Patented July 3, 1928. 1,675,644

UNITED STATES PATENT OFFICE.

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AGE-HARDENING PROCESS.

No Drawing. Application filed September 16, 1924, Serial No. 737,998. Renewed October 20, 1927.

This invention relates to age-hardened metallic alloys and processes of producing them, and more particularly to an improved process of fabricating age-hardenable alloy articles.

Articles made of age-hardened metallic alloys may be produced in two general ways: The article may be cast in finished form and then age-hardened; or the article may be produced by a working process applied to a billet of the alloy and age-hardened, during, or after the forming process has been completed. An article produced by simple casting and age-hardening is more brittle and possesses less tensile strength than a worked article. A worked article, on the contrary, although possessing greater strength and being less brittle, as a general rule, will anneal and soften at a considerably lower temperature than a simple cast alloy.

The object of this invention is to produce age-hardened metalic alloys which are less brittle than simple cast age-hardened alloys and whose softening temperature is higher than the softening temperature of worked age-hardened alloys of the same constitution.

Another object of the invention is the production of storage battery grids and the like so treated that the final heat treatment thereof may be produced with a minimum period of heating.

The process of age-hardening metallic alloys in practice comprises the three steps of heating, quenching and aging the alloy, certain details being observed in each case, depending principally upon the alloy used and the relative qualities desired in the alloy after age-hardening. The heating step is employed for the purpose of forming the alloy into a solid solution, and should preferably be continued until such a condition exists.

According to the main features of this invention, instead of a single heating step, this step of the process is repeated a plurality of times, and intermediate successive heating operations desired work is performed upon the alloy. The result is that at each successive heating step a solid solution is obtained more quickly, and finally it is possible to heat the alloy and obtain such a condition almost instantaneously. The alloy is quenched and aged after the final heating. It may be quenched or cooled at any convenient rate after any preliminary heating operation, but it should not be permitted to age and harden if quenched before all of the work required has been performed. The working of the alloy has the effect of reducing the grain size, and the quick heating which is possible when solid solution forms quickly, reduces the crystal growth due to such heating. In order to produce an alloy of maximum hardness it is essential that no work be performed on the alloy between the final quenching and aging steps. This practice is necessary since working of the alloy between these quenching and aging steps would tend to reduce the size of the crystalline structure, which accordingly would result in a reduction of the hardness.

Although the heating step may be repeated any required number of times it is usually sufficient to heat the alloy to obtain a solid solution, (or to cause the maximum amount of solute material present to enter solution, where there is more than the carrier metal can hold), perform work upon the alloy, reheat quickly to the temperature required to produce a solid solution, quench the alloy and age it.

The invention is particularly adaptable to the treating of age-hardenable lead alloys of the character described in our copending application, Serial No. 690,716, filed February 5, 1924, wherein are disclosed lead alloys containing tin, antimony, etc., and particularly lead-antimony alloys containing about 2.25 per cent antimony. The specific application of the invention to the production of age-hardened lead alloys will now be more fully explained.

The process for producing age-hardened alloys, such as those referred to in our copending application mentioned above, is briefly to heat the alloy until a state of solid solution exists therein, quench the alloy while still in a state of solid solution to a lower temperature, thereby forming a supersaturated solid solution, and then age the alloy at a temperature below 100° C. During the aging process the alloy gradually assumes a more stable state, or a state of equilibrium and the hardness thereof gradually increases. In our copending application,

Serial No. 690,719, filed February 5, 1924, a process for hardening lead-antimony articles upon which work has been performed is disclosed. The principal distinction between the hardening method as applied to cast articles and worked articles is that the constituents of worked alloys can be formed into a solid solution more quickly than the constituents of alloys which are simply cast.

According to the main features of the present invention as applied to lead-alloys, the alloy is first reduced to a solid solution, this treatment causing it to readily re-enter solution after the alloying constituent has separated out of the lead. The article to be produced is then formed from the alloy, raised quickly to the temperature which will permit the maximum amount of solute material to enter solid solution, and immediately quenched. The alloy is then aged in the usual manner as described in our copending application, Serial No. 690,716, referred to above.

By the process constituting this invention, the crystal growth due to the final heating is reduced to a minimum and the alloy, having been previously formed into a solid solution, reforms into a solid solution very quickly with a minimum amount of heating.

