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K. S. SELJESAETER

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ALLOY AND METHOD OF MAKING ALLOYS

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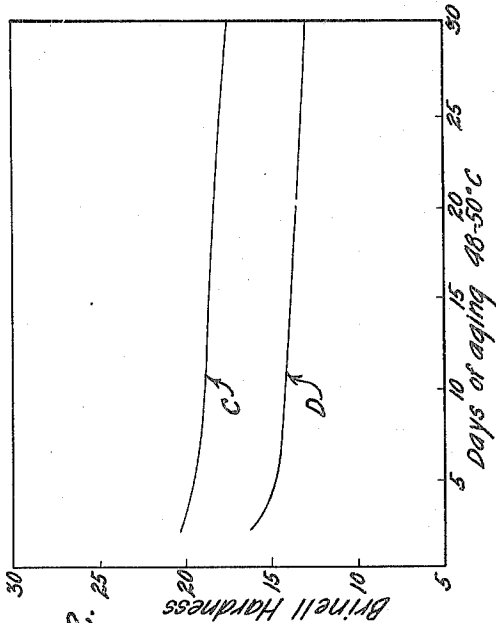


Fig. 2.

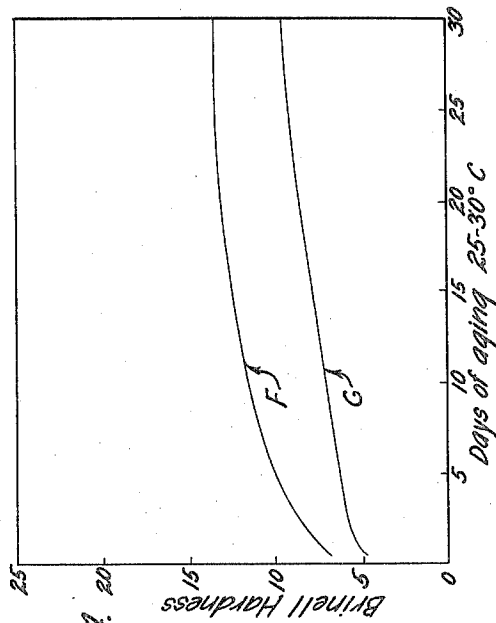


Fig. 4.

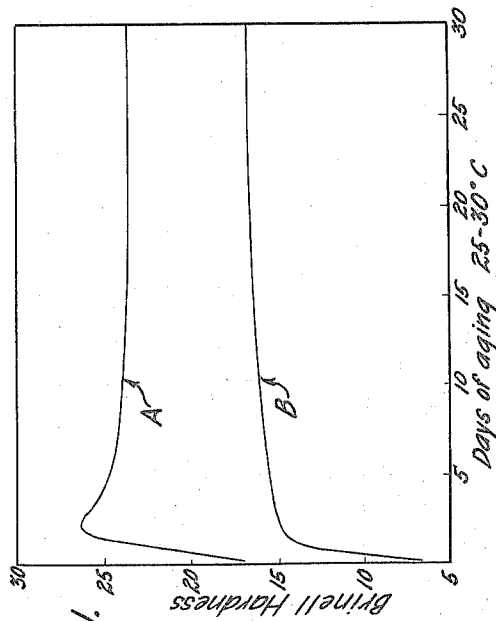


Fig. 1.

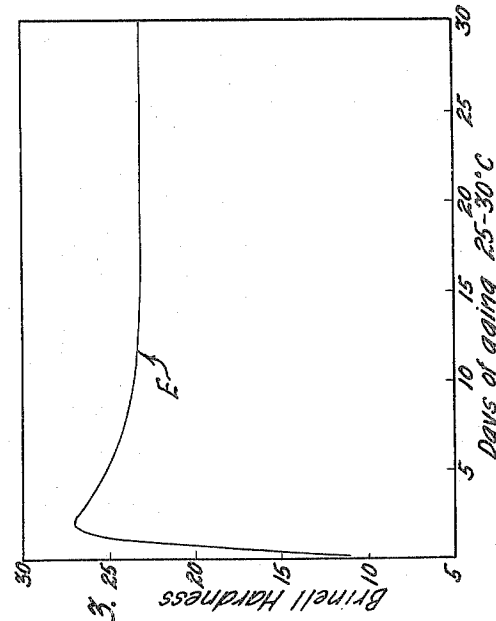


Fig. 3.

