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3,343,948

ALUMINUM BASE ALLOYS AND APPLICATIONS
THEREOF

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ABSTRACT OF THE DISCLOSURE

An aluminum base alloy, particularly suitable for use as an anode in electrolytic cells, formulated of 0.001 to 0.1 percent by weight of mercury and 0.001 to 2.0 percent by weight of gallium as essential alloying elements and at least one of the metals selected from the group consisting of magnesium, zinc, cadmium, lithium, calcium, barium, copper, silicon, manganese, tin and titanium as additional alloying elements, with the remainder being made up of aluminum and incidental impurities.

The present invention relates to new alloys based on aluminum and mercury. The invention is also concerned with new uses for the alloys such as in the formation of anodes for the protection of a cathode and in the formation of electrolytic cells.

Aluminum alloys containing mercury in amounts of about 0.1 percent have previously been manufactured. These alloys are used in the preparation of elements which are outstanding because of their appearance and polish. The elements can be used in bushings and bearings and the like since their smooth finish provides very low friction. The alloys are also advantageously employed as anodes for cathodic protection and for use in voltaic cells. Such alloys are described in applicant's U.S. application Ser. No. 328,195, filed Dec. 5, 1963, now Patent No. 3,257,201, and comprising a continuation-in-part of Ser. No. 852,961, filed Nov. 16, 1959, now abandoned.

The alloys previously employed are characterized by some disadvantages of a practical nature. Specifically, it has been found that the preparation of the alloys presents many difficulties and can be very dangerous to those involved in the preparation.

One object of the present invention is to provide an alloy based on aluminum and mercury which does not have the aforementioned disadvantages since the alloys can be easily prepared in a safe manner.

It is a further object of this invention to provide improved structures which are made possible through the use of the alloys of this invention.

The following table sets forth the preferred composition ranges for the alloys of this invention:

	Percent
Mercury	0.001 to 0.1
Gallium	0.001 to 2
Magnesium	0 to 12
Zinc	0 to 5
Cadmium	0 to 5
Lithium	0 to 8
Calcium	0 to 12
Barium	0 to 12
Copper	0 to 12
Silicon	0 to 12
Manganese	0 to 12
Tin	0 to 5
Titanium	0 to 0.2
Aluminum and incidental impurities	Balance

Alloys formulated in accordance with this invention can be employed for manufacturing elements which are

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to be polished and which must maintain their brightness during use. Elements which are designed to generate low friction when in engagement with one another, such as bushings, bearings, slides, etc., are also advantageously manufactured with these alloys.

A particularly important application of this invention involves the formation of anodes for cathodic protection and the formation of anodes for electrolytic cells.

The invention as thus defined is illustrated by the examples provided herein, but these examples are not intended to limit the scope of the invention.

It has been found that the aforementioned difficulties regarding manufacturing and safety which are inherent in the preparation of aluminum alloys containing mercury are considerably reduced by the presence of gallium. It is frequently advantageous to provide gallium contents higher than the mercury contents previously employed, that is in the order of 0.1 percent. The beneficial results of this invention are even more pronounced when titanium is present along with the gallium. Where titanium is employed, an amount of at least 0.001 percent is utilized.

The alloys of this invention may be divided into four major classes, depending on whether the main component, apart from aluminum, mercury and gallium, is zinc, magnesium, lithium or tin.

The alloys of the first class have the following general composition:

	Percent
Mercury	0.001 to 0.05
Gallium	0.001 to 0.3
Zinc	2 to 5
Magnesium	10 to 0.5
Titanium	0 to 0.20
Aluminum and incidental impurities	Balance

¹ Preferably 0.1 to 0.5%.

The zinc and the magnesium can be partially or completely replaced by one or by several of the elements barium, calcium, copper, silicon and manganese. These alloys are highly suitable for use as electrodes and the desirability of these substitutions depends essentially on the medium in which the alloy is to be used. The electrodes can remain in alkali solutions having a pH higher than 10.6, particularly in the "black liquor" used in the manufacture of paper pulp or in very alkaline brines.

Example No. 1

A depolarizing electrode cell was formed by a cathode of activated carbon made impervious to paraffin, an electrolyte comprising a caustic soda solution with 150 g./l. of sodium sulphite with a pH equal to 14.3 and an anode made of an aluminum-based alloy containing:

	Percent
Mercury	0.02
Gallium	0.08
Zinc	4
Copper	0.25
Magnesium	0.5
Silicon	0.1

The electromotive force of the battery as thus formed was two volts and the upper limiting intensity was 200 ma. per square decimeter of anode surface. The alloy employed has a potential of -1.65 volts in the electrolyte being used, by reference to a calomel electrode in a saturated solution of potassium chloride.

