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METHOD OF PREPARING ALUMINUM CARTRIDGE CASE

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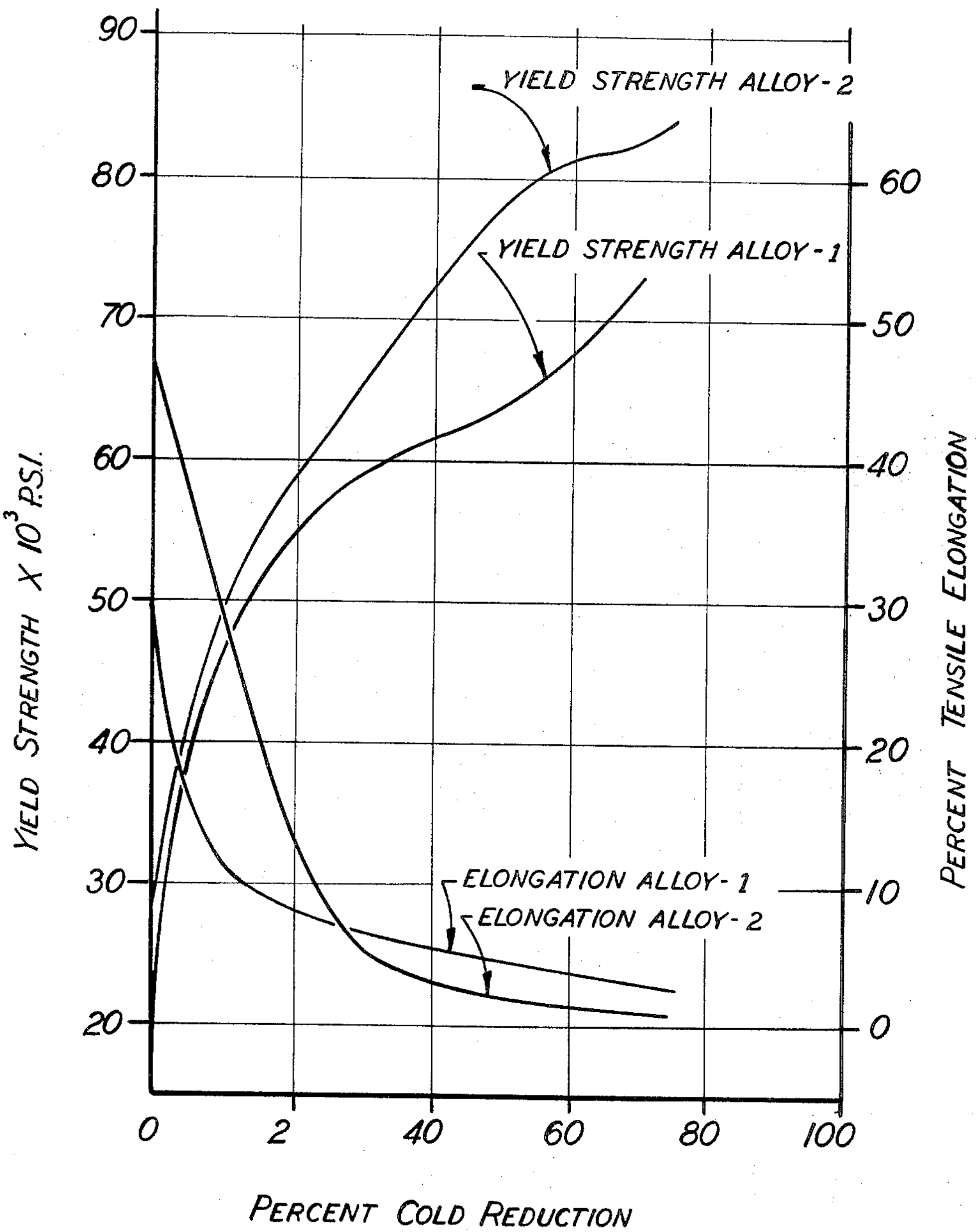



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# METHOD OF PREPARING ALUMINUM CARTRIDGE CASE

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U.S. Cl. 148—11.5 A 7 Claims

## ABSTRACT OF THE DISCLOSURE

The disclosure teaches a non-heat treatable aluminum alloy cartridge case and method of preparing same.

