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PREPARATION OF ALUMINUM ALLOYS

Walter Bonsack, Cleveland, Ohio, assignor to The National Smelting Company, Cleveland, Ohio, a corporation of Ohio

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This invention relates to aluminum and alloys thereof, and more particularly to fluxing material for use in the preparation, recovery, and founding of such alloys.

An object of my invention is to provide fluxing material of advantageous characteristics for use in connection with molten aluminum and alloys thereof from either virgin or secondary sources.

Another object is to provide a flux of advantageous characteristics for use in connection with molten aluminum in the preparation of aluminum alloys.

A further object is to provide a flux of advantageous characteristics for use in the recovery of aluminum and alloys thereof from secondary sources.

Another object of my invention is to provide a flux for the cleansing of molten aluminum and alloys thereof prior to the casting thereof.

A further object is to provide a flux for use with aluminum and alloys thereof capable of readily dissolving non-metallic impurities ordinarily associated with such alloys.

Another object is to provide a flux for use with aluminum and alloys thereof, capable of holding in molten solution materials and compounds which are to react with a molten aluminum bath, and capable also of dissolving products of such reactions, whereby the reactions may proceed properly and to a substantial degree of completion.

Another object is to provide a flux for use with aluminum and alloys thereof, which flux is safe in use, and harmless to workmen and metal.

A further object of this invention is to provide a fluxing medium whereby alloying operations may be carried out readily at relatively low temperatures.

Other objects of the invention will be apparent to those skilled in the art to which this invention appertains.

By my invention I have provided a fluxing material having considerable advantages in the preparation and treatment of aluminum and alloys thereof from either virgin or secondary sources. My improved fluxing material has advantageous application in the preparation of aluminum alloys and in the treatment thereof with the salts of metals and other non-metallic materials, in the recovery of aluminum and alloys thereof from secondary sources, and in the fluxing of aluminum alloys preparatory to the casting thereof. My improved fluxing material comprises the ingredients potassium chloride, sodium chloride, and cryolite ($3\ NaF.AlF_3$), natural or artificial. The proportions of these ingredients as contemplated by my invention are within the range specified below:

	Per cent
KCl	10 to 65
NaCl	15 to 75
Cryolite	5 to 65

The proportions of the ingredients to be used in any particular case will depend upon the composition and melting point of the alloy to be treated and upon the purpose to be accomplished, as will be set forth hereinafter in more detail.

The ternary fluxing material of the range of compositions set forth above, has numerous advantages for the purpose of this invention. The flux itself does not react with aluminum and has a specific gravity less than that of aluminum, whereby the flux will float on the surface of a molten aluminum bath with resultant ease of separation of the flux from the bath. Moreover, no fumes are expelled by the flux when it melts, whereby the fluxing medium does not pollute the atmosphere and endanger the health of workmen. My improved composition, moreover, is not hygroscopic and has a low content of water of crystallization, whereby there is no danger of the flux "exploding", with consequent spattering of molten metal. The flux, moreover, is extremely fluid when molten, while on the other hand it is not volatile. Furthermore, my fluxing material is water soluble so that after the alloy being treated has solidified any flux still adhering to the alloy readily may be removed, and any alloy adhering to the flux may be recovered.

A very important advantage of my improved fluxing composition is its solvent action upon impurities to be removed from the alloy being treated, upon metallic and non-metallic materials with which it may be desired to treat the aluminum alloy, and upon oxides on the aluminum bath and on metals with which the aluminum is to be treated whereby intimate metal contact for reaction may be obtained. The reactions of such materials with the aluminum alloy are thus carried on much more efficiently and rapidly than hitherto possible.

The fluxing material contemplated by this invention constitutes a ternary system, the characteristics and melting point of which may be varied by varying the proportions of the various ingredients within the limits herein specified.

I

In the addition of metals to molten aluminum

to form aluminum alloys and in causing reactions between certain non-metallic materials and molten aluminum, it is desirable that such alloying and other reactions take place at temperatures as close as possible to the melting point of the aluminum metal in order that overheating and consequent deterioration of the aluminum metal may be prevented, and in order that the alloying or other reaction may be carried on as economically and efficiently as possible. To facilitate the alloying or other reaction, it is desirable that the metallic or other non-metallic material which is to react with the aluminum, may come into intimate contact with the molten aluminum and that any product of reaction may be rapidly removed in order that the reaction may proceed at a rapid rate.

