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(71) Applicants:
• **Casa Maristas Azterlan**
48200 Durango (Vizcaya) (ES)
• **Aluminio S.L.**
48950 Erandio (Vizcaya) (ES)

(72) Inventors:
• **Fernández Calvo, Ana, Isabel**
48200, DURANGO (VIZCAYA) (ES)
• **Niklas, Andrea**
48200, DURANGO (VIZCAYA) (ES)
• **Alfaro Abreu, Ignacio**
48950, ERANDIO (Vizcaya) (ES)
• **Anza Ortiz de Apodaca, Iñigo**
48950, ERANDIO (Vizcaya) (ES)

(74) Representative: **Carpintero Lopez, Francisco et al**
Herrero & Asociados, S.L.
Alcalá 35
28014 Madrid (ES)

(54) **Method for obtaining improved mechanical properties in recycled aluminium castings free of platelet-shaped beta-phases**

(57) The present invention relates to iron containing aluminium alloys free of primary platelet-shaped beta-phase of the Al_5FeSi -type in the solidified structure presenting the following chemical composition (in weight %): Si: 6.00 - 9.50; Fe: 0.15 - 0.60; Mn: 0.04 - 0.60; Mg: 0.20 - 0.70; Cr: 0.01 - 0.60; Ti: 0.05 - 0.30; Sr and/or Na: 0.001 - 0.25; V: 0.00 - 0.60; Cu: 0.01 - 0.25; Ni: 0.01 - 0.1; Zn:

0.01 - 0.1; the balance being Al and incidental impurities. The present invention relates also to a process for the preparation of this aluminium alloy and aluminium alloy casting for example as components in aeronautic, automotive and energy industry.

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Description**FIELD OF THE INVENTION**

[0001] The present invention relates to aluminium alloys, more particularly, it relates to aluminium alloy castings suitable as components for instance for vehicles, machines and electric applications which are required to have high strength and high elongation values among other properties. The present invention also relates to a process for its preparation from recycled aluminium alloys in order to obtain recycled aluminium casting free of platelet-shaped beta-phases.

BACKGROUND OF THE INVENTION

[0002] Aluminium alloys are widely used in diverse applications for instance as components in the automotive, aerospace, industrial machines, electric applications etc., because of their excellent mechanical properties as well as other technological properties such as corrosion resistance and reduced hot cracking tendency.

[0003] For the manufacturing of aluminium alloys there are basically two different methods which differ in the raw material: the primary production (primary alloy) which is of minerals rich in aluminium (bauxite) and aluminium recycling (secondary alloy) whose raw material is dross and other residues rich in aluminium.

[0004] The primary alloy production consists basically in reducing the oxide present in bauxite enhancing the purity of aluminium by electrolysis. The most important drawback of this method is the high quantity of energy (from 14 to 15 Kwh/kg) which is necessary to produce aluminium whereas in the aluminium recycling method the costs are about 0,5-0,75 Kwh/kg, that is lower than 5% of the primary production.

[0005] AlSiMg alloys are nowadays one of the most common aluminium castings alloys for high safety parts, such as automotive or aerospace components, which require high mechanical properties. This alloy presents also high ductility due to the low content in impurities and to the addition of elements such as Ti or Sr which refine and modify the microstructure, respectively. AlSiMg alloys are broadly used for castings produced in sand, permanent and investment moulds.

[0006] The high content in impurities, especially the high iron content, in secondary alloys (recycled aluminium) is considered as the main disadvantage. The iron content increases in recycled aluminium after each subsequent melting; its elimination or reduction is technically very complex and rather expensive, not being economically feasible.

[0007] The microstructure of AlSiMg alloys presents alpha aluminium dendrites and Al-Si eutectic and other intermetallic phases among which the iron-rich ones can be highlighted. Iron is well known for being the most common and detrimental impurity in aluminium alloys for mechanical properties, promoting the appearance of hard and brittle intermetallic iron-rich phases during solidification. The platelet-shaped beta phase (Al_5FeSi) is the most prejudicial since it is well known that ductility and toughness are significantly decreased. Therefore, there has been recently an increasing interest in developing methods for producing improved recycled aluminium alloys in which the formation of the beta phase is reduced and the mechanical properties are thus improved.

[0008] Among the different methods mentioned before the chemical neutralization is the most used technique so far. The strategy was based on the inhibition of the platelet morphology by promoting the precipitation of the $\text{Al}_{15}\text{Fe}_3\text{Si}_2$ -type phase with the addition of a neutralizing element (Mn, Cr, Co and Be) and in some case controlling the condition of crystallization.

[0009] Other methods are based on the selection of raw materials with low iron content or on dilution with pure primary aluminium. Other methods relate to sweat melting and sedimentation of iron rich intermetallic phases by the so called sludge. However, all these methods result in considerable aluminium losses (about 10%) and are therefore unacceptable.

