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## COMPOSITION OF MATTER FOR TREATING ALUMINUM ALLOYS

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My invention relates to a composition of matter, and more particularly to a composition of matter comprising a flux having one or more ingriedients associated therewith which act as modifying agents for aluminum, or aluminum alloys, or react therewith to form an aluminum alloy, or which is capable of reacting with another ingredient associated with the flux to form a modifying agent for aluminum or aluminum alloys.

This application is a continuation in part of my application Serial No. 479,790 relating to the Method of improving aluminum and alloys thereof, filed September 4, 1930.

The principal object of my invention is to provide a composition of matter containing a flux having one or more ingredients associated therewith which either form an alloy with aluminum, react with aluminum to form an aluminum alloy, or react with the aluminum or an additional ingredient dissolved in the flux to form a modifying agent for aluminum or aluminum alloys.

Another object of my invention is to provide a composition of matter comprising a flux having one or more elements or compounds associated therewith which, when brought in contact with aluminum or aluminum alloys, form an alloy with the aluminum or act as a modifying agent.

A further object of my invention is to provide a composition of matter, containing a flux having a comparatively low melting point, and a boron compound, or a boron compound and an additional ingredient which is capable of reacting with the boron compound to form a modifying agent for aluminum or aluminum alloys.

Another object of my invention is to provide a composition of matter in which a flux having a melting point approximately the same as, or not substantially more than 100° C. higher than the aluminum or aluminum alloys being treated, serves as a vehicle for carrying alloying ingredients or modifying agents into contact with molten aluminum or aluminum alloys.

A further object of my invention is to provide a composition of matter containing a flux having compounds associated therewith which, when brought into contact with molten aluminum or aluminum alloys, react with the aluminum to to form alloys, or react with the aluminum or an additional ingredient or ingredients in the flux to form modifying agents.

As stated in my copending application Serial No. 479,790, certain elements or compounds, when associated or alloyed with aluminum or aluminum alloys, produce a modifying action which greatly improves the physical properties of the metal. For example, the more common boron compounds, such as borax and boric acid, react with molten aluminum to form boron and aluminum oxide, and the boron thus introduced into the aluminum produces an alloying or modifying effect which decreases the grain size and improves the mechanical and physical properties of the metal. The reaction, however, between the boron and aluminum proceeds slowly because of the high viscosity of the molten boron compound and also because the aluminum oxide formed is not readily soluble in boron compounds.

My invention provides a composition of matter by means of which the reaction between aluminum and compounds which react with the aluminum to form alloying or modifying agents, may be accelerated. This is accomplished by associating the compounds which react with the aluminum with a flux which has a melting point approximately equal to, or not more than 100° C. higher than, the melting point of the aluminum or aluminum alloy being treated.

My invention is also instrumental in providing a flux that forms a solvent for two or more ingredients which react together to form a modifying agent or a compound which will react with molten aluminum to form an alloy.

In practicing my invention, a flux is provided which has a comparatively low melting point and which preferably is a solvent for the halides or oxides of aluminum. A very suitable flux for this purpose comprises a mixture of sodium chloride, potassium chloride and cryolite. This composition is especially desirable because it does not react with aluminum, has a low water of crystallization content, is non-hydroscopic, does not volatilize readily or give off fumes when it melts, and when utilized in certain proportions has a melting temperature which is substantially the same as the melting temperature of aluminum. Furthermore, such a flux is extremely fluid when molten and has a specific gravity less than aluminum so that it floats on the surface of the molten bath, thereby enabling the flux to be readily separated from the metal. It is also quite soluble in water so that after the alloy being treated has solidified, any flux still adhering to the alloy may be readily removed.

The composition of the fluxing ingredients may be varied within certain limits, depending upon the composition of the metal being treated. In treating aluminum or aluminum alloys having a low melting point, I prefer to utilize approximately the eutectic composition consisting of 32.5% sodium chloride, 62.5% potassium chloride, and

5% cryolite. It is, of course, possible to vary the composition of the flux and raise the temperature of the molten metal until the flux possesses the desired fluidity, but such a procedure is expensive, and even when alloys having a higher melting point than aluminum are being treated, a flux having a low viscosity is not disadvantageous. In general, it may be stated that the eutectic composition may be employed or the proportion of the ingredients may be varied within a range of 5% to 10% of the eutectic composition in such a manner that the composition of the flux will not have a melting point substantially more than 100° C. higher than the melting point of aluminum or the aluminum alloy being treated.