Example No. 2

The cathode protection of the walls of a container consisting of sheet steel containing a calcium chloride brine with a density of 1.24 was obtained by means of a cylindrical anode with a diameter of 22 mm. and a height of

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100 mm. The anode comprised an aluminum alloy containing:

	Percent
Mercury -----	0.02
Gallium -----	0.08
Zinc -----	3.5
Copper -----	0.20
Magnesium -----	0.45
Manganese -----	0.10
Silicon -----	0.10

No trace of corrosion was found after four months, and the potential of the anode, by reference to silver chloride, had fallen from 1.15 to 1.08 volts.

The alloys of the second class have the following general composition:

	Percent
Mercury -----	0.001 to 0.08
Gallium -----	0.001 to 0.5
Magnesium -----	1 to 12
Titanium -----	0.005 to 0.2
Aluminum and incidental impurities -----	Balance

The magnesium may be partially or completely replaced by one or by several of the elements barium, calcium, copper, silicon and manganese.

Example No. 3

An electrolytic cell element was formed with an anode consisting of the following aluminum alloy:

	Percent
Mercury -----	0.01
Gallium -----	0.09
Magnesium -----	7
Silicon -----	0.15
Titanium -----	0.04

The cathode comprises manganese dioxide and acetylene black to which barium chromate was added. The electrolyte was a calcium chloride solution with a little barium chromate to prevent the attack in open circuit of 0.02 percent of lauryl-dimethyl benzyl ammonium. The electromotive force of this cell was about two volts.

Example No. 4

An anode of the alloy described in Example 3 was used for the cathodic protection of steel in brine with 37 g. of sodium chloride per liter, containing magnesium hydroxide and having a pH of 8.4. In such a medium, the potential varies with the current density and falls from -1.5 volts for a density of the order of 50 ma./dm.² to about -1.25 volts for a density of 200 ma./dm.².

An alloy of similar properties was obtained by part of the magnesium being replaced by cadmium. An alloy with an aluminum base was then obtained which contains:

	Percent
Mercury -----	0.001 to 0.08
Gallium -----	0.001 to 0.3
Cadmium -----	0.5 to 5
Magnesium -----	0.5 to 3
Titanium -----	0.001 to 0.20

Other elements, such as calcium, barium, copper, silicon and manganese, can also be in the alloy, replacing the magnesium or cadmium.

The alloys of the third class are derived from those of the two first classes by the partial or complete replacement by lithium of the magnesium, zinc or cadmium or of several of these metals.

There are thus obtained alloys based on aluminum and having the composition:

	Percent
Mercury -----	0.001 to 0.06
Gallium -----	0.001 to 2
Lithium -----	0.5 to 8
Magnesium -----	0.5 to 5
Titanium -----	0.001 to 0.2

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An alternative composition is as follows:

	Percent
Mercury -----	0.001 to 0.06
Gallium -----	0.001 to 0.5
Lithium -----	0.5 to 8
Magnesium -----	0.5 to 3
Cadmium -----	0.5 to 2
Titanium -----	0.001 to 0.2

The gallium content higher than 0.5 percent and the lithium content higher than 5 percent are particularly used for the formation of anodes which have to be subjected to very high current densities.

The calcium or the barium are combined with the aluminum so as to form, with the dissolution of the anode, aluminates which, by being combined with the anodically protected metal, assist in the protection by setting up an insoluble deposition which is protective in itself. The silicon further reinforces this effect by the formation of silico aluminate.

The joint use of copper and mercury supplies an anti-fouling effect which is significant and which can be reinforced by the gallium.

The alloys of the fourth class have the following general composition:

	Percent
Mercury -----	0.001 to 0.05
Gallium -----	0.001 to 0.1
Tin -----	3 to 5
Zinc -----	0.2 to 3
Titanium -----	0 to 0.2
Aluminum and incidental impurities -----	Balance

Example No. 5

A bushing is formed with an alloy having the composition:

	Percent
Mercury -----	0.05
Gallium -----	0.05
Tin -----	3.5
Zinc -----	3
Titanium -----	0.05
Aluminum and incidental impurities -----	Balance

This alloy is easily polished and the bushings obtained are characterized by a long life.