[0010] The patent WO 97/13882 discloses a method for producing iron-containing AlSi-alloys in particular Al-Si-Mn-Fe-alloys. The mechanical properties of aforementioned Al-alloys with iron contents between 0,4 and 2.0 wt.% can be improved by controlling the morphology of the iron containing intermetallic precipitates. The precipitation of platelet-shaped beta phase ($\beta\text{-Al}_5\text{FeSi}$) has been found to be suppressed by a primary precipitation of the hexagonal $\text{Al}_8\text{Fe}_2\text{Si}$ -type phase which is in turn less harmful one. The method comprises further controlling the condition of the crystallization by the addition of one or more elements such as Ti, Zr, Sr, Na and Ba.

[0011] In spite of the variety of methods in the state of the art, there is still the necessity of providing a method for obtaining recycled aluminium castings with mechanical properties close to those obtained in primary alloys, but at much lower production costs. The method is based on obtaining free platelet-shaped beta-phases aluminium castings by using recycled aluminium with high iron content.

BRIEF DESCRIPTION OF THE FIGURES

[0012]

Figure 1. Table showing the chemical composition of AlSi7Mg alloys with additions of Mn, Cr and V to recycled ingots (Base Composition).

Figure 2: Tensile test casting used to evaluate the mechanical properties.

Figure 3: General view of secondary AlSi7Mg alloy with Mn, Cr and V additions, correctly degasified, not presenting porosity.

Figure 4: Optical micrographs showing iron-rich intermetallic phases: a) platelet-shape β -Al₅FeSi phase in a secondary AlSi7Mg alloy without Mn, Cr or V additions, b) α -phases with globular shape in a secondary AlSi7Mg alloy with Mn, Cr and V additions.

Figure 5: Backscattered electron images and EDX spectrum of three different secondary AlSi7Mg alloy showing the different intermetallic iron rich precipitates (β -Al₅FeSi, α -Al₁₅(Fe,Mn,Cr,V)₃Si₂) depending on the alloying element added (Mn, Cr, V); a) without alloying elements; b) with Mn and Cr additions and c) with Mn, Cr and V additions.

DESCRIPTION OF THE INVENTION

[0013] One aspect of the present invention refers to an iron containing aluminium alloy, hereinafter referred to as the alloy of the invention, which is free from primary platelet-shaped beta-phase of the Al₅FeSi-type in the solidified structure presenting the following compositions (amounts expressed in weight percentage, wt.% in respect to the total weight of the alloy):

Si	6.00 - 9.50
Fe	0.15 - 0.60
Mn	0.04 - 0.60
Mg	0.20 - 0.70
Cr	0.01 - 0.60
Ti	0.05 - 0.30
Sr and/or Na	0.001 - 0.25
V	0.00 - 0.60
Cu	0.01 - 0.25
Ni	0.01 - 0.1
Zn	0.01 - 0.1

[0014] the balance being Al and incidental impurities.

[0015] In a particular embodiment the iron-containing aluminium alloy of the invention presents a composition characterized in that the amount of Mn plus Cr in weight percentage is equal or larger than 50 % of Fe amount.

[0016] In another particular embodiment the iron-containing aluminium alloy of the invention presents a composition characterized in that the amount of Mn plus Cr plus V in weight percentage is equal or larger than 50 % of Fe amount.

[0017] In a further particular embodiment the iron-containing aluminium alloy of the invention presents a Fe content between 0.15 - 0.40% in weight percentage and an amount of Mn plus Cr plus V comprised between 0.15 - 0.40 wt.%.

[0018] In another aspect the present invention refers to a process for the preparation of the aluminium alloy of the invention comprising the following steps:

a) Melting a secondary AlSi7Mg ingot from recycled aluminium.

b) Adding the alloying elements:

(i) Mn + Cr or

(ii) Mn+Cr+V

in suitable amounts

c) Adding a grain refiner and a eutectic silicon modification agent.

d) Submitting the molten alloy obtained in step c) to a degassing process.

e) Introducing the degassed molten alloy in a mould.

f) Casting solidification inside the mould.

g) Casting extraction from the mould.

[0019] During the melting process of secondary ingots, due to the humidity of both the ingots and ambient itself, and also due to the affinity of the aluminium for oxygen, Al_2O_3 and H_2 are formed. The alumina originated by this way becomes part of the dross and the free hydrogen is dissolved into the melt. The presence of hydrogen generates pores in the solidified castings reducing the ductility and strength. Therefore, the process of the invention comprises the degassing process according to already known methods such as treating the molten alloy with dry nitrogen or dry argon until the hydrogen content dissolved in the melt is low enough.

[0020] The process comprises the addition of alloying elements added as pure elements or as master alloys. The present invention resides in the addition of alloying elements: Mn+Cr or Mn+Cr+V, to the base composition of a secondary AlSi7Mg ingot of second fusion (or recycled aluminium).