This application is a division of copending application Ser. No. 785,108, filed Dec. 19, 1968.

Copper base alloys are conventionally utilized for cartridge cases, specifically cartridge brass which is an alloy containing about 70% copper and about 30% zinc.

For many years, substitutes have been sought for brass in cartridge cases. This has been motivated by frequent copper shortages, increasing copper costs and weight saving considerations.

The optimum choices for substitutes are high strength steel and aluminum alloys. Steel offers the advantage of high strength, while aluminum offers lower weight, lower cost, good availability and a good modulus of elasticity. However, in these materials the surface characteristics and mechanical properties offer serious drawbacks to their utilization as replacement materials. These drawbacks seriously curtain the use of mild steel and various aluminum alloys in cartridge case applications. Generally aluminum alloys suffer from an inability to contain the pressures involved. For steel the modulus of elasticity offers a serious drawback due to a lack of elasticity required when the cartridge is fired, i.e., first expand and seal and then shrink in the chamber for easy extraction.

Specifically, aluminum alloys currently available generally do not have sufficient strength to withstand the dynamic pressures involved in firing unless the alloy is of the high strength and heat treatable variety and then they are notch sensitive. Iron and iron base alloys generally do not have sufficient spring back unless work hardened or heat treated to significantly high yield strength levels. The class of heat treatable aluminum alloys, including aluminum alloys 7075, 7178, and 7002 or 2024 and others, while having sufficient strength to withstand the surge pressures involved and sufficient spring back to be acceptable as cartridge materials, are severely notch sensitive in their high strength form and, therefore, are quite susceptible to cracking. Furthermore, in order to achieve this high strength form sophisticated heat treat practices are required involving solution heat treatments and precipitates hardening reactions. In addition, susceptibility to general corrosion is often a problem, e.g., alloy 2024. Iron and steel also must be specially treated in order to produce yield strengths in excess of 14,000 p.s.i. before they are elastically acceptable for this application and facilities of this type are not currently readily available. Steel also requires extensive corrosion protection which is quite costly.

Accordingly, it is a principal object of the present invention to provide a cartridge case and a method for preparing same which overcomes the foregoing significant disadvantages.

It is a further object of the present invention to provide a cartridge case and method as aforesaid utilizing aluminum base alloys.



It is a still further object of the present invention to provide a cartridge case and method as aforesaid which is inexpensive and readily utilizable on a commercial scale.

Further objects and advantages of the present invention will appear from the ensuing discussion.

In accordance with the present invention, the foregoing objects and advantages are readily obtained. In accordance with the present invention there is provided an aluminum base alloy cartridge case adapted for use in a gun barrel comprising a drawn shell having an open mouth at one end adapted to be closed by a projectile and having a closed bottom end opposite said open mouth, said cartridge case consisting essentially of an aluminum base alloy containing from 5.5 to 10% magnesium, 0.05 to 0.3% chromium and the balance essentially aluminum.

The cartridge case of the present invention is highly useful using standard processing techniques; however, the preferred processing of the present invention has been found to obtain particularly good results. Hence, the present invention also comprises a process for preparing an aluminum base alloy cartridge case which comprises:

(A) providing a cupped blank of an aluminum base alloy consisting essentially of from 5.5 to 10% magnesium, from 0.05 to 0.3% chromium, balance essentially aluminum;

(B) drawing said cup on a succession of punches through a succession of die stages to progressively thin the longitudinal walls thereof and form an elongated cartridge case adapted for use in a gun barrel; and

(C) annealing said cup at a temperature of from 550° F. to 800° F. for from 30 minutes to 6 hours at least twice between alternate die stages, wherein the final anneal is characterized by
   - (1) heating to annealing temperature at a rate of less than 250° F. per hour and preefrably less than 50° F. per hour, and
   - (2) cooling from annealing temperature to 350° F. at a rate of less than 250° F. per hour and preferably less than 50° F. per hour. Rate of cooling below 350° F. is not critical.

In the preferred embodiment, the finally drawn cartridge case is given a stabilizing heat treatment at a temperature of from 150 to 500° F. for from 2 to 24 hours and preferably from 250 to 350° F. for 4 to 8 hours. This effectively stabilizes the mechanical properties obtained by strain hardening. The stabilizing treatment should be after the final deformation, e.g., the stabilizing treatment should be after any mouth sizing and necking treatments.