For the above purposes I employ a low melting flux contemplated by my invention preferably of eutectic composition, namely, KCl about 62.5%, NaCl 32.5%, cryolite 5%. The flux of eutectic composition may be disposed upon the surface of molten aluminum to be treated, for example, in amount of about 3% of the weight of the aluminum bath. The metallic or non-metallic materials with which the aluminum is to be treated may then be introduced into the molten flux covering. When metals are introduced through the flux covering into the bath to be alloyed with the aluminum, the flux serves to dissolve oxides or other materials on the surface of the alloying metal, as well as absorb oxides on the surface of the molten aluminum, and permits clean surfaces of the alloying metal and aluminum to contact, whereby the alloying reaction may be initiated much more rapidly and at considerably lower temperatures.

Furthermore, the presence of the flux covering prevents the formation of additional oxides which might inhibit the continuance of the alloying reaction and prevents the loss of metal by oxidation. The use of this improved flux composition is advantageous for the alloying of numerous metals with aluminum, among which may be mentioned copper, silicon, nickel, magnesium, iron, as well as other metals which form alloys with aluminum.

The advantage of the use of my improved flux composition may be illustrated by the fact that in preparing an alloy of 8% copper, I have introduced copper through a flux covering on a bath of substantially pure aluminum. The alloying reaction took place approximately five times more rapidly with the use of the flux than in the preparation of a similar alloy under the same conditions without the use of the flux. Where large pieces of solid metal are to be alloyed with aluminum, the flux composition further permits the alloying reaction to take place at considerably lower temperatures, as well as more rapidly.

Where solid non-metallic materials, for example, the oxides of boron, the halides or oxides of bismuth, cadmium, cobalt, copper, manganese, nickel, silicon, titanium, tungsten, vanadium, zirconium and other metals, are to be caused to react with molten aluminum for alloying purposes or to accomplish the improvement of the aluminum alloy, the use of the low melting eutectic flux contemplated by my invention has presented considerable advantages. In such cases the non-metallic material or compound is introduced into the molten flux covering the molten aluminum bath. The flux in such cases serves as a solvent for the compound which in itself promotes the reaction between the compound and the aluminum, materials in solution form being more reactive while yet keeping the reaction within controllable bounds. The flux in such cases serves to promote the reaction by dissolving the reaction compound, and moreover by dissolving the products of reaction and removing them from the surface of the aluminum causes reaction between the aluminum and the compounds to proceed still more rapidly.

The compounds which may thus be advantageously employed in association with my improved flux, may include any non-metallic compound in addition to those mentioned hereinabove.

To illustrate the advantages of my flux in connection with the reaction of non-metallic materials with a molten aluminum bath, I have found, for example, in causing 2% of boric acid to react with aluminum alloy the reaction has been caused to go to substantial completion in about three minutes at a temperature of about 750° C., whereas without the flux the corresponding reaction required over five times as long at a temperature several hundred degrees C. higher.

II

The flux compositions contemplated by my invention are extremely advantageous in the recovery of aluminum and alloys thereof from secondary sources, for example, borings, grindings, dross, skimmings, sheet, castings, foil, etc.

The secondary material from which the aluminum is to be recovered, frequently has a high non-metallic content such as SiO_2, dirt, etc. The presence of the non-metallic material requires additional heat and higher temperatures in order to melt and coalesce the dispersed finely divided aluminum. This procedure, however, brings the aluminum to a temperature sufficiently high to cause exothermic reactions to commence between aluminum and oxides in the nature of thermit reactions.

The progress of these highly exothermic reactions results in the oxidation of a considerable portion of the aluminum, and furthermore results in overheating that portion of the aluminum which has become molten. It will be understood that the progress of aluminothermic reactions to a small extent is desirable in order to melt the segregated particles of aluminum, but becomes undesirable when the aluminothermic reactions proceed to such an extent as to oxidize more aluminum than necessary to overheat the molten metal.

