2) is provided in the form of an ingot and includes at least 80 weight percent (wt. %) aluminum; 10.2 wt. % silicon; 0.20 wt. % iron; 0.05 wt. % copper; 0.64 wt. % manganese; 0.33 wt. % magnesium; 0.01 wt. % zinc; 0.06 wt. % titanium; 0.020 wt. % strontium; other elements each in an amount up to 0.030 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy.

[0016] According to another example embodiment, the primary aluminum alloy (Aural 2) is provided in another form. The composition of the primary aluminum alloy at a doser unit in a production process, according to this example embodiment, includes at least 80 weight percent (wt. %) aluminum; 10.26 wt. % silicon; 0.17 wt. % iron; 0.01 wt. % copper; 0.486 wt. % manganese; 0.323 wt. % magnesium; 0.00 wt. % zinc; 0.062 wt. % titanium; 0.020 wt. % strontium; other elements each in an amount up to 0.03 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy. Example compositions of the primary aluminum alloy (Aural 2) are disclosed in Figures 1-3.

[0017] The method of forming the improved aluminum alloy (Aural 2R) includes mixing the recycled aluminum alloy with the primary aluminum alloy. According to a first example embodiment, the method of forming the improved aluminum alloy includes mixing the recycled aluminum alloy (Aural 2R50) in an amount of 40 wt. % to 60 wt. % with the primary aluminum alloy (Aural 2) in an amount of 40 wt. % to 60 wt. %, or the recycled aluminum alloy in an amount of 45 wt. % to 55 wt. % with the primary aluminum alloy in an amount of 45 wt. % to 55 wt. %. In other words, the improved aluminum alloy is formed from 40 wt. % to 60 wt. % of the recycled aluminum alloy and 40 wt. % to 60 wt. % of the primary aluminum alloy, or 45 wt. % to 55 wt. % of the recycled aluminum alloy and 45 wt. % to 55 wt. % of the primary aluminum alloy. According to a preferred embodiment, the improved aluminum alloy (Aural 2R) includes 50 wt. % of the recycled aluminum alloy (Aural 2R50) and 50 wt. % of the primary aluminum alloy (Aural 2). Figure 4 illustrates a method of manufacturing the improved aluminum alloy according to this first example embodiment. Figure 5 includes the compositions of the recycled aluminum alloy, the primary aluminum alloy, and the improved aluminum alloy formed according to the first example embodiment.

[0018] According to a second example embodiment,

the method of forming the improved aluminum alloy includes mixing the recycled aluminum alloy with the primary aluminum alloy and scrap formed of the improved aluminum alloy. The scrap can be obtained from previous production of the improved aluminum alloy, for example, when the improved aluminum alloy is formed according to the first example embodiment. For example, the method can include mixing the recycled aluminum alloy in an amount of 10 wt. % to 30 wt. % with the primary aluminum alloy in an amount of 10 wt. % to 30 wt. % and the scrap improved aluminum alloy in an amount of 50 wt. % to 70 wt. %, based on the total weight of the mixture. More preferably, the method includes mixing the recycled aluminum alloy in an amount of 15 wt. % to 25 wt. % with the primary aluminum alloy in an amount of 15 wt. % to 25 wt. % and the scrap improved aluminum alloy in an amount of 55 wt. % to 65 wt. %, based on the total weight of the mixture. In other words, the improved aluminum alloy is formed from 10 wt. % to 30 wt. % of the recycled aluminum alloy, 10 wt. % to 30 wt. % of the primary aluminum alloy, and 50 wt. % to 70 wt. % of the scrap improved aluminum alloy, and more preferably from 15 wt. % to 25 wt. % of the recycled aluminum alloy, 15 wt. % to 25 wt. % of the primary aluminum alloy, and 55 wt. % to 65 wt. % of the scrap improved aluminum alloy. According to a preferred embodiment, the improved aluminum alloy (Aural 2R) includes 20 wt. % of the recycled aluminum alloy (Aural 2R50), 20 wt. % of the primary aluminum alloy (Aural 2), and 60 wt. % of the scrap improved aluminum alloy (Aural 2R). Figure 6 illustrates a method of manufacturing the improved aluminum alloy according to this second example embodiment. Figure 7 includes the compositions of the recycled aluminum alloy, primary aluminum alloy, and the improved aluminum alloy formed according to the second example embodiment.

[0019] According to example embodiments, after the mixing step, the improved aluminum alloy (Aural 2R) includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.20 wt. % to 0.60 wt. % iron; 0.10 wt. % to 0.60 wt. % copper; 0.20 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 1.5 wt. % zinc; up to 0.15 wt. % titanium; 0.010 wt. % to 0.070 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the improved aluminum alloy.

[0020] According to a preferred embodiment, the improved aluminum alloy (Aural 2R) includes at least 80 weight percent (wt. %) aluminum; 10.2 wt. % silicon; 0.25 wt. % iron; 0.12 wt. % copper; 0.60 wt. % manganese; 0.32 wt. % magnesium; 0.15 wt. % zinc; 0.06 wt. % titanium; 0.020 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the improved aluminum alloy.