In accordance with the present invention it has been found that the foregoing aluminum alloy cartridge cases achieve the physical properties needed for this severe application. The aluminium alloy cartridge cases of the present invention are inexpensive and readily fabricated using conventional equipment. Cartridge cases of the present invention were found to perform quite satisfactorily when shot off in a range with internal pressure from 20,000 to 70,000 p.s.i. There were no deficiencies associated with metal failure, e.g., stress concentration cracking or bursting of the side wall. These are standard reasons for failure of conventional aluminum alloy cartridges cases.

Furthermore, the aluminum alloy cartridge cases of the present invention are non-heat treatable which represent a significant advantage. That is, conventional materials for use in aluminum cartridge cases are heat treatable and require an expensive last heat treating stage which produces a deleterious oxide. Further, conventional heat treatables require protection against corrosion, for example, alcladding, lacquering, anodizing, etc. The aluminum alloy cartridge cases of the present invention do not require this although it may be desirable for mechanical, handling or storage reasons, etc., to oil or otherwise coat the aluminum alloy cartridge cases of the present invention.

Conventional cartridge material is brass which gets its strength from work hardening in a manner similar to the cartridge cases of the present invention. Hence, conventional facilities do not include the heat treatment equipment required for heat treatable aluminum alloy cartridge cases.

Still further, the aluminum alloy cartridge cases conventionally employed are notch sensitive and prone to firing splits which is not the case with the cartridge cases of the present invention. Specifically, the energy required to propagate a crack in the cartridge cases of the present invention is two times the value in conventional high strength heat treatable aluminum alloy cartridge cases.

As stated hereinabove, the aluminum base alloy cartridge cases of the present invention contain from 5.5 to 10% magnesium, from 0.050 to 0.3% chromium, and the balance essentially aluminum. Preferably, an additional additive is prouved which should be selected from the group consisting of indium from 0.002 to 0.80%, gallium from 0.01 to 0.50%, cadmium from 0.03 to 0.50%, boron from 0.001 to 0.350%, thorium from 0.005 to 0.350%, misch metal from 0.005 to 0.30%, hafnium from 0.05 to 0.7%, tellurium from 0.005 to 0.30%, lithium from 0.01 to 0.80%, manganese from 0.05 to 1.0%, germanium from 0.01 to 0.55%, and cobalt from 0.10 to 0.80% plus copper from 0.10 to 0.60%.

In the preferred embodiment of the present invention, the following preferred amounts of materials are utilized; from 6 to 8% magnesium; from 0.1 to 0.2% chromium; from 0.05 to 0.60% indium; from 0.3 to 0.20% gallium; from 0.10% to 0.30% cadmium; from 0.1 to 0.30% germanium; from 0.10 to 0.40% lithium; from 0.01 to 0.10% tellurium; from 0.15 to 0.50% hafnium; from 0.05 to 0.20% misch metal; from 0.02 to 1.0% thorium; from 0.01 to 0.05% boron. It is noted that misch metal is a mixture of the rare earth metals, for example misch metal contains cerium, lanthanum, neodymium, didymium. etc. The preferred amount of manganese is from 0.10 to 0.40%. When manganese is present, one may also utilize zinc in an amount from 0.05 to 1.5%, with a preferred zinc content of from 0.10 to 0.50%. It should be noted that when copper is present, cobalt should also be present. The preferred amount of these materials is copper from 0.15 to 0.40% and cobalt from 0.15 to 0.60%.

In addition to the foregoing alloying additions, naturally the present invention contemplates the use of the normal impurity levels common to commercial grade aluminum. However, impurity ranges should preferably be maintained with the following limits; iron, up to 0.50%; silicon, up to 0.50%; titanium, up to 0.15%; beryllium, up to 0.02%; and others in total up to 0.2%. In fact, it may be desirable to add one or more of the foregoing materials in order to enhance a given property, for example, castability or to minimize staining during annealing. Beryllium is a preferred alloying addition in amounts from 0.00005 to 0.02%, and optimally from 0.001 to 0.0005%.