[0021] The process comprises the addition of grain refiner and eutectic modification agents by means of master alloys additions. The modifier agent Na or Sr are the most common ones and are added to achieve the modification of the eutectic Al-Si structure, which precipitates during solidification, showing a rounded morphology instead of needle structure, typical when such a modifying agent is not added. It is well known that the presence of such needle structures reduces the mechanical properties (ductility, strength) of the alloys, promoting the appearance of cracks. In the case of refining agents, TiB master alloys are used to obtain a microstructures which shows a fine grain size and thus improving the final mechanical properties and also, reducing the porosity tendency.

[0022] According to the process for the preparation of the aluminium alloy of the invention, the platelet-shaped beta phases (Al_5FeSi), so detrimental for the final mechanical properties, disappear and are substituted by globular-shaped alpha-phases ($\text{Al}_8\text{Fe}_2\text{Si}$) obtaining a substantial improvement in mechanical properties (Tensile strength, yield stress and elongation). The properties of the recycled alloys obtained according to the process of the present invention show mechanical properties comparable to those obtained in primary alloys.

[0023] In step e), the degassed molten alloy is poured into a sand and permanent mould. After filling the mould the cast alloy solidifies and an aluminium casting is obtained.

[0024] The aluminium alloys used in high responsibility castings need to fulfil certain mechanical and technological properties. For this reason, these parts are generally submitted to a T6 heat treatment. Another aspect of the present invention relates to a process for making an aluminium alloy casting which comprises submitting the solidified casting as described above to a T6 heat treatment. A T6 treatment comprises a first step of solution heat treatment, heating the castings at a temperature between 500 to 600°C for 2 to 6 hours, followed by quenching. The second step will consist in an artificial aging at a temperature between 150 to 180°C for 2 to 8 hours.

[0025] In a further aspect of the invention refers to an aluminium alloy casting obtainable by the above defined process presenting a tensile strength between 250-300 MPa, a yield strength between 190-230 MPa and elongation values between 4,5-9%.

[0026] The aluminium alloy casting of the invention can be used as a component for transport components such as wheels, suspension parts, brake parts, and energetic industry components.

[0027] A further aspect of the invention relates to a component made from recycled aluminium alloy castings such as steering knuckle, master cylinder and brake calliper.

[0028] According to the invention tensile test specimen are poured in sand mould and permanent moulds from the aluminium alloy of the invention with additions of Mn, Cr and V. The mechanical properties were determined with tensile test specimen according to norm (UNE UNE-EN_1706), (see fig 2). The aluminium alloys present a tensile strength of at least 250 MPa, a yield strength of at least 190 MPa and an elongation of at least 4.5 %. The test pieces according to the invention were submitted to microstructural analysis. The inventors found that the addition of controlled amounts of Mn, Cr and V according to the present invention eliminates the platelet-shape beta-phases (Al_5FeSi).

[0029] On the other hand no interactions have been observed between the additions of Mn, Cr and V and structure modifying elements, such as Ti, B, Na and Sr. No differences have been observed in the grain refinement and Al-Si eutectic modification, with or without additions of Mn, Cr, V. There has not been observed either any interferences of the Mn, Cr, V elements with the conventional degassing method.

[0030] According to the scope of the invention, besides the additions of Mn, Cr and V other elements may be added for other purposes, without affecting the modification characteristics of the iron phases due to the presence of these elements.

[0031] The foregoing is illustrative of the present invention. However, this invention is not limited to the following precise embodiments described herein, but encompasses all equivalent modifications within the scope of the claims which follow.

EXAMPLES**Example 1. Process for preparation of aluminium alloys and castings**

[0032] The aluminium alloys have been produced by using secondary AlSi7Mg ingots, obtained from scrap, recycled aluminium dross and other metal residues rich in aluminium. The following table shows the chemical compositions of recycled ingots used in the examples, with iron contents between 0.28 and 0.34 wt.%. Three recycled ingots (ref. I, II and III) have been used in the experimental tests (Base Composition) are shown, the rest being Al:

Ingot Secondary AlSi7Mg alloy	Chemical Composition (wt.%)										
	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Sr	V
Ref. I	7.11	0.34	0.06	0.09	0.27	0.017	0.01	0.07	0.07	0.005	<0.01
Ref. II	6.94	0.28	0.04	0.04	0.28	0.004	0.00	0.04	0.14	<0.003	<0.01
Ref. III	6.92	0.28	0.04	0.04	0.25	<0.01	0.01	0.04	0.16	<0.003	<0.01
	Aluminium in balance										

[0033] The recycled ingots were melted in an electric furnace (capacity of 50 kg of molten aluminium) at 710-750°C. The melt was then alloyed and liquid treated according to the predetermined following schedule:

1. Ti was added to the melt (only to the melt of Ref I) in the form of TiB master alloys (5%Ti-1% B) in order to adjust the Ti content between 0.15 - 0.20 wt.%.