[0021] The improved aluminum alloy, made from the mixture of the recycled aluminum alloy and the primary aluminum alloy and optionally the scrap, can be used to form components by casting, preferably high pressure

vacuum die casting. Expensive processes, such as filtration and degassing, are not required to remove impurities from the recycled aluminum alloy prior to the mixing step. The filtration and degassing processes are also not needed to remove impurities from the improved aluminum alloy prior to the casting process.

[0022] Typically, the casting process is a high pressure vacuum die casting process and includes melting the improved aluminum alloy and then casting the melted improved aluminum alloy to form a solid component having the shape of the mold, which can be a complex shape. This casting process is conducted under high pressure and under a vacuum, which is preferably less than 60 millibar. This high pressure vacuum die casting typically includes applying a pressure of 40 to 60 MPa to the melted improved aluminum alloy while the melted improved aluminum alloy is at a temperature ranging from 680 to 710° C and the temperature of the die ranges from 150 to 250° C.

[0023] The cast component formed from the casting step can be, for example, a component for use in a vehicle. Many different types of components can be formed by the casting process, for example, a structural, body-in-white, suspension, or chassis component. Typically, after the casting process, the castings are only subjected to a one stage annealing at lower temperature than a solution treatment, which provides the advantage of reduced process time and costs compared to a T7 heat treatment. This one stage annealing process can include annealing at a temperature ranging from 660 to 752° F for 1 to 2 hours.

[0024] However, after the casting process, the cast improved aluminum alloy could be subject to another annealing or heat treating, for example a T7 process. This process typically includes solution heat treating the improved aluminum alloy, quenching the improved aluminum alloy, and the stabilizing the improved aluminum alloy by artificial aging. According to an example embodiment, the T7 process includes heating the improved aluminum alloy to a temperature of about 860 to 914° F for about 40 to 70 minutes, quenching the improved aluminum alloy, and then aging the improved aluminum alloy at a temperature of about 392 to 428° F for about 1 to 3 hrs.

[0025] Figure 8 illustrates mechanical properties of the improved aluminum alloy (Aural 2R) after tempering (F temper condition), after annealing at a temperature ranging from 660 to 752° F for 1 to 2 hours, and after the T7 process, according to example embodiments. According to an example embodiment, after the T7 process, the cast improved aluminum alloy made in part of the recycled aluminum alloy has a yield strength of about 144 MPa, an ultimate tensile strength (UTS) of about 207 MPa, and an elongation of about 13.5%. Figure 9 illustrates the microstructure of the improved aluminum alloy (Aural 2R) after tempering (F temper condition), after annealing at a temperature of 707° F for 1.1 hours, and after the T7 process, according to example embodiments.

[0026] Figure 10 compares the process of producing a cast component from the primary aluminum alloy (Aural 2) to the process of producing a cast component from the improved aluminum alloy (Aural 2R) according to an example embodiment. According to this embodiment, the improved aluminum alloy (Aural 2R) is formed of 20 wt. % of the recycled aluminum alloy (Aural 2R50), 20 wt. % of the primary aluminum alloy (Aural 2), and 60 wt. % of the scrap improved aluminum alloy (Aural 2R). Figure 11 compares the process of producing a cast component from the primary aluminum alloy (Aural 2) to the process of producing a cast component from the improved aluminum alloy (Aural 2R) according to an example embodiment. The annealing step in the process of producing the improved aluminum alloy according to Figure 11 is a one stage annealing process and includes heating the cast aluminum alloy at a temperature ranging from 660 to 752° F for 1 to 2 hours, for example 707° F for 1.1 hours. As shown in Figure 11, the process of producing the cast component from the improved aluminum alloy requires fewer steps, which can save energy, time, and related costs.

[0027] The improved aluminum alloy made in part from the recycled aluminum alloy is able to meet desired customer specifications. For example, the improved aluminum alloy made in part from the recycled aluminum alloy has sufficient yield strength, tensile strength, elongation, corrosion resistance, rivetability, and castability. In addition, the recycled aluminum alloy can be provided in the form of an ingot and can be produced at a location different from the casting location. The use of the recycled aluminum alloy also helps address an issue associated with limited availability of recycled materials and limited secondary scrap ingot production.

[0028] When the improved aluminum alloy is formed of equal parts of the recycled aluminum alloy and the primary aluminum alloy, the improved aluminum alloy includes a recycled content of at least 30 wt. %, based on the total weight of the improved aluminum alloy. Also when the improved aluminum alloy is formed of equal parts of the recycled aluminum alloy and the primary aluminum alloy, the recycled aluminum alloy compensates for chemical composition differences between the primary aluminum alloy and the improved aluminum alloy. The recycled aluminum alloy allows scrap yards with limited capacity to provide high volumes of the improved aluminum alloy. For example, a foundry may require around 11,300 to 12,000 tons per year of the improved aluminum alloy. The scrap yard supplier could provide 5,650 to 6,000 tons of the recycled aluminum alloy and another supplier could provide the primary aluminum alloy.

[0029] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the following claims.