Inventor
Kaare S. Seljesaeter
by *H. H. H. H.* Att'y.

UNITED STATES PATENT OFFICE.

KAARE SVAAR SELJESAETER, OF CHICAGO, ILLINOIS, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ALLOY AND METHOD OF MAKING ALLOYS.

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This invention relates generally to alloys and methods of making alloys, and more particularly to improved ternary alloys having lead and antimony as their principal constituents and methods of making such alloys.

Objects of the invention are to provide improved alloys containing lead and antimony and having increased hardness and tensile strength as compared with pure lead or binary alloys of lead and antimony, and to provide an improved method of making such alloys.

In accomplishing the objects of the invention, antimony and a small amount of another material, such as arsenic, are alloyed with lead and the alloy allowed to solidify. The solidified material is then treated in a manner similar to that described in Patents Nos. 1,674,954 and 1,674,958, issued June 26, 1928 to R. S. Dean and W. E. Hudson, for treating binary alloys. Briefly stated, the treatment consists in heating the alloy to produce a saturated solid solution of the antimony in the lead (quenching the alloy to produce a supersaturated solid solution, and then aging the alloy.

Other features and objects of the invention will be apparent from the following detailed description taken in connection with the attached drawing and will be particularly indicated in the appended claims.

In the drawing,

Fig. 1 is a graph showing the relationship between the Brinell hardness of a ternary alloy produced in accordance with the invention after being age-hardened at 25 to 30° C. for various periods of time and the Brinell hardness of a binary alloy of lead and antimony age-hardened under like conditions.

Fig. 2 is a similar graph illustrating a like relationship between the same alloys age-hardened for various periods at 48 to 50° C.;

Fig. 3 is a graph showing the Brinell hardness of a ternary alloy of another composition age-hardened at 25 to 30° C. for various periods, and

Fig. 4 is a graph similar to that shown in Fig. 1 showing a like relationship between still another ternary alloy and another binary alloy age-hardened at 25 to 30° C.

The aforementioned patents disclose a method whereby binary alloys composed of materials, such as lead and antimony, one of

which has a solid solubility in the other 55 which varies with temperature, may be treated to produce improvements, such as increased hardness and tensile strength, in such alloys. Alloys so treated not only have properties superior to those of pure lead but also 60 superior to similar alloys which had not been subjected to the treatment outlined therein. Those patents also disclose the fact that the optimum percentage of the material alloyed with the major ingredient in order to produce 65 improvement in the binary alloy is the maximum amount which will form a solid solution with the major constituent at any temperature. For lead-antimony alloys, the maximum percentage of antimony soluble in 70 solid lead is approximately 2.5%.

Experiments have shown that if a small amount of a third ingredient which is substantially insoluble in lead, but which combines with antimony, is alloyed with a binary 75 lead-antimony alloy of the type disclosed in the aforementioned application and the resulting ternary alloy is subjected to a treatment consisting of heating, quenching and aging, the resulting alloy will have enhanced 80 properties superior to those of similar binary alloys. Among the materials which have been found to have the above described characteristics and to produce a noticeable improvement when alloyed with lead and antimony and subjected to proper treatment are cadmium, sulphur, arsenic, tellurium, thallium and bismuth. In order to enable a person skilled in the art to practice the invention, the process embodying the invention will be 90 described as employed with ternary alloys consisting of lead, antimony and arsenic. It is to be understood, of course, that the invention may be practiced with alloys containing lead, antimony and another material, such as 95 one of those listed above, and satisfactory results be obtained.