2. Thereafter Mn, Cr, V were added by using master alloys. The specific quantities of the alloying elements were added using master alloys:

- o By using Mn-90 wt.% (Al-10 wt.%).
- o By using Cr-80 wt.% (Al-20 wt.%).
- o By using V-10 wt.% (Al-90 wt.%).

3. Finally, Sr-10% master alloy was added to the melt to adjust the Sr content between 0.005-0.025% Sr; and Mg was added in order to adjust its content between 0.25 - 0.70% Mg in agreement with the norm UNE-EN 1706 (AlSi7Mg).

[0034] The melt was held for 10 minutes between consecutive additions for chemical homogenization.

[0035] In order to determine the composition of the alloys that had been produced, medals were cast and analysed thereafter by means of spark emission spectrometry.

[0036] Once the aluminium alloys were tested to have the correct chemical compositions, (see Table in Figure 1), the melt was subjected to degassing by using N₂ during approximately 20 minutes. The effectiveness of degassing (the presence of hydrogen in aluminium) was checked by means of Reduced Pressure or Straube-Pfeiffer Test where samples for alloy density evaluation were taken after degassing. In all cases, a minimum density of 2.65 gr/cm³ was obtained in samples solidified in vacuum.

[0037] Then, the next step was as follows: The metal liquid was poured into chemically bonded sand moulds, at temperatures between 710 y 740 °C, in order to obtain tensile test specimens (norm UNE-EN-ISO 6892-1).

[0038] The tensile test specimens (Figure 2) were subjected to a T6 heat treatment in a laboratory furnace with a temperature control of ± 2 °C. The sequences of this thermal process were the following:

1. Solution heat treatment for 7.5 h at 540 °C,
2. After solution heat treatment, the samples were quenched in water at room temperature,
3. After quenching; the final step is the artificial aging of the samples for 5.5h at 155°C.

[0039] The microstructures of the cast alloys were examined using optical and scanning electron microscopy: grain size, modification rate, iron rich phases and porosity have been evaluated in the tensile casting, see example in Figure 3.

[0040] The Figure 4 shows different morphologies of iron phases observed in recycled aluminium alloys by using optical microscopy. Iron is known to be the most common and at the same time most detrimental impurity in aluminium alloys since it causes hard and brittle iron-rich intermetallic phases to precipitate during solidification. The most detrimental

phase in the microstructure is the beta-phase of the Al_5FeSi - type because of its platelet-shape, see Figure 4a). This figure shows a typical $\beta-Al_5FeSi$ phase with a monoclinic crystal structure and plate like morphology. Such platelets may have an extension of several millimetres and appear as needles in micrographic sections. In order to avoid the platelet morphology, chemical neutralization (additions of MnCrV or MnCr) are used according to the present invention which

have been shown to inhibit this beta morphology promoting the precipitation of $\alpha-Al_{15}(Fe,Mn,Cr,V)_3Si_2$ with globular/chinese script morphology, as shown in Figure 4.b), containing substantial amounts of alloying elements (Mn, Cr, V).

[0041] The aluminium alloys with Mn, Cr and V additions do not present interactions with TiB master alloys (grain refiner agent) and Sr additions (modification of Si eutectic phases), obtaining good levels of grain refinement, Si modification and hydrogen degassing.

Example 2. Effect of different quantities of alloying elements (Mn,Cr,V)

[0042] When the content of the rest of chemicals elements keep constant, it is possible to study el effect of Mn, Cr and V by varying the content of these latter ones. Several chemical compositions were prepared in accordance with the present invention, see Table in Figure 1.

[0043] In order to determine the effectiveness of beta-phases modification, metallographic analyses were performed in all the tensile specimens. Optical microscopy and scanning electron microscopy, SEM, were used. The preparation procedure consisted of sectioning, grinding and polishing of the specimens.

[0044] The Figure 5 shows micrographs which correspond to aluminium alloys: a) without alloying additions (Mn, Cr, V) and b) with the additions of Mn + Cr and c) with the addition of Mn, Cr and V. From results it can be seen that in b) and c) no platelet-shape phases (beta-phases) were found when performing the aforementioned additions in the conditions previously described in opposition to a) where these platelet-shape phases can be clearly observed (see arrows pointing thereto). Therefore, with the obtained results, it is possible to conclude that the beta phase morphology (platelet-shape) is modified with the additions of Mn plus Cr or Mn plus Cr plus V, obtaining phases with a globular/chinese script morphology less harmful to mechanical properties.