Claims

1. A recycled aluminum alloy, comprising:
at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper, 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20 wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy.
2. The recycled aluminum alloy of claim 1 including at least 80 weight percent (wt. %) aluminum; 10.2 wt. % silicon; 0.32 wt. % iron; 0.30 wt. % copper; 0.59 wt. % manganese; 0.28 wt. % magnesium; 0.30 wt. % zinc; 0.06 wt. % titanium; 0.015 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy.
3. A method of manufacturing an improved aluminum alloy, comprising the steps of:

mixing a recycled aluminum alloy with a primary aluminum alloy;
the recycled aluminum alloy including at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.25 wt. % to 0.50 wt. % iron; 0.20 wt. % to 0.40 wt. % copper, 0.45 to 0.65 wt. % manganese; 0.20 wt. % to 0.35 wt. % magnesium; 0.20 wt. % to 0.40 wt. % zinc; 0.01 wt. % to 0.10 wt. % titanium; 0.01 wt. % to 0.10 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the recycled aluminum alloy;
the primary aluminum alloy including at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; up to 0.25 wt. % iron; up to 0.05 wt. % copper, 0.40 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 0.05 wt. % zinc; up to 0.12 wt. % titanium; 0.010 wt. % to 0.025 wt. % strontium; other elements each in an amount up to 0.030 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy.
4. The method of claim 3, wherein the recycled aluminum alloy is present in an amount of 40 wt. % to 60 wt. % and the primary aluminum alloy is present in an amount of 40 wt. % to 60 wt. %, based on the total weight of the mixture, wherein in particular the recycled aluminum alloy is present in an amount of 50 wt. % and the primary aluminum alloy is present in an amount of 50 wt. %, based on the total weight of the mixture.
5. The method of claim 3, wherein the improved aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.20 wt. % to 0.60 wt. % iron; 0.10 wt. % to 0.60 wt. % copper, 0.20 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 1.5 wt. % zinc; up to 0.15 wt. % titanium; 0.010 wt. % to 0.070 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the improved aluminum alloy.
6. The method of claim 3, wherein a portion of the improved aluminum alloy is formed into a component and a portion of the improved aluminum alloy is scrap.
7. The method of claim 6 further including mixing the recycled aluminum alloy and the primary aluminum alloy with the scrap to form the improved aluminum alloy.
8. The method of claim 7, wherein the recycled aluminum alloy is present in an amount of 10 wt. % to 30 wt. %, the primary aluminum alloy is present in an amount of 10 wt. % to 30 wt. %, and the scrap is present in an amount of 50 wt. % to 70 wt. %, based on the total weight of the mixture.
9. The method of claim 8, wherein the recycled aluminum alloy is present in an amount of 20 wt. %, the primary aluminum alloy is present in an amount of 20 wt. %, and the scrap is present in an amount of 60 wt. %, based on the total weight of the mixture.
10. The method of claim 7, wherein the improved aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 9.5 to 11.5 wt. % silicon; 0.20 wt. % to 0.60 wt. % iron; 0.10 wt. % to 0.60 wt. % copper, 0.20 to 0.60 wt. % manganese; 0.10 wt. % to 0.60 wt. % magnesium; up to 1.5 wt. % zinc; up to 0.15 wt. % titanium; 0.010 wt. % to 0.070 wt. % strontium; other elements each in an amount up to 0.05 wt. % and in a total amount up to 0.15 wt. %, based on the total weight of the improved aluminum alloy.
11. The method of claim 3, wherein the primary aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 10.2 wt. % silicon; 0.20 wt. % iron; 0.05 wt. % copper; 0.64 wt. % manganese; 0.33 wt. % magnesium; 0.01 wt. % zinc; 0.06 wt. % titanium; 0.020 wt. % strontium; other elements each in an amount up to 0.030 wt. % and in a total amount up to 0.10 wt. %, based on the total weight of the primary aluminum alloy; or wherein the primary aluminum alloy includes at least 80 weight percent (wt. %) aluminum; 10.26 wt. % silicon; 0.17 wt. % iron; 0.01 wt. % copper; 0.486 wt. % manganese; 0.323 wt. % magnesium; 0.00 wt. %

zinc; 0.062 wt. % titanium; 0.020 wt. % strontium;
other elements each in an amount up to 0.03 wt. %
and in a total amount up to 0.10 wt. %, based on the
total weight of the primary aluminum alloy.

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- 12.** A method of manufacturing a cast component, comprising the steps of:
casting the improved aluminum alloy formed by the
method of claim 3.

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- 13.** The method of claim 12, wherein the casting step
includes casting under pressure and under a vacuum.

- 14.** The method of claim 12, wherein one of the following
a) to c) is fulfilled: 15

a) the recycled aluminum alloy is present in an
amount of 40 wt. % to 60 wt. % and the primary
aluminum alloy is present in an amount of 40 wt.
% to 60 wt. %, based on the total weight of the
mixture; 20

b) the recycled aluminum alloy is present in an
amount of 50 wt. % and the primary aluminum
alloy is present in an amount of 50 wt. %, based
on the total weight of the mixture; 25

c) the improved aluminum alloy includes at least
80 weight percent (wt. %) aluminum; 9.5 to 11.5
wt. % silicon; 0.20 wt. % to 0.60 wt. % iron; 0.10
wt. % to 0.60 wt. % copper, 0.20 to 0.60 wt. %
manganese; 0.10 wt. % to 0.60 wt. % magne-
sium; up to 1.5 wt. % zinc; up to 0.15 wt. %
titanium; 0.010 wt. % to 0.070 wt. % strontium;
other elements each in an amount up to 0.05 wt.
% and in a total amount up to 0.15 wt. %, based
on the total weight of the improved aluminum
alloy. 30 35

