Aug. 8, 1967 F. KRAUS 3,334,781

HOLLOW BODY AND METHOD OF MAKING THE SAME

Filed Feb. 11, 1963

Fig. 1

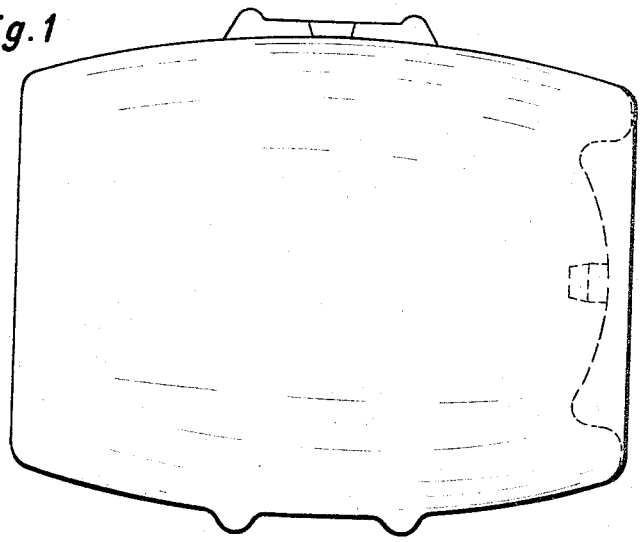


Fig. 2

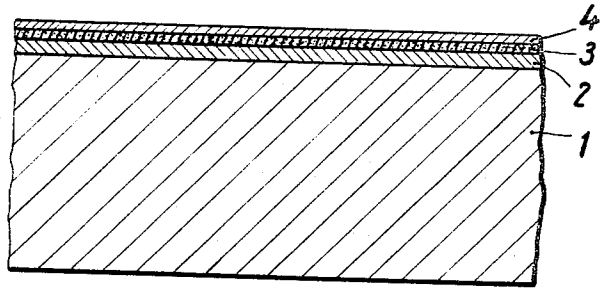
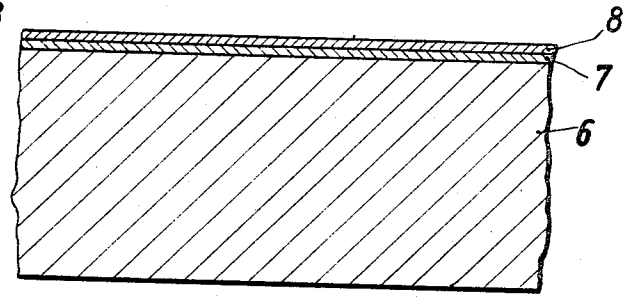


Fig. 3



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3,334,781

HOLLOW BODY AND METHOD OF MAKING THE SAME

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12 Claims. (Cl. 220—64)

The present invention relates to a hollow body and a method of making the same and, more particularly, the present invention is concerned with containers such as beer barrels or hollow bodies such as floats, which containers or hollow bodies are adapted to engage a liquid and include wall portions facing the liquid which wall portions consist of a light metal, preferably of aluminum, or aluminum alloys.

The present application is a continuation-in-part of my co-pending application, Ser. No. 243,151, filed Dec. 7, 1962, and entitled, "Hollow Body and Method of Making the Same."

In the case of beer barrels, as well as for other purposes, the wall portions of light metal which face the liquid must be protected against corrosion. For instance, it has been proposed to form an oxide layer having a thickness of between 12 and 16 microns on such wall portion and to coat the oxide layer with a suitable baked enamel, such as an epoxy layer.

Certain difficulties are encountered by proceeding in this manner, inasmuch as the oxide layer which thus would be interposed between the light metal wall and the surface enamel, tends to tear or to form cracks when exposed to mechanical impacts, for instance by dropping a beer barrel from a truck. Such crack formation in the oxide layer has an adverse effect on the durability of the enamel layer and on the useful life span of the beer barrel or the like.