Example 3. Mechanical Properties Evaluation

[0045] In order to characterize the mechanical properties of aluminium cast alloys according to the invention, tensile test specimens were tested at room temperature in accordance with the method established in the norm UNE-EN-ISO 6892-1. Tensile tests were carried out using an Instron Universal testing machine to obtain yield strength ($R_{0.2}$, MPa), ultimate stress (R_m , MPa) and elongation percentage (%). From tensile tests, the following yield strength, ultimate stress and elongation have been achieved:

- Yield strength, $R_{0.2} = 200$ MPa.
- Ultimate stress, $R_m = 274$ MPa.
- Elongation = 8.5 %.

Claims

1. An iron containing aluminium alloy free of primary platelet-shaped beta-phase of the Al_5FeSi -type in the solidified structure presenting the following composition (amounts expressed in % by weight in respect to the total weight of the alloy):

Si	6.00 - 9.50
Fe	0.15 - 0.60
Mn	0.04 - 0.60
Mg	0.20 - 0.70
Cr	0.01 - 0.60
Ti	0.05 - 0.30
Sr and/or Na	0.001 - 0.25
V	0.00 - 0.60
Cu	0.01 - 0.25

(continued)

Ni	0.01 - 0.1
Zn	0.01 - 0.1

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balance being Al and incidental impurities.

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2. An iron-containing aluminium alloy according to claim 1, presenting a composition **characterized in that** the total amount of Mn and Cr in weight percentage (wt.%) is equal or larger than 50 % of the Fe amount.

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3. An iron-containing aluminium alloy according to claim 1, presenting a composition **characterized in that** the total amount of Mn, Cr and V in weight percentage (wt.%) is equal or larger than 50 % of the Fe amount.

4. An iron-containing aluminium alloy according to claim 1, presenting a Fe content of 0.15 - 0.40% by weight and an amount of Mn, Cr and V taken together which is comprised between 0.15 - 0.40 % by weight.

5. A process for the preparation of the aluminium alloy of claims 1 to 4, comprising the following steps:

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a) Melting a secondary AISi7Mg ingot from recycled aluminium.

b) Adding the alloying elements:

(i) Mn + Cr or

(ii) Mn+Cr+V

in suitable amounts

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c) Adding a grain refiner and a eutectic silicon modification agent

d) Submitting the molten alloy obtained in step c) to a degassing process

e) Introducing the degassed molten alloy in a mould

f) Casting solidification inside the mould

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g) Casting extraction from the mould.

6. A process according to claim 5, wherein the alloying elements are added as pure elements or as master alloys.

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7. A process for making an aluminium alloy casting which comprises submitting a solidified casting as obtained according to the process of claims 5 or 6, to a T6 heat treatment.

8. An aluminium alloy casting presenting tensile strength between 250-300 MPa, a yield strength between 190-230 MPa and elongation values between 4,5-9% obtainable by the process of claim 7.

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9. Use of the aluminium alloy casting of claim 8, as a component for transport components selected from wheels, suspension parts and brake parts, or as a component for energetic industry.

10. A component made from the aluminium alloy casting of claim 8, selected from steering knuckle, master cylinder and brake calliper.

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Addition	Ref.	Chemical composition (wt. %)											Ingot Reference	Beta phases
		Si	Fe	Cu	Mn	Mg	Cr	Ti	Ni	Zn	Sr	V		
MnCrV	Ref. 1	6.56	0.25	0.04	0.15	0.24	0.12	0.16	<0.01	0.04	0.011	0.11	Ref. II	No
	Ref. 2	6.64	0.31	0.04	0.15	0.62	0.21	0.17	<0.01	0.04	0.005	0.17	Ref. II	No
	Ref. 3	6.63	0.38	0.04	0.19	0.55	0.16	0.15	<0.01	0.04	0.018	0.14	Ref. I + II	No
	Ref. 4	6.85	0.29	0.04	0.20	0.61	0.18	0.18	<0.01	0.04	0.008	0.09	Ref. III	No
	Ref. 5	6.90	0.28	0.04	0.19	0.34	0.17	0.17	<0.01	0.04	0.014	0.05	Ref. III	No
	Ref. 6	6.47	0.22	0.04	0.10	0.27	0.12	0.16	<0.01	0.04	0.012	0.04	Ref. II	No
	Ref. 7	6.68	0.25	0.04	0.12	0.25	0.11	0.18	<0.01	0.04	0.020	0.09	Ref. II	No
MnCr	Ref. 8	6.76	0.33	0.04	0.15	0.56	0.15	0.21	<0.01	0.04	0.005	0.00	Ref. II	No
	Ref. 9	6.88	0.32	0.04	0.20	0.55	0.09	0.14	<0.01	0.04	0.008	0.00	Ref. II	No
	Ref. 10	6.93	0.28	0.04	0.18	0.61	0.16	0.18	<0.01	0.04	0.023	0.00	Ref. III	No

