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PROCESS OF PURIFYING ALUMINUM BY
DISTILLATION OF MIXTURES THEREOF
WITH OTHER METALSHirsch Loevenstein, New York, N. Y., assignor to
Independent Aluminum Corporation, a corpo-
ration of New YorkNo Drawing. Application September 25, 1946,
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9 Claims. (Cl. 75-68)

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The present invention relates to a process of purifying aluminum by distillation of mixtures thereof with other metals.

It has previously been observed that when a ternary alloy of aluminum, zinc and cadmium is heated under a reduced pressure and at a temperature high enough to distill off all of the zinc and cadmium components of the alloy, a substantial part of the aluminum content of the alloy will also be distilled off with the zinc and cadmium.

According to the present invention it is made possible to effect a separation or distillation of aluminum from its alloys with iron, silicon, titanium and other metals having a higher boiling point than aluminum at the working temperature and pressure used and the vapor pressures of which are relatively low as compared with the vapor pressure of aluminum under similar conditions of temperature and pressure. This is brought about by utilizing the ability of certain relatively volatile metals to entrain aluminum vapors when passed as vapors over or through a molten bath of aluminum or an aluminum alloy with one of the higher boiling point metals such as iron, silicon and titanium and thereafter separating the aluminum so removed from the entraining metal vapors by condensation.

The relatively volatile metals selected are those that are either insoluble or only slightly soluble in liquid aluminum and generally do not mix with aluminum. The metals that I prefer to use for this purpose are cadmium, sodium and potassium, although rubidium, caesium and mercury, as well as alloys of two or more of these metals, may be employed. Aluminum may be recovered from vapor mixtures of these metals and aluminum by condensing the vapor mixture and allowing the aluminum to separate from the conveying metal by gravity. The condensed conveying metal may then be returned to the aluminum-containing bath that is undergoing the separation treatment.

The invention has for an object to obtain aluminum in a high state of purity from aluminum-containing alloys or impure aluminum as produced in the electric furnace and in other ways.

Other objects and advantages will appear as the description proceeds.

By way of specific example, an aluminum alloy, such as silico-aluminum or ferro-aluminum as produced in the electric furnace and which is usually contaminated, respectively, with iron or silicon and also with titanium, is placed in a suitable closed container and heated to a tempera-

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ture between the melting point of the eutectic alloy and the boiling point of aluminum. The temperature will, of course, also depend on the pressure prevailing in the system.

A stream of vapors of one of the more volatile metals above-mentioned, for example, cadmium, is then passed in contact with the molten bath of aluminum alloy either by bubbling the vapors through the molten aluminum alloy or by causing them to sweep over the surface of the bath in contact therewith. The resulting vapor mixture of the conveying metal and the aluminum vapors is conducted to a condenser and condensed. Condensers of various known forms may be used. If the condenser is of a type and so operated that the condensed metals are recovered in the same vessel, they lend themselves to ready separation because of the differences in their specific gravities. After separation, the conveying metal (cadmium, in the example) may be re-vaporized and returned to the aluminum entraining chamber.

Alternatively, the mixture of vapors may be passed through a condenser wherein the larger part of the aluminum vapors are condensed in one chamber and the remaining portion with more or less of the entraining metal is condensed in a second or successive chambers. Any portion of the vapors of the entraining metal not condensed is returned for reuse in the cycle.

The aluminum from the condenser can be continuously or intermittently removed and, if necessary, subjected to a second distillation under normal or reduced pressure or a substantial vacuum in order to remove any small quantities of the conveying metal which may have remained admixed with the aluminum. By this process a very pure aluminum is obtained.

If desired the condensed liquid metal can be directly returned to the aluminum vaporizing chamber and there evaporated instead of distilling vapors thereof in a separate chamber and then transferring these to the aluminum vaporizing chamber.

It is preferable to carry on the operation at a reduced pressure or under vacuum because the vapor pressure of aluminum increases faster with lowering of the pressure imposed on the system than the vapor pressures of the metals alloyed therewith. For example, the boiling points of aluminum, silicon and copper at 760 mm. Hg are, respectively, 2270° C., 2355° C., 2335° C. At a pressure of 1 mm. of mercury these boiling points are: Aluminum, 1030° C.; silicon, 1687° C.; and copper, 1400° C.