In treating aluminum or aliminum alloys, the flux is disposed on the surface of molten aluminum or aluminum alloys in amounts ranging from about ½% to 5% of the molten bath. The substances or compounds associated with the flux with which it is desired to treat the aluminum are then introduced into the molten flux or, if preferred, the ingredients may be mixed together and the composition superimposed upon the molten aluminum. My improved flux in the molten state serves as a carrier for a large number of metallic and non-metallic ingredients or compounds which, upon reaction with molten aluminum, serve as desirable alloying ingredients or modifying agents for the aluminum.

By utilizing a flux which is molten at the melting point of the aluminum or aluminum alloy being treated, and which is a solvent for the metallic or non-metallic substances or compounds with which it is desired to treat the aluminum or aluminum alloy, I have provided a composition of matter which is highly advantageous in the metallurgical art. The particular metallic or non-metallic substances which are associated with the flux will, of course, depend upon the alloying or modifying effect desired.

As an illustration of my invention, an oxide, nitride or fluoride of boron or the double salts of boron, such as ammonium boro-fluoride or potassium boro-fluoride, or a halide or oxide of cobalt, copper, manganese, nickel, silicon, titanium, tungsten, uranium, vanadium, or zirconium, is dissolved in or mixed with the flux covering the molten aluminum, or associated with the flux and superimposed upon the molten aluminum. I have found that the reaction between the compound and molten aluminum takes place much more rapidly than when a flux is not present, and since the cryolite in the flux is also a solvent for the reaction product, such as aluminum oxide or aluminum halide, the reaction product is dissolved and removed from the sphere of the reaction. The withdrawal of the reaction products also accelerates the reaction and causes it to proceed to substantial completion in a comparatively short period of time. The amount of treating substance which is added to the flux will, of course, be dependent upon the solvent action of the flux for the particular treating substance which is utilized.

My improved flux is not only instrumental in providing a vehicle for alloying ingredients, such as those specified, but it is also a solvent for materials or compounds which have a modifying action upon aluminum or aluminum alloys, such as alkali metal hydroxides, carbonates or bicarbonates, and my invention also contemplates the addition of such compounds to the flux to provide a composition of matter which is especially useful in the treatment of aluminum or aluminum alloys.

Instead of dissolving the modifying agent directly in the molten flux, two or more ingredients may be dissolved in the flux which will react to form the modifying agent. For example, I may add an alkaline earth metal halide, such as barium, strontium or calcium fluoride, and a boron compound such as boric oxide or boric acid, to the flux and form a composition of matter in which the alkaline earth metal fluoride reacts with the boron compound to form a fluoride of boron which, being in contact with the aluminum or aluminum alloy, exerts its modifying effect. Other halides, such as chlorides, may also be employed.

In preparing the composition I may utilize, for example, approximately 40 to 60 parts of a flux and 60 to 40 parts of a mixture of calcium fluoride and boric oxide in substantial equimolecular proportion. The mixture of the flux and the additional ingredients may be first formed and placed over the molten aluminum, or the flux may be liquefied by first superimposing it upon the aluminum or aluminum alloy and the additional ingredients may then be dissolved in the flux. It will be understood, of course, that the proportion of the flux to the calcium fluoride and boric oxide, as well as the ratio of the boric oxide to calcium fluoride, may be widely varied. There should, however, be sufficient flux present to dissolve the calcium fluoride and boric oxide and a sufficient amount of calcium fluoride and boric oxide should be present so that the amount of boron fluoride formed by the reaction will be sufficient to modify the aluminum or aluminum alloys which are being treated.

The following specific example, showing how my improved composition of matter may be utilized in modifying aluminum alloys, will serve to illustrate and explain my invention, although it will be understood that I do not desire to limit myself to the particular ingredients or proportions specified. An alloy consisting of 92 parts by weight of aluminum and 8 parts by weight of copper having a melting temperature of about 620° C. was melted in a suitable container. A flux consisting of approximately 33 parts by weight of potassium chloride, 14 parts by weight of sodium chloride, 3 parts by weight of cryolite, was prepared. To this flux about 39 parts by weight of calcium fluoride and 11 parts by weight of boric acid was added. The mixture, thus prepared, in the amount of about 1% of the alloy being treated, was placed upon the surface of the molten bath, which was maintained at a temperature of about 700° C. The molten metal and flux mixture were agitated vigorously for about thirty seconds and after about three minutes the metal was poured. During the process the calcium fluoride reacts with the boric oxide, forming boron fluoride which serves as the modifying agent. The resulting solidified metal was found to exhibit extremely fine grain size, higher tensile strength, greater elongation, and somewhat greater hardness than corresponding alloys not subjected to such a treatment. The improvement in properties imparted to the alloy by the process persisted throughout several subsequent operations of remelting and resolidification.