FIG. 1

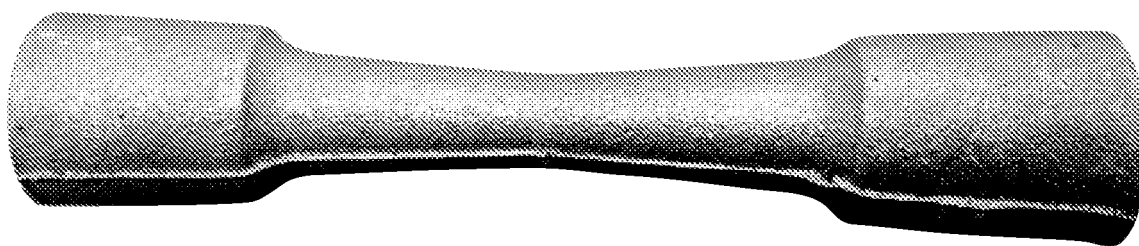


FIG. 2

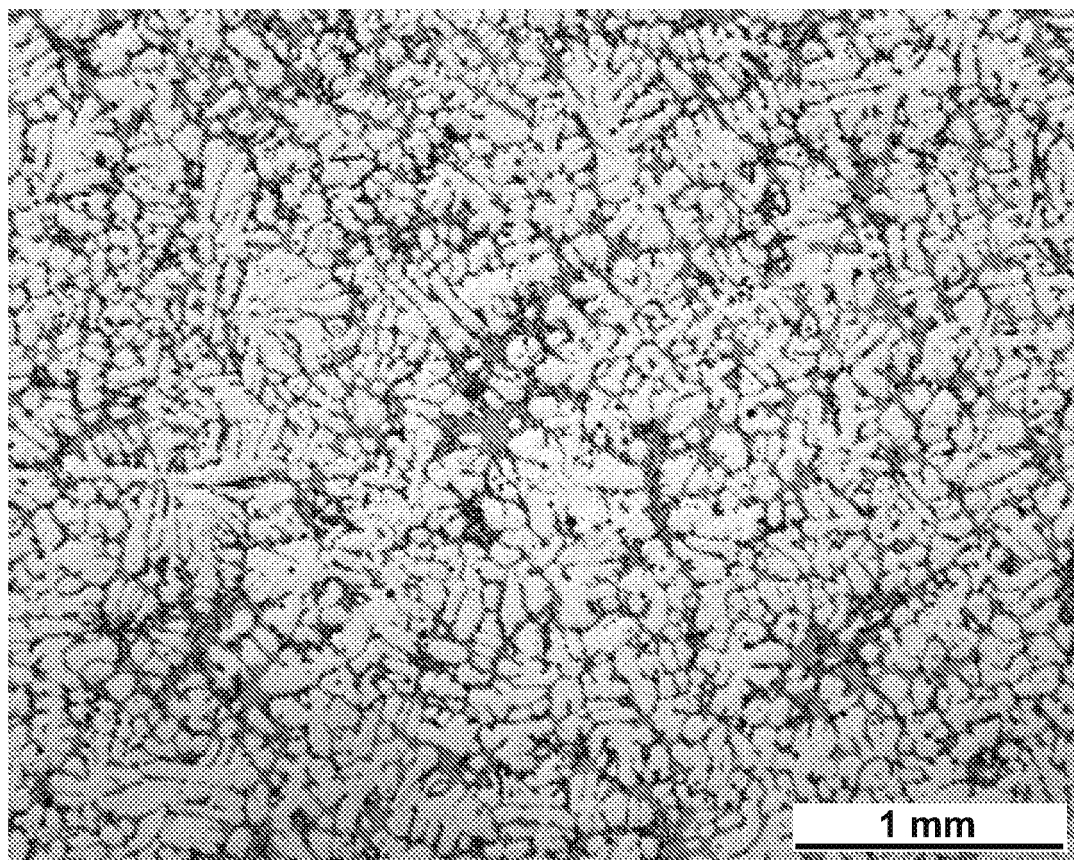


FIG. 3

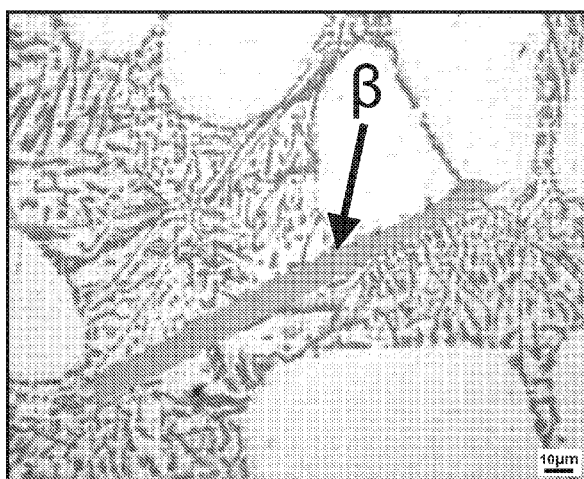


FIG. 4a

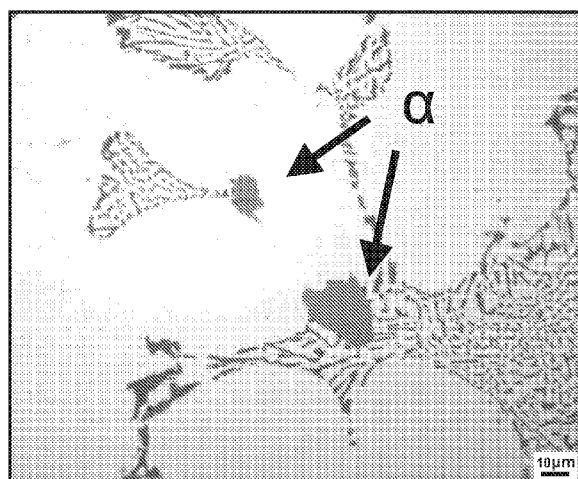


FIG. 4b

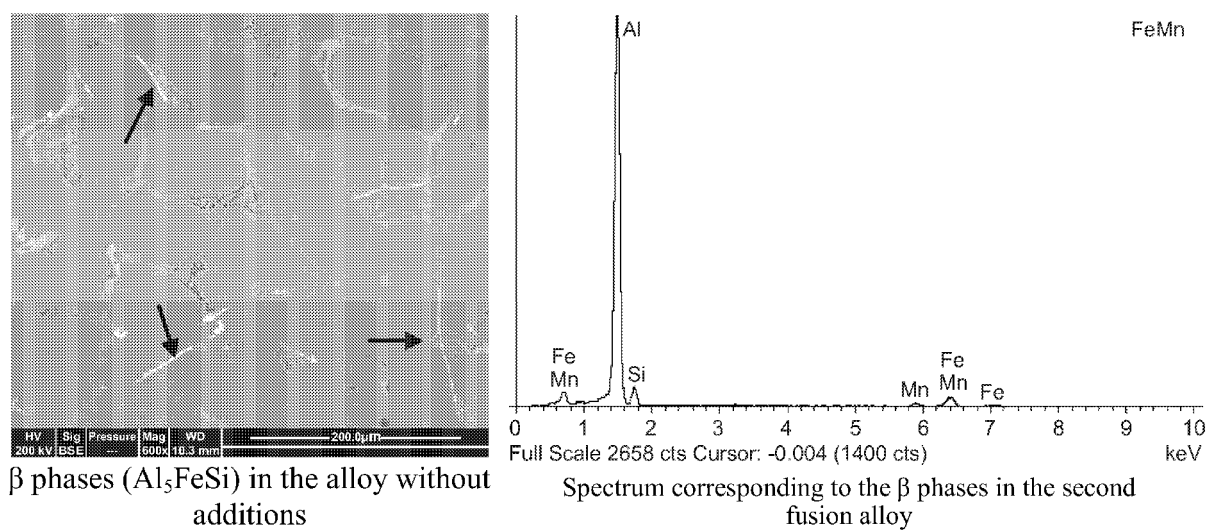


FIG. 5a

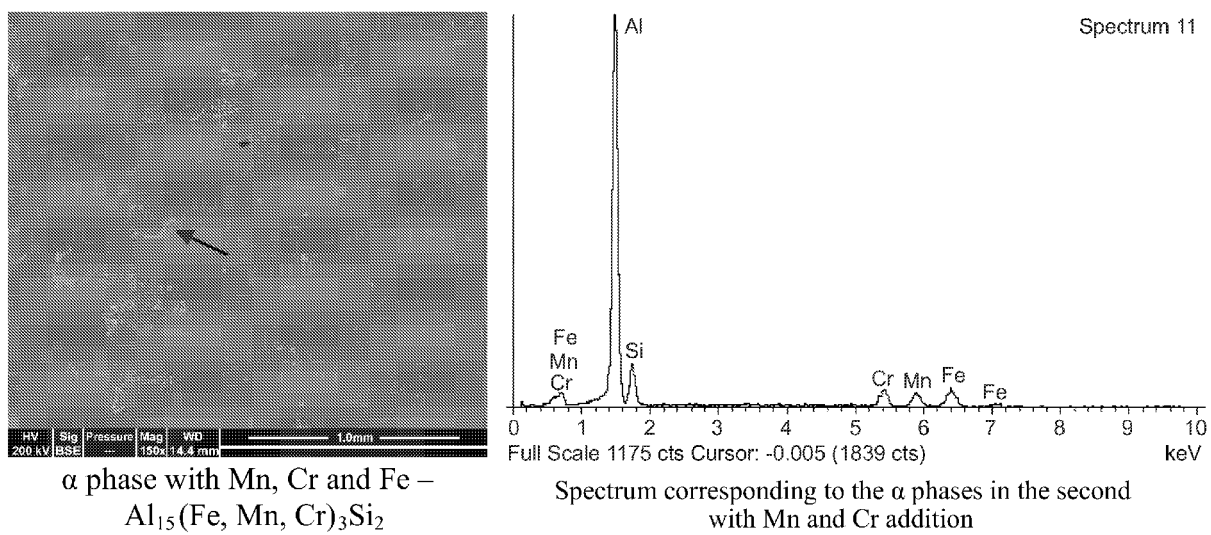


FIG. 5b

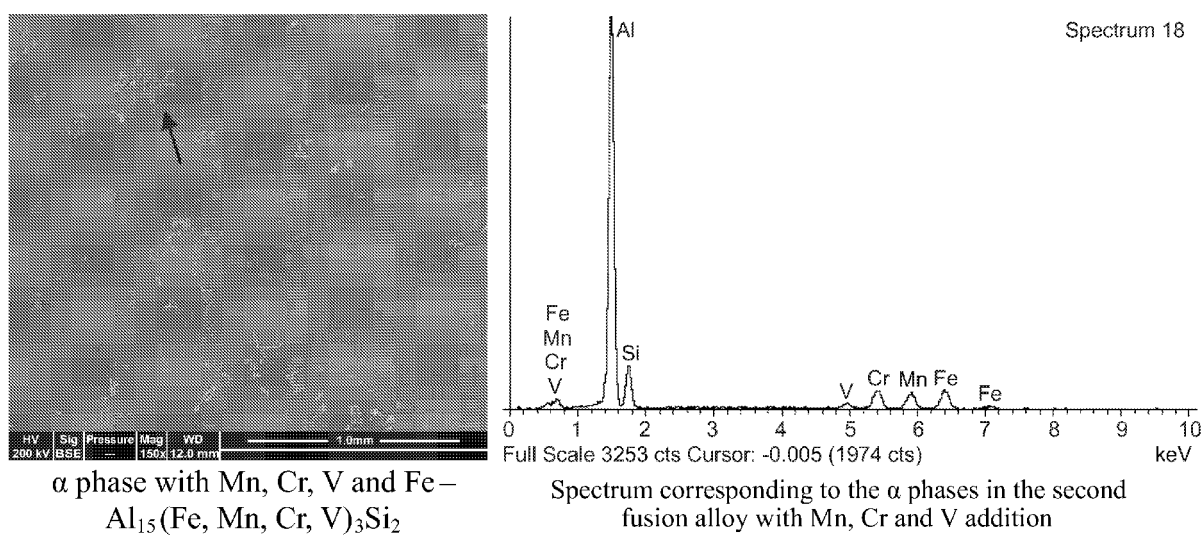


FIG. 5c



EUROPEAN SEARCH REPORT

Application Number
EP 10 38 2360

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2009/297393 A1 (WUST JURGEN [DE] ET AL) 3 December 2009 (2009-12-03) * the whole document *	1-10	INV. C22C21/04 C22F1/043 C22C1/02 C22C1/03
A,D	WO 97/13882 A1 (OPTICAST AB [SE]; BAECKERUD LENNART [SE]; ARNBERG LARS [NO]; CHAI GUOC) 17 April 1997 (1997-04-17) * the whole document *	1-10	