- 15.** The method of claim 12, wherein a portion of the
improved aluminum alloy is formed into a component
and a portion of the improved aluminum alloy is
scrap, wherein the method in particular further in-
cluding mixing the recycled aluminum alloy and the
primary aluminum alloy with the scrap to form the
improved aluminum alloy. 40 45

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Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Sr	Others	Total Others
Aural 2 (ingot) Primary	10 - 11.0	0.13 - 0.20	0.03 max	0.47 - 0.55	0.27 - 0.33	0.03 max	0.04 - 0.07	0.01 - 0.03	0.03 max	0.10 max
Aural 2R50 Secondary	9.5 - 11.5	0.25 - 0.5	0.20 - 0.40	0.45 - 0.65	0.20 - 0.35	0.2 - 0.4	0.01 - 0.10	0.01 - 0.1	0.05 max	0.15 max

FIG. 1

Examples of Chemical Composition of Secondary Aural 2R50, Aural 2R alloys
vs. Primary Aural 2 alloy ingot and Aural 2 alloy production (wt. %)

Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Sr	Others	Total Others
Aural 2 (ingot) Primary	10.26	0.17	0.01	0.486	0.323	0.00	0.062	0.020	0.03 max	0.10 max
Aural 2 (production baseline) Primary	10.10	0.19	0.02	0.50	0.30	0.01	0.06	0.023	0.05 max	0.15 max
Aural 2R Secondary	10.18	0.24	0.15	0.55	0.29	0.15	0.06	0.015	0.05 max	0.15 max
Aural 2R50 Secondary	10.20	0.32	0.30	0.59	0.28	0.30	0.06	0.015	0.05 max	0.15 max

FIG. 2

Alloy name in customer spec	Alloy in labels	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	OT
		Min	Max	Min	Max	Min	Min	Max	Min	Min	Max
AURAL-2 (Si10MnMg)	AlSi10MgMnS r	10.0	11.0	0.13	0.20				0.03	0.04	0.07
						0.27	0.33			0.03	0.10