My improved flux is highly desirable for use in connection with the above described recovery of secondary aluminum. The composition is arranged so that the flux will be in a pasty condition at the smelting temperature. The pasty condition of the flux results, of course, from the fact that the ternary system sodium chloride, potassium chloride and cryolite involves compounds which melt at varying temperatures. The use of a flux which will be in a pasty condition at the smelting temperature permits the commencement of aluminothermic reactions to an extent sufficient to melt readily the small particles of metallic aluminum dispersed in the non-metallic, relatively non-conducting material. As the temperature rises, however, the flux becomes more molten and impedes the progress of the aluminothermic reactions and prevents an undue increase in temperature and an undue loss of aluminum by oxidation. The result is that optimum yields

of aluminum from secondary materials is obtained.

For the smelting of aluminum alloys from secondary sources I have found a range of composition as follows suitable for this purpose:

	Per cent
KCl	25 to 65
NaCl	25 to 75
Cryolite	5 to 40

For the usual smelting purposes the flux may be employed in amount from ½ to 1½% of the weight of the metal being smelted. Of course, increased amounts of flux may be employed if so desired.

In the smelting of secondary materials the flux serves to dissolve a relatively large amount of non-metallic impurities and serves further to dissolve oxides and other substances from the surface of the metal particles, thereby enabling the metal particles themselves to coalesce more readily and rapidly to form a body of molten metal substantially free from non-metallic particles. The flux moreover serves to protect the resulting molten metal from oxidation or other deterioration from the atmosphere.

By the use of my improved flux in smelting operations such as herein indicated, I have found that the smelting operation may be carried out more rapidly and with a higher recovery of metal from the raw materials employed. The product, moreover, is considerably more free from non-metallic impurities and inclusions.

III

My improved fluxing composition has further important application in the treatment of molten aluminum alloys immediately prior to casting in foundry operations in order to remove dirt and other non-metallic impurities which have entered the molten metal from one source or another.

A flux for this purpose preferably is relatively non-fluid in character because fluid or liquid fluxes tend to adhere to furnaces and ladles, hot crucibles, etc. and have some tendency to react with the metal of such ladles, pots, etc. A relatively dry or non-liquid flux on the other hand is relatively easy to remove from the surface of the molten metal by skimming and is more readily handled in general in the foundry.

Furthermore, for the reasons given above in II, in foundry work it is desirable that the flux be in somewhat pasty rather than fluid condition in order first that any aluminothermic reactions in the surface skim may take place to an extent such as to raise the temperature high enough to coalesce more readily aluminum particles in the skim, and furthermore to prevent aluminothermic reactions in the skim from proceeding far enough to overheat the casting metal. Since higher temperatures are ordinarily employed in foundry practice than in smelting practice, the flux for foundry work is ordinarily of higher melting point than is the case for smelting.

For foundry purposes in fluxing immediately before casting, I have found that my flux of the following range of composition is particularly adaptable, namely, KCl 10 to 50%, NaCl 15 to 25%, cryolite 25 to 65%. The composition, of course, may be varied to suit the melting of the particular alloy being treated, the composition being arranged so that the melting point of the flux is somewhat above that of the temperature at which the molten metal bath is maintained.

For ordinary purposes an amount of flux from ¼ to ½% by weight of the bath may be disposed on the surface of the bath, and if desired may be stirred throughout the bath in order to accomplish more readily the removal of non-metallic impurities from the bath.

From the above disclosure it will be obvious that in recovering aluminum from secondary sources, preparing therefrom an alloy of predetermined composition, and casting such alloy in a mold, that several fluxes of different composition within the range contemplated by my invention will be employed in the various stages in the preparation of the alloy. Thus, for example, one composition of flux may be employed in the recovery of the aluminum from scrap material, another composition may be employed in the preparation of an alloy of predetermined composition from such recovered metal, and immediately before casting in the foundry a third composition of flux may be employed for fluxing. Likewise, in the preparation and casting of aluminum alloys from virgin sources, several fluxes may be employed in the manner indicated above in the various steps of metal treatment.