It has been proposed to improve the quality of beer barrels or the like by subjecting the inner light metal face of the beer barrel to a lustring treatment prior to anodic oxidation thereof. In other words, the inner wall of such beer barrel, or the entire wall of the beer barrel will then consist of a suitable light metal, such as aluminum or an aluminum alloy which can be successfully subjected to lustring treatment, and after the inner face has been smoothed by such lustring treatment, an oxide layer is formed thereon, for instance by anodic oxidation, which oxide layer conventionally will have a thickness of between about 12 and 16 microns. However, the above discussed disadvantages still do occur by proceeding in this manner, namely that the oxide layer, upon exposure of the beer barrel or the like to mechanical impact will tend to break and form cracks. This disadvantage cannot be overcome by applying an enamel coating to the free face of the oxide layer, since it has been found that cracks formed in the oxide layer will have an adverse effect on the superposed enamel and will cause crack formation therein. Reduction in the thickness of the oxide layer to less than 12 microns, such as to between 5 and 10 microns did not improve the tear resistance of the oxide layer.

It is therefore an object of the present invention to overcome the above discussed disadvantages and difficulties.

It is another object of the present invention to provide a method for producing a corrosion-resistant surface on hollow bodies such as beer barrels, floats or other types of containers, which can be carried out in a simple and economical manner and which will overcome the above discussed difficulties, particularly the undesirable crack formation in liquid-contacting surface portions thereof.

It is a further object of the present invention to provide a corrosion-resistant surface portion on a liquid-engaging hollow body, such as a beer barrel, float or the like which will have a prolonged useful life span due to reduction of the tendency to crack formation at the liquid-engaging surface portion.

Other objects and advantages of the present invention will become apparent from a further reading of the description and of the appended claims.

With the above and other objects in view, the present invention contemplates a liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid, the wall consisting essentially of a layer of baked enamel forming the face, a layer of light metal selected from the group consisting of aluminum and aluminum alloys, and an oxide layer having a thickness of less than 2 microns interposed between and adhering to the layers of light metal and baked enamel.

The liquid-engaging hollow body according to the present invention may also include a wall having a face which is adapted to be directed toward the liquid and which is composed of an enamel layer, the wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards the enamel layer, and the wall also including an oxide layer having a thickness of less than 2 microns formed on the smooth lustrous surface of the layer of light metal and contacting the enamel layer.

According to one embodiment, the present invention comprises a beer barrel including an outer wall, an inner wall plated onto the outer wall and forming the inner face of the beer barrel, the inner wall consisting essentially of a light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustred surface directed toward the interior of the beer barrel, an uncompacted oxide film having a thickness of less than 2 microns formed on and covering the smooth lustred surface, and a baked enamel coating covering the oxide film.

The present invention also contemplates a method of producing a corrosion-resistant surface on a liquid-engaging hollow body having a wall adapted to be directed toward the liquid and including a layer of light metal selected from the group consisting of aluminum and aluminum alloys, comprising the steps of subjecting the surface of the wall directed towards the liquid to a lustring treatment so as to form a smooth lustrous surface on the wall, providing an oxide film having a thickness of less than 2 microns on the thus formed smooth lustrous surface, and coating the oxide film with a layer of enamel.

Preferably, the oxide film formed according to the present invention will have a thickness of about 1 micron.

The present method of producing a corrosion-resistant surface on a liquid-engaging hollow body having a wall adapted to be directed towards the liquid, which wall preferably will consist of an aluminum-magnesium-silicon alloy, may also be carried out by subjecting the surface of the wall directed toward the liquid to anodic oxidation in an electrolytic bath consisting essentially of aqueous sulfuric acid and between 3 and 30% of a trivalent alcohol, preferably glycerin, so as to form on the surface of the wall an oxide film having a thickness of less than 2 microns, preferably of about 1 micron, and forming a layer of baked enamel, for instance of an epoxy baking enamel, on the oxide film.