These alloys are mainly used in the manufacture of anodes for electrolytic cells and for anodic protection. They are also adaptable, particularly the alloys containing tin, to the formation of elements which are intended to have gentle friction, such as bearings, bushings and slides. In addition, the alloys, particularly those containing magnesium, are highly suitable for elements which can be easily polished which will retain their brightness.

The alloys of this invention are preferably prepared by mixing from a mother alloy containing aluminum and gallium. Any conventional technique is, however, contemplated.

It will be understood that various changes and modifications may be made in the foregoing alloys and applications thereof which provide the characteristics of this invention without departing from the spirit thereof particularly as defined in the following claims.

That which is claimed is:

1. An aluminum base alloy consisting essentially of the following:

	Percent
Mercury -----	0.001 to 0.1
Gallium -----	0.001 to 2

and at least one of the metals selected from the group consisting of

	Percent
Magnesium -----	up to 12
Zinc -----	up to 5
Cadmium -----	up to 5
Lithium -----	up to 8

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	Percent
Calcium -----	up to 12
Barium -----	up to 12
Copper -----	up to 12
Silicon -----	up to 12
Manganese -----	up to 12
Tin -----	up to 5
Titanium -----	up to 0.2
Aluminum and incidental impurities -----	Balance

2. An alloy in accordance with claim 1 consisting essentially of:

	Percent
Mercury -----	0.001 to 0.05
Gallium -----	0.001 to 0.3
Zinc -----	2 to 5
Magnesium -----	up to 0.5
Titanium -----	up to 0.20
Aluminum and incidental impurities -----	Balance

3. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.02
Gallium -----	0.08
Zinc -----	4
Copper -----	0.25
Magnesium -----	0.5
Silicon -----	0.1
Aluminum and incidental impurities -----	Balance

4. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.001 to 0.08
Gallium -----	0.001 to 0.5
Magnesium -----	1 to 12
Titanium -----	0.005 to 0.2
Aluminum and incidental impurities -----	Balance

5. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.001 to 0.08
Gallium -----	0.001 to 0.3
Cadmium -----	0.5 to 5
Magnesium -----	0.5 to 3
Titanium -----	0.001 to 0.2
Aluminum and incidental impurities -----	Balance

6. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.001 to 0.06
Gallium -----	0.001 to 2
Lithium -----	0.5 to 8
Magnesium -----	0.5 to 5
Titanium -----	0.001 to 0.2
Aluminum and incidental impurities -----	Balance

7. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.001 to 0.06
Gallium -----	0.001 to 0.5
Lithium -----	0.5 to 8
Magnesium -----	0.5 to 3
Cadmium -----	0.5 to 2
Titanium -----	0.001 to 0.2
Aluminum and incidental impurities -----	Balance

8. An alloy according to claim 1, consisting essentially of:

	Percent
Mercury -----	0.001 to 0.05
Gallium -----	0.001 to 0.1
Tin -----	3 to 5
Zinc -----	0.2 to 3
Titanium -----	up to 0.2
Aluminum and incidental impurities -----	Balance

9. An anode for an electrolytic cell formed of an aluminum base alloy consisting essentially of the following:

	Percent
Mercury -----	0.001 to 0.1
Gallium -----	0.001 to 2
and at least one of the metals selected from the group consisting of	

	Percent
20 Magnesium -----	up to 12
Zinc -----	up to 5
Cadmium -----	up to 5
Lithium -----	up to 8
Calcium -----	up to 12
25 Barium -----	up to 12
Copper -----	up to 12
Silicon -----	up to 12
Manganese -----	up to 12
Tin -----	up to 5
30 Titanium -----	up to 0.2
Aluminum and incidental impurities -----	Balance

10. An anode for use in the protection of cathodes, said anode being formed of an aluminum base alloy consisting essentially of the following:

	Percent
35 Mercury -----	0.001 to 0.1
Gallium -----	0.001 to 2
and at least one of the metals selected from the group consisting of	
	Percent
40 Magnesium -----	up to 12
Zinc -----	up to 5
Cadmium -----	up to 5
45 Lithium -----	up to 8
Calcium -----	up to 12
Barium -----	up to 12
Copper -----	up to 12
Silicon -----	up to 12
50 Manganese -----	up to 12
Tin -----	up to 5
Titanium -----	up to 0.2
Aluminum and incidental impurities -----	Balance

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