Other advantages obtained by carrying out the

process at a reduced pressure are: a saving of fuel or energy for heating and the possibility of using metallic containers formed of relatively inexpensive materials such as iron and iron alloys in which to carry out the treatment.

It will be understood that the process is applicable in the recovery of aluminum from its commercial alloys as well as in purifying raw aluminum or thermally produced aluminum alloys.

Various modifications may be made in the details of the procedure involved without departing from the invention which is not to be deemed as limited otherwise than as indicated by the appended claims.

I claim:

1. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises heating the alloy under reduced pressure in the presence of vapors of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury, and, while maintaining the alloy in at least a partly liquid state and below the boiling point of aluminum at the pressure imposed, withdrawing the resulting vapor mixture of aluminum and said selected metal from the heating zone, and thereafter condensing the aluminum vapors and separating the condensed aluminum from said relatively volatile metal.

2. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while adjusting the temperature and pressure thereof so as to minimize the vapor pressures of the higher boiling point metals present and at the same time vaporizing aluminum from said bath, entraining aluminum vapors evolved from said bath in a current of vapors of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury, and thereafter separating the aluminum from said volatile metal by condensation of the aluminum vapors.

3. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while maintaining a substantially reduced pressure and controlling the temperature within a range insuring vaporization of aluminum from said bath but below a temperature at which the higher boiling point metals present will exhibit substantial vapor pressures, entraining aluminum vapors evolved from said bath in a current of vapors of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury, and thereafter separating the aluminum from said volatile metal.

4. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while maintaining a substantially reduced pressure and controlling the temperature within a

range insuring vaporization of aluminum from said bath but below a temperature at which the higher boiling point metals present will exhibit substantial vapor pressures, entraining aluminum vapors evolved from said bath in a current of vapors of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury, thereafter separating the aluminum from said volatile metal by condensation of the aluminum vapors and returning the separated more volatile metal to the aluminum vaporizing zone for re-use as vapors in entraining additional aluminum vapors and removing them from the region of said bath.

5. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while adjusting the temperature and pressure thereof so as to minimize the vapor pressures of the higher boiling point metals present and at the same time vaporizing aluminum from said bath, entraining aluminum vapors evolved from said bath in a current of vapors of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury, thereafter condensing the vapor mixture and subjecting the resulting condensed mixture to gravity separation, and finally subjecting the aluminum to controlled re-distillation to remove minor amounts of the more volatile metal remaining therein.

6. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while adjusting the temperature and pressure thereof so as to minimize the vapor pressures of the higher boiling point metals present and at the same time vaporizing aluminum from said bath, entraining aluminum vapors evolved from said bath in a current of sodium vapors, and thereafter condensing the mixture of sodium and aluminum vapors and separating the condensed aluminum from the sodium by gravity separation.

7. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while adjusting the temperature and pressure thereof so as to minimize the vapor pressures of the higher boiling point metals present and at the same time vaporizing aluminum from said bath, entraining aluminum vapors evolved from said bath in a current of cadmium vapors, and thereafter condensing the mixture of cadmium and aluminum vapors, separating the bulk of the cadmium from the aluminum by gravity separation, and thereafter subjecting the aluminum to re-distillation to drive off the residue of the cadmium.

8. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures such as iron, silicon and titanium, which comprises forming a molten bath of the alloy and, while adjusting the temperature and pressure thereof so as to minimize the vapor pressures of

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the higher boiling point metals present and at the same time vaporizing aluminum from said bath, entraining aluminum vapors evolved from said bath in a current of potassium vapors, and thereafter condensing the mixture of potassium and aluminum vapors and separating the condensed aluminum from the potassium by gravity separation.

9. The process of separating aluminum from its alloys with higher boiling point metals having a relatively lessened tendency as compared to aluminum to vaporize on heating at reduced pressures, which comprises heating the alloy to a temperature between the melting point of the alloy and the boiling point of aluminum at the pressure maintained, adjusting the pressure to minimize the vapor pressures of said higher boiling point metals present in the alloy, passing a stream of vapor of a relatively volatile metal selected from the group consisting of sodium, potassium, rubidium, caesium, cadmium and mercury

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in contact with the molten aluminum to form composite vapors of aluminum and the selected relatively volatile metal and separating the aluminum from the said relatively volatile metal.

HIRSCH LOEVENSTEIN.

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