It will thus be seen that I have provided a fluxing material of advantageous characteristics for use with aluminum and alloys thereof in the various stages of the preparation and use of such alloy.

It will further be noted that for aluminum and alloys thereof I have provided a flux of extremely desirable characteristics, not only with respect to the affect of the flux upon the metal itself but also one which produces no disagreeable and harmful fumes during its use, and furthermore has no characteristics which would cause it to be dangerous in operation.

Furthermore, it is to be understood that the particular compounds disclosed, and the procedure set forth, are presented for purposes of explanation and illustration and that various equivalents can be used and modifications of said procedure made without departing from my invention as defined in the appended claims.

What I claim is:

1. A flux for use in the preparation and founding of aluminum and alloys thereof, consisting of potassium chloride from 10 to 65%, sodium chloride from 15 to 75%, and cryolite from 5 to 65%.

2. A flux composition for use in the preparation of aluminum alloys, comprising a substantially eutectic mixture of potassium chloride, sodium chloride and cryolite, said mixture containing about 62.5% potassium chloride, about 32.5% sodium chloride, and about 5% cryolite.

3. A flux composition particularly adapted for cleaning aluminum and alloys thereof prior to casting, comprising potassium chloride from about 10 to 50%, sodium chloride from about 15 to 25%, and cryolite from about 25 to 65%, said flux being of such a composition that it is in a somewhat pasty condition at a temperature considerably above the melting point of aluminum or the aluminum alloy being cast.

4. The method of forming aluminum alloys rapidly and advantageously, which comprises maintaining in contact with a molten aluminum bath a substantially eutectic mixture of potassium chloride, sodium chloride and cryolite, and associating the material to be alloyed with the aluminum with both the flux and aluminum, whereby the alloying operation may be carried out rapidly and efficiently.

5. The process of forming aluminum alloys,

which comprises introducing a flux containing potassium chloride, sodium chloride and cryolite over the surface of molten aluminum and introducing the alloying ingredient through the flux.

6. The process of forming aluminum alloys, which comprises introducing a flux containing potassium chloride, sodium chloride, and cryolite in an approximately eutectic mixture over the surface of molten aluminum and introducing the alloying ingredient through the flux.

7. The process of treating aluminum from secondary sources, which comprises introducing a pasty flux comprising 25% to 65% potassium chloride, 25% to 75% sodium chloride and 5% to 40% cryolite over the metal, melting the aluminum and recovering the aluminum, introducing a low melting flux comprising potassium chloride, sodium chloride and cryolite in approximately eutectic mixture over the surface of the molten aluminum, introducing an alloying ingredient into the molten flux, recovering the molten aluminum alloy thus formed, and then introducing a flux over the aluminum alloy comprising potassium chloride, sodium chloride and cryolite in such proportions that the flux will have a melting point considerably above that of the molten alloy before casting for the purpose of removing dirt and other impurities.

8. A flux composition for use in the smelting and refining of secondary aluminum and alloys thereof containing non-metallic oxides comprising potassium chloride about 25% to 65%, sodium chloride about 25% to 75%, and cryolite about 5% to 40%, said flux having the property of becoming pasty at the melting temperature of aluminum, thereby permitting alumino-thermic reactions between the aluminum and non-metallic oxides to an extent sufficient to permit the melting of particles of aluminum in the non-metallic particles, and the property of becoming molten at a higher temperature so as to prevent loss of aluminum by oxidation.

9. A substantially non-hygroscopic flux composition for use in refining and founding aluminum or aluminum alloys comprising 10% to 65% potassium chloride, 15% to 75% sodium chloride, and 5% to 65% cryolite, the proportions of the ingredients in the flux being such that the flux will be pasty at the melting point of aluminum, thereby permitting alumino-thermic reactions to take place between aluminum and any non-metallic oxide particles that may be present to an extent sufficient to permit the melting of aluminum in the non-metallic particles and of becoming molten at higher temperatures so as to prevent loss of aluminum by oxidation, and said flux being substantially free from hygroscopic ingredients which absorb sufficient moisture to cause spattering of the molten metal.

WALTER BONSACK.