In practicing the invention, in one specific embodiment thereof, lead, antimony and arsenic are melted together in the proportions of not more than 2½% antimony, not more than 1% arsenic, and the remainder lead, and the resulting alloy is allowed to solidify. The alloy is then heated at a temperature of approximately 240° C. for a period of time 105 sufficient to cause the antimony to form a homogeneous solid solution in the lead. The material is then quenched or suddenly cooled

to room temperature to produce a supersaturated solid solution of the antimony in the lead, and the alloy is then aged at a temperature below 100° C. in order to permit the alloy to assume a substantially stable condition.

The beneficial results obtained by making lead-antimony-arsenic alloys of the above described constituents and subjecting them to the above outlined treatment are apparent from the graphs shown in the accompanying drawing. In Fig. 1 of the drawing, the curve A indicates the variation in Brinell hardness of a ternary alloy comprising 2% antimony, .05% arsenic, and the remainder lead, which has been subjected to the heating and quenching steps outlined above, with variation in time of aging, at a temperature of 25 to 30° C., while curve B indicates the variation in Brinell hardness of a binary alloy containing 2% antimony and the remainder lead, which has been subjected to a similar treatment, with variation in time of aging at the same temperature. In Fig. 2 the curve C indicates the variation in Brinell hardness of the same alloy as indicated in curve A with time of aging at a temperature of 48 to 50° C., while curve D indicates the Brinell hardness of the alloy indicated in curve B when subjected to the same treatment as the alloy indicated in curve C. The curve E in Fig. 3 indicates variations in Brinell hardness of a ternary alloy containing 2% antimony, 1% arsenate, and the remainder lead with time of age-hardening at a temperature of 25 to 30° C. after having been heated and quenched as described above. In Fig. 4, curves F and G show the relationship between the Brinell hardness of a ternary alloy comprising 1% antimony, .15% arsenic, and the remainder lead, and a binary alloy composed of 1% antimony and the remainder lead when subjected to a similar heating and quenching treatment and age-hardened at a temperature of 25 to 30° C.

An examination of the above described curves will show that in every instance a ternary alloy containing a small amount of arsenic has superior hardness to a similar alloy in which the arsenic is absent and when the age-hardening step is carried out at a sufficiently low temperature. For example, after aging for thirty days at 25 to 30° C. an alloy containing 2% antimony and .05% arsenic had a Brinell hardness of approximately 24, while an alloy containing 2% antimony and no arsenic which had aged at the same temperature for thirty days had a Brinell hardness of approximately 17. The hardness curves for the other alloys illustrated show similar results. It has been found by experiments, however, that when the aging step is performed at a temperature above 100° C. substantially no beneficial results are obtained and consequently the aging

step should be carried out at a temperature not exceeding 100° C. Experiments indicate that other properties, such as tensile strength, of ternary alloys of the above described class, are also superior to those of the corresponding binary alloy and also that improvements in hardness and tensile strength result when materials other than arsenic, such as those listed hereinbefore, are alloyed with lead and antimony.

The improved properties of the alloy are believed to be due primarily to the presence of finely divided, dispersed particles of antimony in a matrix of lead. The improvements resulting from employing the above outlined treatment upon ternary alloys of the class described seem to result from the fact that the antimony which separates out in finely divided particles throughout the lead when the supersaturated solution of antimony in lead is aged is prevented by the third ingredient which is present from agglomerating or forming large particles and thereby rendering the material unsatisfactory. It is believed that the explanation of this phenomenon lies in the fact that the third ingredient alloyed with the lead and antimony is practically insoluble or only slightly soluble in solid lead while it combines with the antimony to form either a true solid solution or else a compound therewith. When a supersaturated solution of antimony in lead is permitted to age, the antimony tends to slowly separate out of the lead in minute particles and the third constituent, which is dispersed throughout the lead since it is insoluble therein, either by forming a protective film around the finely divided, widely dispersed particles of antimony, or by some other means, prevents agglomeration of the antimony particles.