Surprisingly it has been found that, notwithstanding the fact that oxide layers of a thickness of somewhat less than 12 microns show an even greater tendency to crack formation than oxide layers having a thickness of between 12 and 16 microns such as are usually employed in beer barrels wherein the oxide layer has been covered with an enamel layer, oxide layers which are very much

thinner, namely having a thickness of less than 2 microns, will be less subject to crack formation and will be able to withstand mechanical impacts without breaking so that also the enamel covering will remain unbroken and free of cracks.

According to one embodiment of the present invention, the light metal wall portion which is to be protected against corrosion will be first subjected to lustring treatment, thereafter an oxide layer will be formed thereon, which oxide layer must be very thin, namely of a thickness of less than 2 microns and preferably of about 1 micron, and thereafter, preferably immediately after formation of the oxide layer, a baked enamel layer is formed on the free surface of the oxide layer. During prolonged usage of thus treated containers, for instance beer barrels, it has been found that notwithstanding rough handling and exposure to mechanical impacts, the very thin oxide layer will not be subject to cracking and tear formation and consequently, the superposed enamel layer also will remain intact.

While the present invention is primarily described and has been successfully applied to the production of and for use in beer barrels, it is not to be considered limited thereto and it is also not necessary that the lustring of the aluminum or aluminum alloy layer, which need not be carried out in all cases as will be discussed further below, the formation of an oxide layer of less than 2 microns thickness thereon and the covering of the oxide layer with an enamel layer has to be carried out on the surface of a container such as a beer barrel. The same treatment can also be carried out at the outer face of a container or the like, for instance on the outer face of a float which outer face will come in contact with a liquid and is to be protected against corrosion.

The protection of the outer face of hollow bodies in accordance with the present invention, for instance, will be advantageous in certain liquid dispensing devices, as well as in any other number of devices the outer faces of which will come in contact with liquids and should be protected against corrosion.

Extensive tests with beer barrels according to the present invention have shown that the same are far superior to more or less similar barrels which, however, include an oxide layer of conventional thickness, i.e. a thickness of for instance between 12 and 16 microns. The advantages of beer barrels according to the present invention are found in the greater durability of the enamel coating, since the same will not tend to form cracks even if the beer barrel as a whole be exposed to severe mechanical impact. Thereby the durability and useful life span of the barrel is very considerably improved. Furthermore, the previously existing danger is avoided that upon cleaning of the used barrels the enamel will be attacked and will crumble at cracked portions.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is an elevational schematic view of a beer barrel;

FIG. 2 is a greatly enlarged fragmentary cross-sectional view of the barrel wall according to one embodiment of the present invention; and

FIG. 3 is a greatly enlarged fragmentary view of the barrel wall according to another embodiment of the present invention.

Referring now to the drawing, and particularly to FIGS. 1 and 2, it will be seen that the inner wall portion of barrel includes a layer **2** plated on wall **1** and consisting of a light metal which can be successfully subjected

to a lustring and smoothing treatment, preferably of aluminum or suitable aluminum alloys. The face of plated layer **2** which is directed towards the interior of the beer barrel has been subjected to such smoothing and lustring treatment and oxide layer **3** has been formed thereon, for instance by anodic oxidation and so that oxide layer **3** will have a thickness of less than 2 microns, preferably a thickness of about 1 micron. The free face of oxide layer **3** is covered with enamel layer **4**, preferably a conventional baked enamel layer such as an epoxy enamel which is applied immediately after the forming of the oxide layer and without compacting of the latter.

According to FIG. 3, the barrel wall is not plated but consists of a light metal, preferably aluminum-magnesium-silicon alloy, layer or sheet **6**, the inner face of which has been subjected to anodic oxidation so that oxide layer **7** having a thickness of less than 2 microns has been formed thereon, and of baked enamel layer **8** covering the free face of oxide layer **7**.

The following description of specific embodiments and examples is given as illustrative only and not intended to limit the scope of the invention to the specific details thereof.