The melting and casting of the aluminum alloys utilized for the cartridge case is not particularly critical. The alloys may be melt and cast by any conventional method, such as, for example, the Direct Chill or Tilt Mold method. The alloys may then be rolled to sheet form by conventional methods and blanks for drawing may then be obtained.

A cupped blank of the aluminum alloy is then obtained and the cup is drawn on a succession of punches through a succession of die stages in the conventional manner. This serves to progressively thin the longitudinal walls of the cup and form an elongated cartridge case adapted for use in a gun barrel. In the present specification the term



"drawing" encompasses the term "ironing." Ironing is side wall thinning and extending to increase the depth of the cup without seriously affecting the cup base thickness.

The cup is fully annealed at a temperature of from 550° F. to 800° F. for from 30 minutes to 6 hours at least twice between altrnate die stages. A critical step in the processing is the final full anneal. In accordance with the present invention, the heat up time to final full annealing temperature should be at a rate of not more than 250° F. per hour and preferably not more than 50° F. per hour and cool down rate from final full annealing temperature to 350° F. should be at a rate not more than 250° F. per hour and preferably not more than 50° F. per hour.

In accordance with the present invention one might wish to anneal between each die stage or between certain of the die stages. The only restriction is that the ultimate or final full anneal must be done early enough in the processing so that the final cartridge case reflects 10 to 70% equivalent cold work. The final cartridge case should reflect this property even after any final stabilizing treatment or partial anneal.

The annealing treatment need not be between consecutive drawing operations and naturally more than two annealing treatment may be used, if desired.

For high pressures, e.g., rifle cartridge cases or high pressure machine guns, a standard necking operation is performed after the final anneal. A mouth anneal is generally required to do this. The mouth anneal is a separate operation and can be a torch anneal if the maximum temperature achieved is the annealing temperature described above, i.e., this is a partial anneal.

Furthermore, it is preferred in accordance with the present invention to provide a final heat stabilizing step at a temperature of from 150 to 500° F. for from 2 to 24 hours and preferably from 250 to 350° F. for from 4 to 8 hours.

In the preferred embodiment, there are four cycles of annealing and drawing and there are preferably six drawing operations.

In the preferred embodiment, the annealed blank is cupped, annealed, first drawn, annealed, second drawn, annealed, third drawn, annealed, fourth drawn, fifth drawn, sixth drawn, the head formed, mouth annealed, necked, sized, and then stabilized.

Other preferred operations are as follows. The same practice through and including the fourth draw, followed by annealing the mouth area only, fifth drawn, sixth drawn, the head formed, necked, sized and stabilized.

Another preferred operation follows the following practice: The same procedure through and including the fourth draw, annealed, fifth drawn, sixth drawn, the head formed, mouth annealed, necked, sized, and stabilized.

Alternatively, some draws may be combined into multiple stage operations or more severely drawn in one stage to cut down the total number of draws and anneals.

In accordance with the present invention it has been found that the foregoing cartridge case and process achieves numerous and highly advantageous results. Some of these have been referred to hereinabove. An additional advantage is the fact that the cartridge case of the present invention is substantially lighter than conventional cartridge cases. The density of brass, for example, is 0.308 pound per cubic inch; whereas, a representative cartridge case of the present invention is 0.095 pound per cubic inch. Hence, the cartridge case of the present invention is substantially lighter. Although, the present cartridge cases are weaker than 70/30 brass or heat treatable alloys, this can be readily tolerated with respect to the instant cartridge cases since we can utilize additional wall thickness in order to give additional wall strength, if it is desired.

It may be desirable for appearance or other reasons to clad the cartridge case of the present invention with from

3 to 20% and preferably from 5 to 15% of a copper base alloy, for example, 70–30 brass.

The present invention will be more readily apparent from a consideration of the following illustrative examples.

### EXAMPLE I

Circular blanks approximately one inch in diameter were obtained from annealed strip 0.140" thick. The strip had the following composition:

| | Percent |
|---|---|
| Magnesium | 7.05 |
| Chromium | 0.19 |
| Iron | 0.22 |
| Silicon | 0.10 |
| Copper | 0.08 |
| Beryllium | 0.006 |
| Boron | 0.007 |

Aluminum essentially the balance.