A process embodying this invention may be of particular advantage in the production of storage battery grids, such as those described in our copending application, Serial No. 690,720, filed February 5, 1924. When employed for this purpose the details of the process may be as follows: The alloy is cast into the form of a billet and heated until a solid solution is obtained. It is then cooled at any convenient rate and when cooled is rolled into thin sheets. It is then again heated to the temperature of maximum solubility and quenched from that temperature. The storage battery grid may then be stamped from the sheet, preferably before the sheet has had sufficient time to harden. After the grid has been formed, it is again raised to the temperature required to obtain solid solution and immediately quenched. Since the storage battery grid is a comparatively small article and since its surface is large in proportion to its bulk, it can be heated to an elevated temperature practically instantaneously and on account of the previous treatment a solid solution is produced without the necessity of continued application of heat. The crystal growth due to the final heating is therefore reduced to a minimum. The term softening temperature as used in the specification and the appended claims is defined as the temperature at which the age-hardened alloy will begin to lose its hardness.

Although the process has been described as applying particularly to the treating of lead-alloys and more specifically to the production of storage battery grids, it is to be understood that the invention is to be limited only by the scope of the appended claims.

What is claimed is:

1. The method of treating an age-hardenable lead alloy, which consists in raising said alloy a plurality of times to the temperature at which the maximum amount of solute material present will enter solid solution, performing work thereon between successive heating steps, quenching said alloy and then aging said alloy.

2. The method of treating age-hardenable lead alloys, which consists in forming the constituents of the alloy into a solid solution, cooling the alloy, performing work upon the alloy, heating said alloy to reform the solid solution, then quenching and aging the alloy.

3. The method of treating age-hardenable lead alloys, which consists in casting the alloy, heating the alloy to obtain a solid solution, cooling the alloy, performing work upon the alloy, reheating the alloy to the temperature at which the maximum amount of solute material present will enter solid solution, then quenching and aging the alloy.

4. The method of treating a lead alloy, which consists in casting a billet of said alloy, heating said billet at the temperature at which the maximum amount of solute material present will enter solid solution, cooling the billet, performing work thereon, reheating said alloy to the temperature at which the maximum amount of solute material present will enter solid solution, then quenching and aging said alloy.

5. The method of producing a storage battery grid, which consists in casting a billet of an age-hardenable lead alloy, heating said billet until the maximum amount of solute material present enters solid solution, cooling said billet, fabricating a grid therefrom, reheating the grid to the temperature necessary to produce solid solution, then quenching and aging said grid.

6. The method of producing a storage battery grid, which consists in casting a billet of an age-hardenable lead alloy, heating said billet until the maximum amount of solute material in said alloy enters solid solution, cooling said billet, rolling said billet to a flat sheet, reheating said alloy in the resulting flat sheet form until the maximum amount of solute material therein enters solid solution, quenching said sheet, stamping a grid therefrom, reheating said grid, quenching said grid and aging the grid.

7. The method of treating an age-hardenable lead alloy, which consists in forming the constitutents thereof into a solid solution a plurality of times, performing work thereon between successive solid solution forming steps, then quenching and aging the alloy.

8. The method of producing age-hardened

lead alloys, which consists in alloying antimony with lead, forming the constituents thereof into a solid solution and cooling the alloy a plurality of times, performing work thereon between successive solid solution forming steps and cooling steps, and aging the alloy after the final cooling step.

9. The method of treating an age-hardenable lead alloy, which consists in forming the constituents thereof into a solid solution, cooling the alloy, performing work upon the alloy, again forming the constituents into a solid solution, quenching the alloy, and aging the alloy.

10. The method of producing age-hardenable alloys, which consists in alloying antimony with lead, forming the constituents of the alloy into a solid solution, cooling the alloy, performing work upon the alloy, again forming the constituents into a solid solution, then quenching and aging the alloy.

11. The method of producing age-hardened alloys, which consists in alloying about 2.25 per cent antimony with lead, forming the constituents of the alloy into a solid solution, cooling the alloy, performing work upon the alloy, again forming the constituents into a solid solution, then quenching and aging the alloy.

12. The method of producing a storage battery grid, which consists in casting a billet of an age-hardenable lead-antimony alloy, heating said billet until the antimony present enters solid solution, cooling said billet, fabricating a grid therefrom, reheating the grid to the temperature necessary to produce solid solution, then quenching and aging said grid.

13. The method of producing a storage battery grid, which consists in casting a billet of an age-hardenable lead-antimony alloy containing about 2.25 per cent antimony, heating said billet until the antimony present enters solid solution, cooling said billet, fabricating a grid therefrom, reheating the grid to the temperature necessary to produce solid solution, then quenching and aging said grid.

14. The method of producing a storage battery grid, which consists in casting a billet of an age-hardenable lead-antimony alloy, heating said billet until the antimony in said alloy enters solid solution, cooling said billet, rolling said billet to a flat sheet, reheating said alloy in the resulting flat sheet form until the antimony therein enters solid solution, quenching said sheet, stamping a grid therefrom, reheating said grid to reform the solid solution, quenching said grid, and aging the grid.

In witness whereof, we hereunto subscribe our names this 29th day of August, A. D. 1924.

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