Example 1

A beer barrel according to the present invention is produced from a blank consisting of a sheet of an aluminum-magnesium-silicon alloy onto one face of which a layer of pure aluminum has been plated. This blank is drawn into two halves of a beer barrel, and the two halves are then welded together.

Thereafter, the interior face of the beer barrel which is now formed by the pure aluminum plating is first pickled in conventional manner, for instance with sodium hydroxide and, after rinsing, subjected to a smoothing and lustring treatment, for instance as described in German Patent No. 835,821. Following the lustring treatment, the interior face of the barrel is provided with an anodic oxide layer of substantially even thickness of about 1 micron. Thereafter, an enamel layer, for instance a commercially available Epicote-clear enamel is applied to the free face of the oxide layer and baked thereon. The lustring treatment of the aluminum or aluminum alloy layer may also be carried out in accordance with the methods described in U.S. Patents 2,746,849 and 2,756,131.

The very thin oxide layer is produced substantially in accordance with conventional method of producing anodic oxide layers, preferably in a sulfuric acid electrolyte, as described for instance in the 11th Edition of "Aluminium-Taschenbuch," 1955, pages 581 and 582. However, a certain modification of the method described therein is desirable, inasmuch as it is preferred according to the present invention to incorporate in the electrolyte a trivalent alcohol, preferably glycerin. Thus, the anodization according to the present invention is carried out with an electrolyte consisting of diluted sulfuric acid with the addition of at least one trivalent alcohol in a concentration which preferably will be between 3 and 25%. Anodization is preferably carried out at a temperature of between 15 and 30° C. at a current load which, depending on the surface area of the workpiece, will be between 10 and 300 amperes.

A layer of baking enamel is then applied to the freshly prepared oxide layer. Preferably an epoxy baking enamel is used such as is known for instance under the trade name Epicote. It has been found very advantageous to apply two enamel layers having a combined thickness of between 12 and 18 microns. The baking of these enamels is carried out at temperatures of 190° C. and higher, for instance in the manner described in an article entitled "Innenchutz von Aluminium-Bierfaessern" which appeared in the Journal "Aluminium," Issue No. 9 of the Volume of 1962, pages 609–613.

Oxide layers of the aforementioned type are generally produced in a bath of diluted sulfuric acid. The aluminum

cask to be anodized acts as the anode. The cathode is an aluminum tube. When electric current passes through, i.e. after applying direct current, hydrogen, formed through the electrolytical decomposition of the sulfuric acid bath, is deposited in gaseous state at the cathode. At the anode the nascent oxygen reacts with the inner aluminum surface, thus producing an oxide layer which is integral with the metal itself. The open pores of ordinary oxide layers generally are sealed after anodizing, i.e. due to absorption of water by the oxide layer consisting of amorphous Al_2O_3 a crystalline aluminum-oxide-hydroxide is formed on the surface, closing the pores by enlarging its volume. The freshly produced unsealed or uncompacted oxide layer is especially suited as "key" surface for the stoved varnish or baked enamel, provided the thickness of the layer is below 2 microns, since such limited thickness will provide for a certain elasticity. Such thin layers may be produced in a sulfuric acid bath consisting of aqueous sulfuric acid having a concentration of between 21 and 25% to which between 20 and 30% of a trivalent alcohol have been added. Anodizing is then carried out at a temperature of between 20 and 25° C. and requires a current of between 0.8 and 1.2 amperes per 100 sq. centimeters. After anodizing, the oxidized surface is carefully rinsed and dried. The "open" oxide layer is now covered with varnish, i.e., baking enamel pre-dried and stored. The above-mentioned thin oxide layers are not only a first class key surface, they are likewise able to meet deformation caused by bulging, stretching or upsetting without causing any splitting effect on the varnish film.

As described above, the beer barrel or the like may be formed of an aluminum-magnesium-silicon alloy which is plated with aluminum or an aluminum alloy suitable for lustring treatment, for instance with high purity aluminum. The free face of the plating layer is then subjected to a lustring treatment and thereafter to anodic oxidation so as to form an oxide layer having a thickness of less than 2 microns and, finally, a baked enamel layer is superposed upon the oxide layer.