FIG. 3

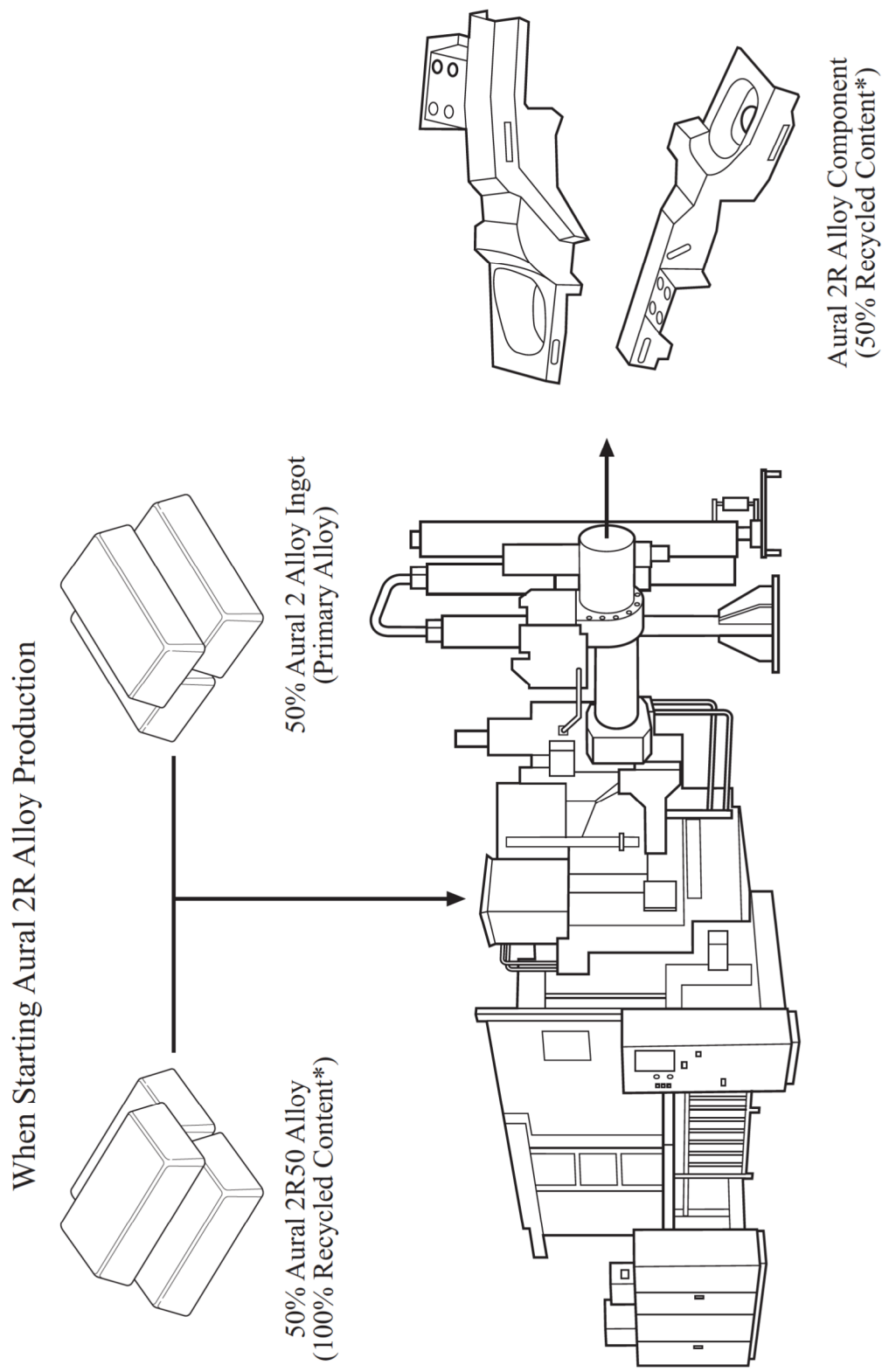


FIG. 4

Aural 2R50 100% recycled	5000	kg
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Aural 2R50 Ingot

Si	Fe	Cu	Mn	Mg	Ni	Zn	Ti	Cr	Sn	Sr
10.2	0.32	0.3	0.59	0.28		0.3	0.06	0		0.015

Aural 2 Primary Ingot	5000	kg
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C65k Ingot

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Sn	Sr
10.26	0.17	0.01	0.486	0.323		0.003	0.062	0		0.02

Weight of Elements in Melter:

Si	510	kg
Fe	16	kg
Mn	29.5	kg
Mg	14.00	kg
Sr	0.75	kg
Ti	3	kg
Cu	15	kg
Zn	15	kg

Weight of Elements in Aural 2 Primary Ingot:

Si	513	kg
Fe	8.5	kg
Mn	24.3	kg
Mg	16.15	kg
Sr	1	kg
Ti	3.1	kg
Cu	0.5	kg
Zn	0.15	kg

Weight of Elements After Mixing:

Si	1023	kg
Fe	24.5	kg
Mn	53.8	kg
Mg	30.15	kg
Sr	1.75	kg
Ti	6.1	kg
Cu	15.5	kg
Zn	15.15	kg

Aural 2R Chemical Composition After Mixing (wt. %)