It has also been found by experiment that enhanced properties result when percentages of antimony greater than 2.5%, the maximum percentage which enters solid solution in lead, are employed and that an improvement results when a third constituent of the type described above is alloyed with a lead-antimony alloy of any composition up to 4% antimony. It is believed that when alloys containing more than 2.5% antimony are heated at a temperature of approximately 240° C. only 2.5% of the antimony enters solid solution in the lead and the remainder of the antimony is present in the form of dispersed particles. When this material is quenched and aged, the small antimony particles which separate out of the resulting supersaturated solid solution are prevented, as in the case of alloys containing 2.5% antimony or less, by the third ingredient from agglomerating with the undissolved dispersed particles and with each other to form large particles. It seems then that in lead alloys containing from 2.5 to 4% antimony and a small amount of a third ingredient which is substantially insoluble in lead,

but which combines with antimony, which have been heated, quenched and aged in the manner outlined above the resulting product consists of a matrix of lead throughout which
 5 finely divided particles which separate out from the supersaturated solution produced by the quenching step are widely dispersed and throughout which matrix are also dispersed larger particles of antimony or antimony
 10 combined with the third ingredient.

Experiments conducted upon alloys of compositions other than those hereinbefore described showed an alloy containing approximately 2.5% antimony, about .13% arsenic
 15 and the remainder lead, after heat treatment and aging, to have a Brinell hardness of 27, while a binary lead alloy containing approximately 2.5% antimony and no arsenic had a Brinell hardness of 21.6. Also an alloy comprising approximately 4% antimony, about
 20 .12% arsenic and the remainder lead after being subjected to the above described treatment exhibited a Brinell hardness of 29, while a lead alloy containing approximately 4% antimony and no arsenic exhibited a Brinell
 25 hardness of 21.6. One 4% antimony alloy containing a small amount of arsenic had a Brinell hardness of 33.5. Experiments also show that no appreciable improvements result when more than 1% of the third ingredient is alloyed with lead and antimony
 30 alloys of any composition up to 4% antimony and consequently the use of more than 1% of the third ingredient is unnecessary in order to obtain the desired results.

A material of the type produced by practicing this invention is especially useful in the production of articles which are usually made of lead or lead alloys and in which in-
 35 creased hardness and tensile strength are desirable. Among such articles are battery grids, bearings and sheaths for electrical cables. Since a desirable metal for use in bearings is one in which there is a hard ingredient dispersed throughout a matrix of a
 45 softer material, it is evident that alloys of the type produced by practicing this invention which comprise a matrix of lead throughout which the antimony and the third ingredient are dispersed are especially applicable to the
 50 manufacture of bearings.

What is claimed is:

1. A process for improving the properties of an alloy composed of a plurality of constituents with which is alloyed another constituent which is substantially insoluble in one of the first mentioned constituents and which combines with another one of said constituents, consisting in reducing the alloy to a super-saturated solid solution, and causing
 55 the alloy to assume a more stable state.

2. A process for making an improved ternary alloy, which consists in alloying with a constituent thereof a constituent which has a
 65 varying solid solubility in said constituent

and another constituent which is substantially insoluble in said first mentioned constituent and which combines with said second mentioned constituent, reducing the resulting alloy to a super-saturated solid solution, and
 70 allowing the alloy to assume a more stable state.

3. A process for producing an improved ternary alloy, which consists in alloying with lead and antimony a small amount of another
 75 material which is substantially soluble in lead and which combines with antimony, forming the resulting alloy into a substantially homogeneous solid solution, reducing the alloy to a super-saturated solid solution, and
 80 aging the alloy.

4. A process for making an improved ternary lead-antimony containing alloy, which consists in alloying therewith a small amount of a third ingredient which is soluble in antimony and substantially insoluble in lead, reducing the resulting alloy to a supersaturated solid solution, and allowing the alloy to
 85 assume a more stable state.

5. A process for making an improved ternary alloy, which consists in alloying with lead not more than 4% antimony and a small amount of another material which is soluble in antimony and substantially insoluble in lead, reducing the resulting alloy to a super-
 90 saturated solid solution, and allowing the alloy to assume a more stable state.

6. A process for making an improved ternary alloy, which consists in alloying with lead antimony and not more than 1% of another material which is soluble in antimony and substantially insoluble in lead, reducing the resulting alloy to a supersaturated solid solution, and allowing the alloy to assume
 100 a more stable state.