However, according to a frequently preferred embodiment of the present invention, the beer barrel or the like is formed of an aluminum-magnesium-silicon alloy without plating and without lustring treatment. According to the presently described embodiment, the inner face of the unplated beer barrel wall (or the liquid-contacting face of the hollow body) is subjected to anodic oxidation to form the oxide layer of less than 2 microns, and thereafter the baked enamel is applied.

The last described embodiment is more economical since plating and lustring treatment need not be carried out. Furthermore, deep-drawing of the unplated alloy can be carried out without forming grooves or causing other mechanical damage in the liquid-contacting face. The first described embodiment which includes plating and lustring treatment is, however, particularly important in connection with the repair of used barrels which should be subjected to lustring treatment in order to smoothen the inner face of the metal wall of the barrel, particularly if the same has been somewhat corroded.

It is thus essential, in accordance with the present invention, that the thickness of the oxide layer be below 2 microns. The oxide layer may be formed on a surface which has or has not been subjected to lustring, and the surface which is thus treated may be part of a uniform aluminum or aluminum alloy wall of suitable composition, or may be the free surface of a plating layer, preferably of high purity aluminum, which has been plated onto an underlying light metal wall portion.

The metal wall of the beer barrel or the like which may be used without plating, preferably will consist of a heat hardened aluminum-magnesium-silicon alloy containing as little copper as possible, preferably less than 0.05% and at most 0.1%.

Without limiting the composition of the aluminum alloy to the data given below, alloys of a composition within the indicated ranges are well suitable for anodic oxidation and application of the baked enamel layer without plating and lustring:

	Percent
Cu	up to 0.1
Mn	0.4–0.8
Mg	0.6–1.2
Si	0.6–1.2
Fe	up to 0.5
Zn	up to 0.2
Ti	up to 0.2
Cr	up to 0.2

Example 2

The barrel is formed by welding together two halves of the above indicated alloy composition so as to connect the two barrel halves with a circular-seam weld. The barrel is then annealed at between 500 and 540° C., quenched and age-tempered at 180° C. After testing the mechanical strength and fluid tightness of the barrel, the same is immersed in a de-fatting bath so as to be subjected at its inner end and outer faces to an alkaline de-fatting treatment, thereafter pickled with 15% sodium hydroxide pickling solution and neutralized with 10–15% nitric acid. This is followed by intensive rinsing with clear water. The lustring treatment which would now follow in the case of a barrel wall plated with pure aluminum, such as aluminum of 99.8% purity, is omitted in the present case since the aluminum alloy of the present barrel wall is harder than such pure aluminum and capable of being subjected to deep drawing without mechanical damage, groove or scratch formation on the surface thereof.

The thus pickled and rinsed barrel, or at least the liquid-contacting surface of the hollow body is now subjected to anodic oxidation in an electrolytic bath composed of aqueous sulfuric acid of between 21 and 25% concentration and of between 3 and 30%, preferably between 20 and 30%, or about 25% of a trivalent alcohol, preferably glycerin. Anodic oxidation is carried out at a temperature of between 20 and 25° C. for a period of between 10 and 18 minutes and at a current density of between 0.8 and 1.2 amperes per 100 sq. centimeters. The barrel serves as anode and the tubular cathode is inserted into the barrel through the bunghole, of course insulated from the barrel wall.

By proceeding in this manner, the thickness of the thus-formed oxide layer will be below 2 microns. This oxide layer is capable of causing excellent, firm adhesion of the baked enamel thereto, and, in addition, will be capable of conforming to any stretching, bending, denting, buckling or upsetting of the barrel wall without causing crack formation in the superposed baked enamel layer.

The freshly formed oxide layer is rinsed several times with tap water in order to remove any residual acid, and thereafter at least once with distilled water in order to remove any chloriné originating from tap water. Thereafter, the oxide layer is quickly dried to prevent or at least limit swelling of the same.