A plurality of the fully annealed blanks were cupped and drawn by the following sequence.

All materials were treated as follows: the cups were annealed at 650° F. for 4 hours, first drawn, annealed 650° F. for 4 hours, second drawn, annealed 650° F. for 4 hours, third drawn, annealed 650° F. for 4 hours and fourth drawn.

Three alternative final fabrication sequences were followed.

(A) Fifth drawn, sixth drawn, headed, mouth annealed by flash annealing at about 550° F. for about 15 seconds, necked, sized, and stabilized at 300° F. for 4 hours.

(B) The mouth portion only annealed at 650° F. for 4 hours, fifth drawn, sixth drawn, headed, necked, sized, and stabilized for 4 hours at 300° F.

(C) Annealed 650° F. for 4 hours, fifth drawn, sixth drawn, headed, mouth annealed as in (A), necked, sized, and stabilized for 4 hours at 300° F.

In all cases, the final full anneal was characterized by heating to annealing temperature at a rate of 50° F. per hour and cooling from annealing temperature to 350° F. at a rate of 50° F. per hour.

The properties of the resulting cartridges are given in the following table.

TABLE I

| | Yield strength, p.s.i. | Tensile elongation, percent |
|---|---|---|
| Treatment: | | |
| A | 63,000–66,000 | 5.0 to 5.5. |
| B | 58,000–61,000 | 6.0 to 6.5. |
| C | 55,000–57,000 | 6.0 to 7.0. |

### EXAMPLE II

The cartridge cases obtained in Example I were fitted with a bullet and primed and loaded in the conventional ammunition manner.

Several of each were shot off in a range with internal pressure from 20,000 to 45,500 p.s.i. There were no deficencies associated with the metal failure.

### EXAMPLE III

In this example the alloy of Example I (alloy 1) and 70–30 brass (alloy 2) were tensile tested after varying percentages of cold reduction. The results are shown in the figure which is a part of the present specification. The figure compares the yield strength and elongation of alloys 1 and 2. The results show a surprising similarity between the alloy of the present invention and 70–30 brass. The results also provide an indication of the strengthening levels required to make a successful cartridge case.



This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency are intended to be embraced therein.

What is claimed is:

**1.** A process for preparing an aluminum base alloy cartridge case which comprises:

(A) providing a cupped blank of an aluminum base alloy consisting essentially of from 5.5 to 10.0% magnesium, from 0.05 to 0.3% chromium, balance aluminum;

(B) drawing said cup on a succession of punches through a succession of die stages to progressively thin the longitudinal walls thereof and form an elongated cartridge case adapted for use in a gun barrel; and

(C) annealing said cup at a temperature of from 550 to 800° F. for from 30 minutes to 6 hours at least twice between alternate die stages, wherein the final anneal is characterized by

(1) heating to annealing temperature at a rate of less than 250° F. per hour, and

(2) cooling from annealing temperature to 350° F. at a rate of less than 250° F. per hour.

**2.** A process according to claim **1** wherein the cartridge case is given a final stabilizing treatment at a temperature of from 150 to 500° F. for from 2 to 24 hours.

**3.** A process according to claim **2** wherein said aluminum base alloy contains a material selected from the group consisting of indium from 0.002 to 0.80%, gallium from 0.01 to 0.50%, cadmium from 0.03 to 0.50%, boron from 0.001 to 0.350%, thorium from 0.005 to 0.350%, misch metal from 0.005 to 0.30%, hafnium from 0.05 to 0.7%, tellurium from 0.005 to 0.30%, lithium from 0.01 to 0.80%, manganese from 0.05 to 1.0%, germanium from 0.01 to 0.55%, and cobalt from 0.10 to 0.80% plus copper from 0.10 to 0.60%.

**4.** A process according to claim **2** wherein there are four cycles of annealing and drawing.

**5.** A process according to claim **2** wherein said heating and cooling rates are less than 50° F. per hour.

**6.** A process according to claim **2** wherein said stabilization treatment is for 250 to 350° F. for from 4 to 8 hours.

**7.** A process according to claim **4** wherein said four cycles of annealing and drawing are followed by two additional drawing operations, followed by forming the cartridge head, followed by mouth annealing, necking, sizing and said stabilization treatment.


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