7. A process for making an improved ternary alloy, which consists in alloying with lead not more than 2.5% antimony and not more than 1% of another material which is soluble in antimony and substantially insoluble in lead, reducing the resulting alloy to a supersaturated solid solution, and allowing the alloy to assume a more stable state.
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8. A process for making an improved ternary lead-antimony alloy, which consists in alloying a small amount of arsenic therewith, reducing the resulting alloy to a supersaturated solid solution, said solution containing the major portion of the antimony and substantially all of the arsenic, and allowing the alloy to assume a more stable state.
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9. A process for making an improved ternary alloy, which consists in alloying not more than 4% antimony and a small amount of arsenic with lead, reducing the resulting alloy to a supersaturated solid solution, said solution containing the major portion of the antimony and substantially all of the arsenic, and allowing the alloy to assume a more stable state.
 120

10. A process for making an improved ternary alloy, which consists in alloying antimony and not more than 1% of arsenic with lead, reducing the resulting alloy to a super-saturated solid solution, said solution containing the major portion of the antimony and substantially all of the arsenic, and allowing the alloy to assume a more stable state.

11. A process for making an improved ternary alloy, which consists in alloying not more than 2.5% antimony and a small amount of arsenic with lead, heating the resulting alloy until a substantially homogeneous solid solution is formed, said solution containing the major portion of the antimony and substantially all of the arsenic; quenching the alloy, and aging.

12. A process for making an improved ternary alloy, which consists in alloying not more than 4% antimony and not more than 1% of arsenic with lead, reducing the resulting alloy to a supersaturated solid solution, and allowing the alloy to assume a more stable state.

13. An improved ternary alloy comprising lead, antimony and a small amount of a third material which is substantially insoluble in lead and which combines with antimony, and characterized by the presence of minute particles of the antimony and the third ingredient dispersed substantially uniformly throughout the lead.

14. An improved ternary alloy comprising lead, antimony and a third ingredient in which minute particles of the antimony and the third ingredient are dispersed substantially uniform throughout the lead.

15. An improved ternary alloy comprising lead, antimony and a small amount of a third material characterized by the presence of minute particles of the antimony and the third ingredient dispersed substantially uniformly throughout the lead.

16. An improved ternary alloy comprising not more than 2.5% antimony, a small amount of another material and the remainder lead, and characterized by the presence of the minute particles of the antimony and the third ingredient dispersed substantially uniformly throughout the lead.

17. An improved ternary alloy comprising lead, antimony and not more than 1% of another material, and characterized by the presence of the minute particles of the antimony and the third ingredient dispersed substantially uniformly throughout the lead.

18. An improved ternary alloy comprising not more than 4% antimony, not more than 1% of another material, and the remainder lead, and characterized by the presence of the minute particles of the antimony and the third ingredient dispersed substantially uniformly throughout the lead.

19. An improved ternary alloy comprising lead, antimony and a small amount of arsenic, characterized by the presence of minute particles of antimony and arsenic dispersed substantially uniformly throughout the lead.

20. An improved ternary alloy comprising not more than 4% antimony, a small amount of arsenic, and the remainder lead, and characterized by the presence of minute particles of antimony and arsenic dispersed substantially uniformly throughout the lead.

21. A process for improving the properties of a ternary alloy composed of not more than 4% antimony, not more than 1% arsenic and the remainder lead, which consists in forming the alloy into a substantially homogeneous solid solution, quenching the alloy to produce a super-saturated solid solution, and aging the alloy to cause the separation of minute particles of antimony and arsenic substantially uniformly throughout the lead.

22. A process for improving the properties of a ternary alloy composed of not more than 2.5% antimony, not more than 1% arsenic and the remainder lead, which consists in reducing the alloy to a super-saturated solid solution, and causing the alloy to assume a more stable state.

23. An improved ternary alloy comprising not more than 2.5% antimony, not more than 1% arsenic, and the remainder lead.

24. An improved ternary alloy comprising not more than 4% antimony, not more than 1% arsenic, and the remainder lead.

In witness whereof, I hereunto subscribe my name this 23d day of June A. D., 1927.

KAARE SVAAR SELJESAETER.