(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 282 162**
A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **88301074.6**

(22) Date of filing: **09.02.88**

(51) Int. Cl.4: **C22C 21/14**, C22C 21/16, C22F 1/05

(30) Priority: **24.02.87 US 18089**

(43) Date of publication of application: **14.09.88 Bulletin 88/37**

(84) Designated Contracting States: **AT BE CH DE ES FR GB IT LI NL SE**

(71) Applicant: **ALCAN INTERNATIONAL LIMITED**
1188 Sherbrooke Street West
Montreal Quebec H3A 3G2(CA)

(72) Inventor: **Bull, Michael Jackson**
3 Church Close Adderbury
Banbury Oxon, OX17 3LN(GB)
Inventor: **Mills, Peter Edmund**
55 Princess Street
Gananoque Ontario(CA)

(74) Representative: **Wilkinson, Stephen John et al**
c/o Stevens, Hewlett & Perkins 5 Quality Court Chancery Lane
London WC2A 1HZ(GB)

(54) **Aluminium alloy can ends and method of manufacture.**

(57) Production of beverage can ends from an aluminum alloy containing 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al. An ingot of the alloy, direct chill cast and homogenized or strip cast between twin belts, is successively hot rolled, cold rolled to an intermediate gauge, solution-heat-treated and quenched, further cold rolled with at least about 20% reduction to a final can end stock gauge, artificially aged, and formed into can ends.

EP 0 282 162 A1

ALUMINUM ALLOY CAN ENDS AND METHOD OF MANUFACTURE

This invention relates to ends or lids for aluminum alloy beverage cans and the like, and to methods of making these can ends, as well as to the production of can end stock from which such ends are made.

A typical present-day commercial beverage can has a thin-walled, one-piece, drawn and ironed aluminum alloy can body, and a can end or lid secured around its rim to the free upper edge of the body. The lid is formed from aluminum alloy sheet of suitable composition, microstructure, properties and gauge (such sheet being hereinafter sometimes termed "can end stock") by drawing and stretching.

Currently preferred can end stock is sheet of AA 5182 (Aluminum Association designation) alloy in H28 temper at a gauge of, e.g., 0.29 mm. This stock is lacquered, and the lacquer is cured with heat before being formed into can ends. The lacquered stock has acceptable strength and formability for such use.

It may be potentially desirable to reduce the gauge of can end stock, for the sake of reducing material costs. However, certain characteristics of AA 5182 stock make it difficult to have a reduction in gauge, because it would require increased yield strength and maintained substantial formability. When AA 5182 can end stock is lacquer-cured, its yield strength drops to about 3,100-3,400 Kg/cm^2; although some improvement in as-rolled (pre-curing) strength may be attainable, it is difficult to maintain this increased strength during the lacquer-curing operation, and in addition, at the higher strength levels there is a noticeable decrease in formability. An additional drawback of using can end stock of a high work hardening alloy such as AA 5182 (even at present can end stock gauge) is that processing costs are generally high owing to the large number of rolling passes required.

For these and other reasons, it would be advantageous to fabricate can ends of an aluminum alloy can end stock which has improved strength, and/or reduced production costs (yet with an at least substantially equally acceptable combination of strength and formability), as compared to AA 5182-H28 stock. Various heat-treatable alloys such as AA 6061 in T6/T8 temper, which offer higher strength than AA 5182-H28, have heretofore been proposed or tested for can end stock use; however, while AA 6061-T6/T8 exhibits improvement in strength, it is found to present some forming difficulties and to achieve a lower buckle pressure than is provided by AA 5182-H28. Both of these problems are at present believed attributable to the lower work-hardening performance of AA 6061-T6/T8 as compared to AA 5182-H28.

Summary of the Invention

The present invention, in a first aspect, broadly contemplates the provision of a method of making aluminum alloy can ends, comprising the successive steps of providing a progressively cast, hot-rollable ingot of an alloy consisting essentially of 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al; hot rolling the ingot to produce hot-rolled strip; cold rolling the strip to an intermediate gauge from which a reduction of at least about 20% is required to achieve a predetermined final gauge; solution-heat-treating the strip by successively heating and quenching it; thereafter, without any intervening heat treatment, cold rolling the strip to final gauge; artificially aging the strip by heating it for increasing its yield strength and formability (as represnted by % elongation); and forming portions of the strip into can ends, e.g. by drawing and stretching. In accordance with conventional procedure, the strip at final gauge is lacquered and heated to cure the lacquer before being formed into can ends; as further explained below, lacquering is performed incident to the artificial aging step. "Strip," as used herein, refers to a slab or sheet article or workpiece of indeterminate length advanced longitudinally in rolling operations, and typically coiled for storage and/or batch-type thermal treatments. All composition proportions and percentages herein are given by weight.

By "progressively cast, hot-rollable ingot" is meant an ingot which has been cast by progressive advance through and beyond a casting zone with concomitant progressive supply of molten metal to that zone. Thus, the ingot-providing step may comprise direct-chill-casting an ingot of the alloy and homogenizing the ingot to remove as-cast Mg_2Si constituents. As an alternative, this step may be performed by casting a strip ingot of the alloy between chilled moving surfaces (e.g. twin belt casting); in such case, hot rolling is performed directly on the as-cast ingot without intervening homogenization.

Conveniently or preferably, the strip is naturally aged after quenching and before the final cold rolling step. The artificial aging step may be performed simply as the heating operation for curing lacquer, i.e. after lacquer is applied to the final-gauge cold rolled strip; preferably, however, it includes a heating operation prior to lacquering. Also preferably, in that operation the strip is heated to a predetermined temperature for a period of time shorter than that required to achieve maximum yield strength attainable by artificial aging of the strip at such temperature, and the heating is terminated at the end of that time period.