The baked enamel layer is then applied to the carefully dried oxide layer by spraying under pressure so as to form an even layer on the entire inner surface of the beer barrel. After each spraying step, excess lacquer, i.e., excess baking enamel, is sucked off. It is important that each enamel layer which is thus applied by spraying be free of blisters. The first applied enamel layer preferably will have a thickness of between 4 and 6 microns, and the subsequently applied second or outer enamel layer preferably has a thickness of between about 10 and 12 microns. It is not desirable to apply lacquer layers of greater thickness, since a lacquer layer of greater cross sectional dimensions might peel off upon deformation of the barrel. The lacquer layers are then baked in conventional manner, in the case of epoxy based baking enamels preferably at a maximum temperature of 200° C. for the

first baking step and at a maximum temperature of 220° C. for the last baking step.

The oxide layer which has been quickly dried so as not to swell to any substantial degree is also referred to herein as an uncompacted oxide layer.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention, and therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid, said wall consisting essentially of a layer of baked enamel forming said face, a layer of light metal selected from the group consisting of aluminum and aluminum alloys, and an oxide layer having a thickness of less than 2 microns interposed between and adhering to said layers of light metal and baked enamel.

2. A beer barrel including a wall having a face which is adapted to be directed toward the interior of said barrel, said wall consisting essentially of a layer of baked enamel forming said face, a layer of light metal selected from the group consisitng of aluminum and aluminum alloys, and an oxide layer having a thickness of about 1 micron interposed between and adhering to said layers of light metal and baked enamel.

3. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid, said wall consisting essentially of a layer of baked enamel forming said face, a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed toward said layer of baked enamel, and an oxide layer having a thickness of less than 2 microns interposed between and adhering to said layers of light metal and baked enamel.

4. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid, said wall consisting essentially of a layer of baked enamel forming said face, a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a thickness of at least 1 millimeter, and an uncompacted oxide layer having a thickness of less than 2 microns interposed between and adhering to said layers of light metal and baked enamel.

5. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid and which is composed of a baked enamel layer, said wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said wall also including an oxide layer having a thickness of less than 2 microns formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

6. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward the liquid and which is composed of a baked enamel layer, said wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said wall also including an uncompacted oxide layer having a thickness of about 1 micron formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

7. A container adapted to hold a liquid, including an inner wall having a face which is adapted to be directed toward the liquid and which is composed of a baked enamel layer, said inner wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said inner wall also including an oxide layer having a thickness of less than 2 microns formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

8. A beer barrel including an inner wall having a face which is directed toward the interior of said barrel and which is composed of a baked enamel layer, said inner wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said inner wall also including an oxide layer having a thickness of less than 2 microns formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

9. A float including an outer wall having a face which is adapted to be directed toward a liquid and which is composed of a baked enamel layer, said outer wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said outer wall also including an oxide layer having a thickness of less than 2 microns formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

10. A beer barrel including an inner wall having a thickness of at least 1 mm. and having a face which is directed toward the interior of said barrel and which is composed of a baked enamel layer, said inner wall including a layer of light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed towards said enamel layer, and said inner wall also including an uncompacted oxide layer having a thickness of about 1 micron formed on said smooth lustrous surface of said layer of light metal and contacting said enamel layer.

11. A beer barrel including an outer wall; an inner wall plated onto said outer wall and forming the inner face of said beer barrel, said inner wall consisting essentially of a light metal selected from the group consisting of aluminum and aluminum alloys and having a smooth lustrous surface directed toward the interior of said beer barrel; an uncompacted oxide film having a thickness of less than 2 microns formed on and covering said smooth lustrous surface; and a baked enamel coating covering said oxide film.

12. A liquid-engaging hollow body including a wall having a face which is adapted to be directed toward a liquid, said wall consisting essentially of a layer of baked enamel forming said face, a light metal layer of aluminum-magnesium-silicon alloy, and an oxide layer having a thickness of less than 2 microns interposed between and adhering to said layers of light metal and baked enamel.

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