Si	Fe	Mn	Mg	Sr	Ti	Cu	Zn
10.23	0.25	0.54	0.3015	0.02	0.06	0.16	0.15

FIG. 5

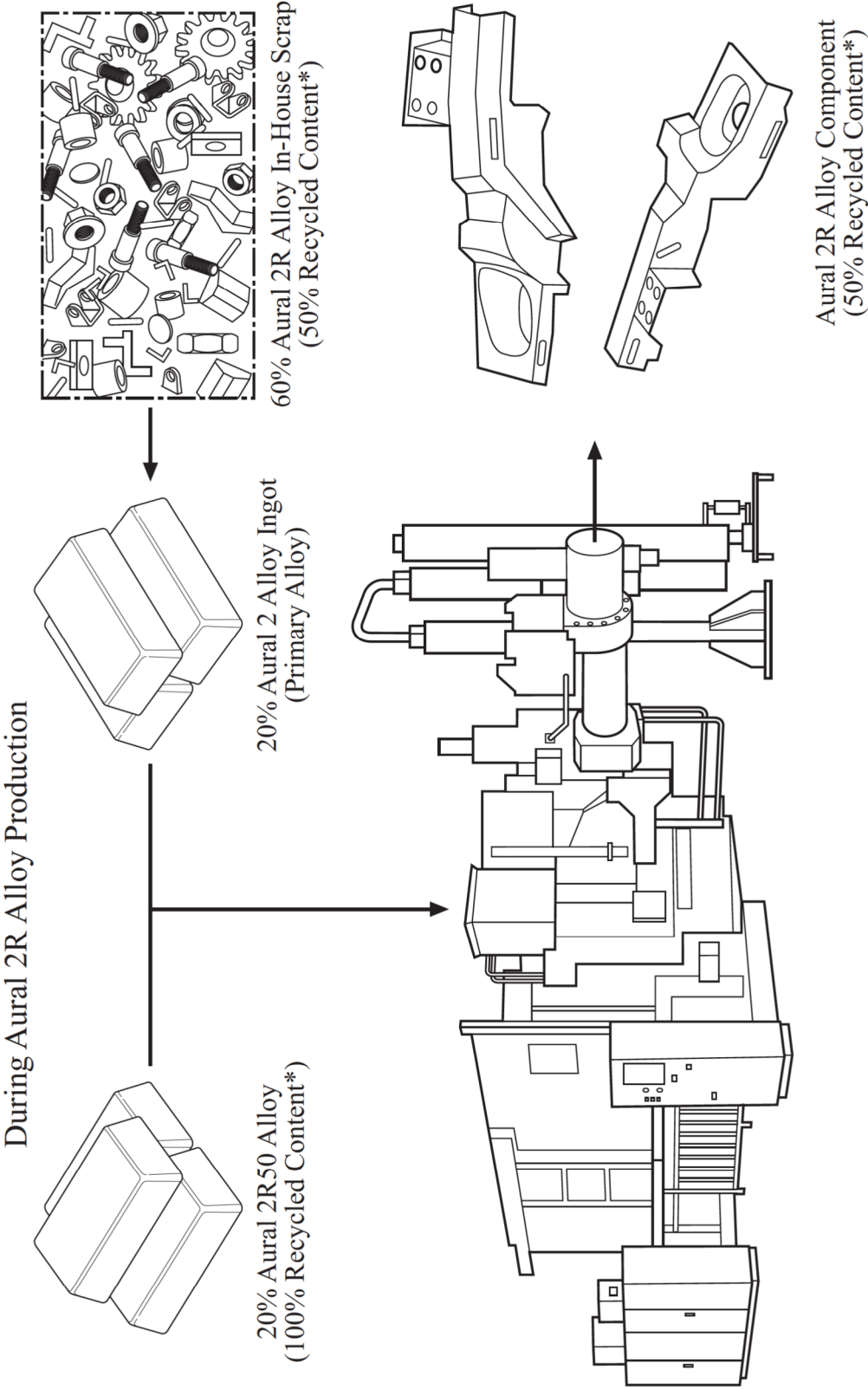


FIG. 6

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Aural 2R50 (100% recycled)	2000 kg
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Aural 2R50 Ingot

Si	Fe	Cu	Mn	Mg	Ni	Zn	Ti	Cr	Sn	Sr
10.2	0.32	0.3	0.59	0.28		0.3	0.06	0		0.015

Weight of Elements in Melter:

Si	204	kg
Fe	6.4	kg
Mn	11.8	kg
Mg	5.60	kg
Sr	0.3	kg
Ti	1.2	kg
Cu	6	kg
Zn	6	kg

Soest In-House Returns	6000 kg
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Aural 2R In-House Returns

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Sn	Sr
10.15	0.235	0.15	0.55	0.29		0.15	0.06		0	0.15

Weight of Elements in Soest In-House Returns:

Si	609	kg
Fe	14.1	kg
Mn	33	kg
Mg	17.40	kg
Sr	0.78	kg
Ti	3.6	kg
Cu	9	kg
Zn	9	kg

Weight of Elements After Mixing:

Si	1018.2	kg
Fe	23.9	kg
Mn	54.52	kg
Mg	29.46	kg
Sr	1.48	kg
Ti	6.04	kg
Cu	15.2	kg
Zn	15.06	kg

Aural 2R Chemical Composition After Mixing (wt. %):

Si	Fe	Mn	Mg	Sr	Ti	Cu	Zn
10.18	0.24	0.55	0.2946	0.01	0.06	0.15	0.15

C65 Ingot Primary	2000 kg
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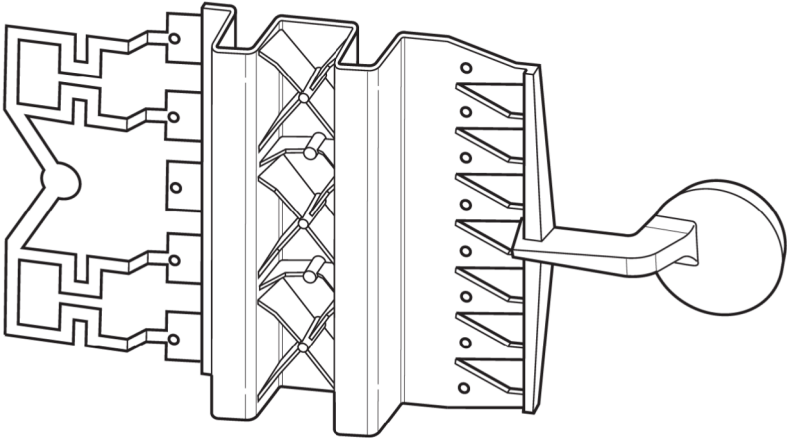
C65k Ingot

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Sn	Sr
10.26	0.17	0.1	0.49	0.325		0	0.06	0		0.02

Weight of Elements in Alcoa Primary Ingot:

Si	205.2	kg
Fe	3.4	kg
Mn	9.72	kg
Mg	6.46	kg
Sr	0.4	kg
Ti	1.24	kg
Cu	0.2	kg
Zn	0.06	kg

FIG. 7



Alloy-Temper	YS (MPa)	UTS (MPa)	Elongation (%)
Au2 F Primary	152.1	284.8	8.6
Au2R F Secondary	152.6	291.2	7.8
Au2 Annealing Primary	107.9	190.8	14.0
Au2R Annealing Secondary	112.3	198.2	13.4
Au2 T7 Primary	138.3	201.4	14.0
Au2R T7 Secondary	144.3	207.7	13.5