A	WO 2005/071127 A1 (ALCOA INC [US]) 4 August 2005 (2005-08-04) * the whole document *	1-10	
A	EP 0 997 550 A1 (ALUSUISSE LONZA SERVICES AG [CH] ALCAN TECH & MAN AG [CH]) 3 May 2000 (2000-05-03) * the whole document *	1-10	
A	JP 11 012705 A (SUMITOMO LIGHT METAL IND) 19 January 1999 (1999-01-19) * abstract * * tables 1,4 *	1-10	
A	KOCH H ET AL: "Eisenarme Aluminium-Druckgusslegierungen als Substitutionswerkstoff fuer Stahlblechkonstruktionen im Automobilbau // Low-iron aluminum die cast alloys as substitute material for steel sheet constructions in automobile manufacture", GIESSEREIPRAXIS, FACHVERLAG SCHIELE UND SCHON GMBH, BERLIN, DE, no. 4, 1 January 2000 (2000-01-01), pages 148-152, XP009099393, ISSN: 0016-9781 * the whole document *	1-10	TECHNICAL FIELDS SEARCHED (IPC) C22C C22F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 July 2011	Examiner Patton, Guy
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 T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.02 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
EP 10 38 2360

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	KOPPER, ADAM ET AL: "Solder resistance mechanisms of novel Al-Sr-Si die casting alloys", LIGHT METALS (WARRENDALE, PA, UNITED STATES) 801-805 CODEN: LMPMDF; ISSN: 0147-0809, 2006, XP009150752, * tables I,III * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 July 2011	Examiner Patton, Guy
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