From the foregoing explanation and examples illustrating my invention, it will be apparent that I have provided an improved composition of matter by means of which alloying ingredients or

modifying agents may be introduced into aluminum or aluminum alloys. Various modifications of my invention will be apparent to those skilled in the art. For example, the amount of modifying agents or compounds in the flux will be dependent upon the effect of the modifying agent upon the aluminum or particular aluminum alloy being treated, or the amount of alloying ingredient which is desired in the finished alloy. In treating aluminum or aluminum alloys with boron compounds, the amount of the boron compound should preferably be present in amount ranging from an appreciable amount up to 1.5% of the metal bath, and there should be sufficient flux present to dissolve the boron compound. In the event that the composition carrying the boron compound constitutes 3% of the weight of the metal bath, it will be apparent that the boron compound should be present in proportions ranging from an appreciable amount up to 50% of the composition.

When a flux containing sodium chloride, potassium chloride and cryolite is employed, I prefer to utilize the eutectic composition because it has the lowest melting point. In treating aluminum alloys having a higher melting point, however, it will be apparent that the composition may be varied. In treating aluminum or aluminum alloys having a low melting point, it will also be apparent that a flux having a somewhat higher melting point may be employed and the molten metal raised to a sufficient temperature to liquefy the flux, although such a process is expensive. I therefore desire to utilize a flux in which the melting point of the flux is not substantially 100° C. higher than the melting point of the metal bath. When the term "approximately eutectic composition" or "substantially eutectic mixture" is utilized in the specification and claims, it will be understood that it contemplates a composition in which the proportions of the ingredients of the flux are such that a eutectic mixture is present or varied in such a manner that the melting point of the flux will not be substantially more than 100° C. higher than the melting point of the aluminum. The proportion of the flux to the compounds which are utilized in reacting with or modifying aluminum or aluminum alloys may, of course, be widely varied and will be dependent upon the amount of such elements or compounds that are necessary to be utilized in the treating of aluminum alloys. It will be apparent, however, that there should be sufficient flux present to dissolve the modifying or alloying compounds, or to form a vehicle for alloying ingredients which are not soluble in the flux.

My improved composition is especially valuable in that it enables special alloying or modifying agents to react much more rapidly with the aluminum. For example, I have found that in causing 2% of boric acid to react with an aluminum alloy, the reaction has been caused to go to substantial completion in about three minutes at a temperature of approximately 750° C., whereas without the flux the corresponding reaction required over five times as long at a temperature several hundred degrees higher.

By utilizing a flux to dissolve the special reaction element or substance, a covering is also provided for the metal bath which prevents the formation of additional oxides which might inhibit the alloying or modifying action and also prevents the loss of metal by oxidation. The presence of cryolite in my preferred flux also has the property of dissolving aluminum oxide or halides which may be formed either by oxidation of the aluminum or as products of the reaction. The dissolving of the aluminum oxide, thus formed, enables the reaction of the aluminum and the special ingredients or compounds to proceed much more rapidly. This property is especially valuable when the oxides of the special treating compounds are utilized because, in such cases, the reaction with the aluminum forms aluminum oxides and if they are not removed, they inhibit the speed of the reaction.

My improved composition of matter is not only effective in carrying the special reacting element or substance into the molten aluminum or aluminum alloys in soluble form, but it also serves to remove undesirable impurities from the aluminum itself and is effective in increasing the fluidity of the metal, thereby improving its casting properties.

It will be understood that my improved composition may be utilized for treating aluminum of either virgin or secondary sources, and by reason of the relative ease with which the improvement of the characteristics may be attained, it renders secondary aluminum more feasible for casting properties, on the one hand, and on the other hand decreases the cost of both sand and chill castings, or metal mold aluminum castings, by reason of the fact that more secondary metal may be employed therein with equal, if not better, results than have heretofore been readily possible by the use of more expensive metal.

While I have explained my invention in considerable detail and have set forth, numerous examples, it will be understood that they should be construed as illustrative and not by way of limitation, and in view of the numerous modifications which may be effected therein without departing from the spirit and scope of this invention, it is desired that only such limitations shall be imposed as are indicated in the appended claims.

What I claim is:

1. A composition of matter for treating aluminum or aluminum alloys comprising a flux containing a mixture of potassium chloride, sodium chloride and cryolite and a boron compound.

2. A composition of matter for treating aluminum or aluminum alloys comprising a flux containing a mixture of potassium chloride, sodium chloride, cryolite, a boron compound and an alkali earth metal halide.

3. A composition of matter for treating aluminum or aluminum alloys comprising an approximately eutectic mixture of potassium chloride, sodium chloride and cryolite, together with a fluoride compound and boric oxide.

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