FIG. 8

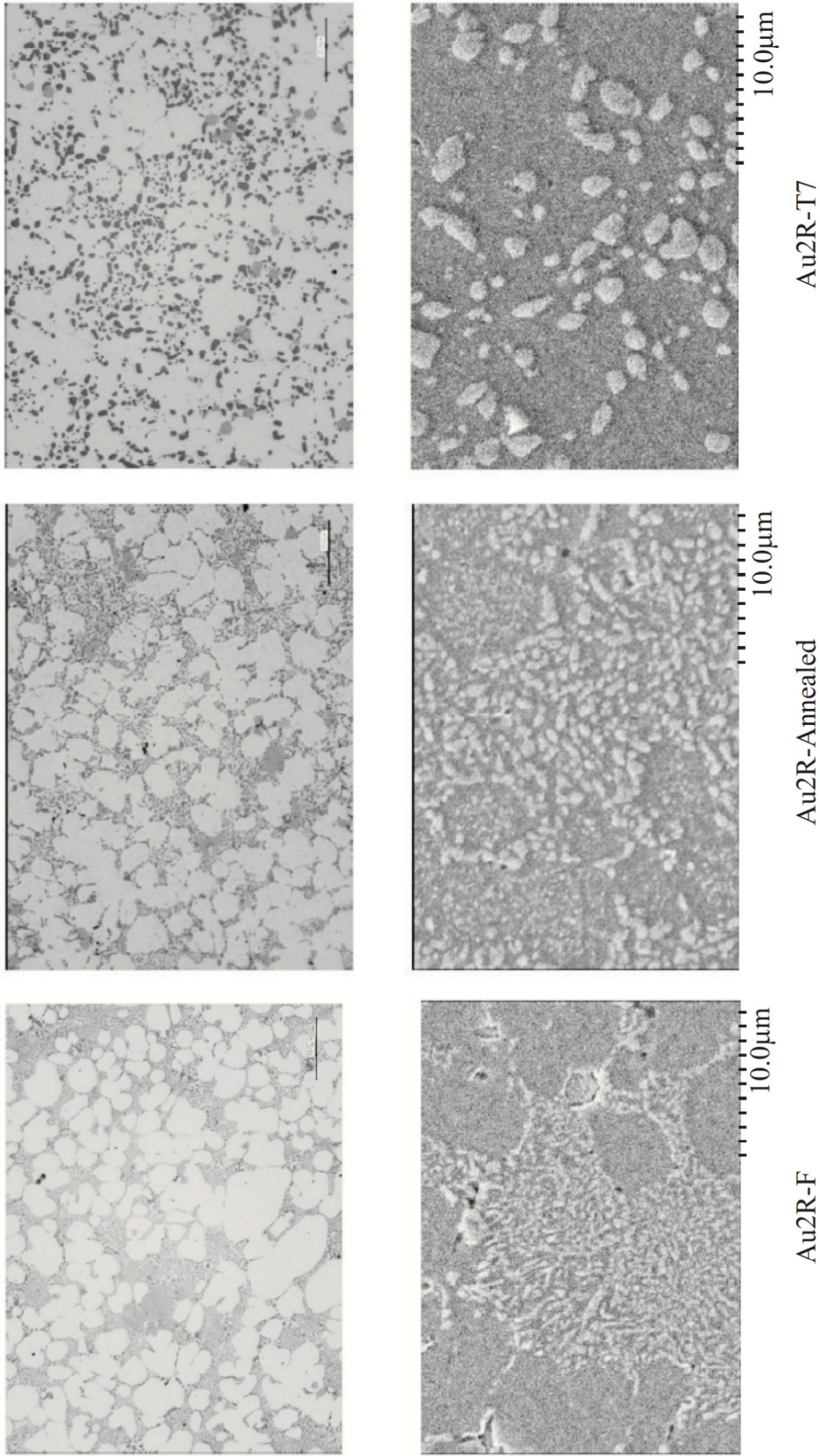


FIG. 9

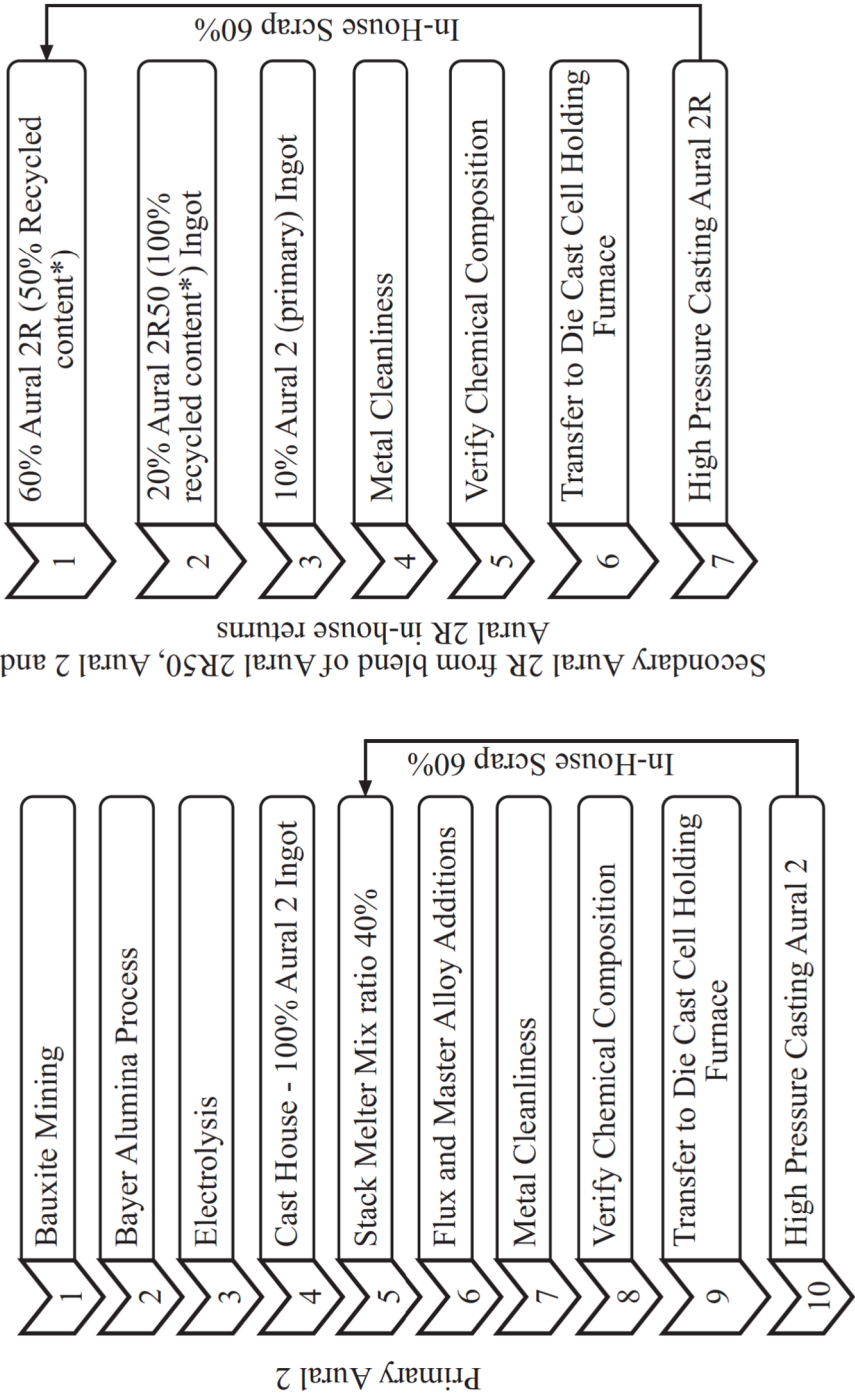


FIG. 10

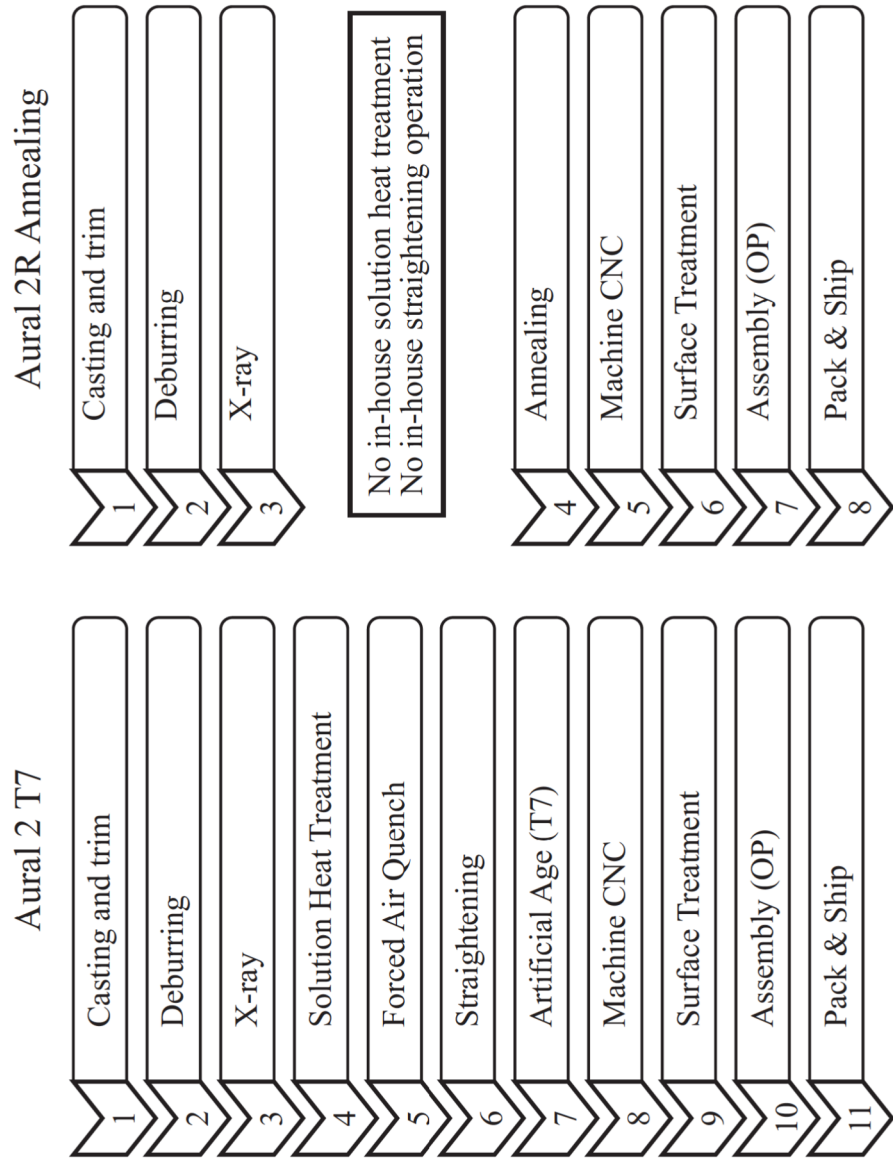


FIG. 11



EUROPEAN SEARCH REPORT

Application Number

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			C22C B22D B32B C22B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		22 July 2026	Helgadóttir, Inga
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
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