Preferred composition features include an upper limit of 2.1% Mg (most preferably an Mg content of 1.9-2.0%), a lower limit of 0.20% Si (especially in the case of directchill-cast ingot), a ratio of % Fe to % Si greater than one, and, in many though not all instances, an alloy essentially free of Cr. One particularly preferred composition is an alloy consisting essentially of about 0.40% Cu, about 1.9% Mg, about 0.40% Mn, about 0.22% Si, about 0.23% Fe, balance Al.

In a second aspect, the invention contemplates the provision of aluminum alloy can ends formed of an alloy consisting essentially of 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al, and preferably or advantageously produced by the foregoing method.

In further aspects, the invention contemplates methods of making can end stock, and can end stock produced by such methods. The broad method of making end stock in accordance with the invention corresponds to the above-described broad method of making can ends, up to and including the artificial aging step (but not necessarily including the lacquering operation).

The above-described composition and processing features cooperatively provide sheet stock characterized by a superior combination of properties of strength and formability for the production of can ends, and, upon forming, achieve highly satisfactory can end products, with beneficially low processing costs. The alloy composition shares the advantages of alloys such as AA 6061 with respect to high strength (afforded by precipitation of Mg_2Si) and corrosion resistance after aging, but offers significantly improved post-aging formability as compared to AA 6061, principally (as at present believed) because its excess Mg and Cu additions, together with processing features, improve post-aging work-hardening ability by providing for solute hardening after the aging treatment.

Particularly critical, for the attainment of satisfactory can ends with the present composition and processing features, is the low (0.29%, and preferably 0.25%) upper limit of Fe in the alloy. In can end stock it is important to avoid coarse intermetallic particles, which can cause "voiding" in the sheet (resulting in tearing) during the can-end-forming operation. The maintenance of a low level of Fe, in conjunction with the selection of other alloying elements and proportions and the fabrication schedule, is found to be highly effective in avoiding coarse (e.g. 2 micron size) intermetallic particles.

Further features and advantages of the invention will be apparent from the detailed description hereinbelow set forth.

The invention will be described as embodied in a method of making aluminum alloy can ends for beverage cans having one-piece drawn-and-ironed bodies, and in can ends produced by this method. Stated briefly, the method in the described embodiment includes the production of can end stock (sheet in final gauge for forming can ends) by successively casting, hot rolling, and cold rolling an alloy of specified composition, with intervening and final thermal treatments, and forming the final-gauge stock into can ends. The final gauge of the can end stock is typically about 0.33 mm or less, e.g. (in accordance with current preference) about 0.28 mm. The hot rolling, cold rolling and thermal treatment steps of the present method conform generally to the corresponding steps of the method described in Jeffery et al., U.S. Patent 4,637,842, issued January 20, 1987. However, the present invention utilizes an alloy of composition different from that specified in U.S. Patent 4,637,842. The end-forming step or steps of the present method are conventional.

Alloy Composition

The method of the invention employs an aluminum alloy consisting essentially of the following elements, within the specified ranges or maxima:

Element	Range or Maximum (%)
Cu	0.25-0.60
Mg	1.5-2.4
Mn	0.15-0.50
Si	0.15-0.40
Fe	0.29
Cr	0.20
Others (each/total)	0.05/0.15
Al	balance

In this alloy, as in known alloys of the heat-treatable AA 6000 series (e.g. AA 6061), high strength is afforded by the precipitation of Mg_2Si. Unlike most known AA 6000 series alloys, however, the present alloy provides for solute hardening after the aging step (which follows cold rolling to final gauge, as explained below) by including excess Mg (i.e. above the stoichiometric amount for formation of Mg_2Si) and additions of Cu. This feature aids in imparting to the can end stock the post-aging formability required for the manufacture of beverage can ends.

Heretofore, alloys containing excess Mg have not attracted much attention, because the solubility of Mg_2Si decreases as a function of excess Mg. However, there exists an approximate "window" of compositions bordered by about 1.5-2.4% Mg, about 0.15-0.4% Si, and about 0.25-0.60% Cu which will allow for the dissolution of the Mg_2Si phase during homogenization and subsequent solution heat treatment and which provides both sufficient age-hardening response to achieve requisite strength at final gauge, and excess solutes affording increased work-hardening ability after thermal aging. The effective solubility of Mg_2Si is not controlled solely by alloy chemistry but is also affected by process variables such as solidification rate during casting and cooling rate after solution heat treatment. Rapidly cooled continuously cast alloy strip, such as strip produced from twin-belt-cast ingots (further discussed below), owing to the nature of the solidification process, offers in effect a larger "window" of alloy compositions.

In particular, the use of an "excess Mg" type of magnesium silicide alloy in the present invention provides an improved work-hardening coefficient $\underline{n}$, which contributes very significantly to the added strength of the final can end by virtue of the work hardening that develops during the actual forming (drawing and stretching) of the can end.

A preferred maximum for Mg in the alloy compositions used in the practice of the invention is 2.1% and the most preferred range for Mg is 1.9-2.0%. For strip produced from conventionally direct-chill-cast ingot, the preferred range for Si is 0.2-0.4%, but in the case of strip produced from twin-belt-cast ingot, good results are obtained with alloys containing as little as 0.15% Si. A currently most preferred value for Si is about 0.22%.

Cu, in the alloys employed in the practice of the invention, has the dual function of providing some solid solution hardening and speeding up the kinetics of the precipitation of Mg_2Si. Mn helps to avoid the formation of large Fe intermetallics and provides grain size control in the wrought product.

When the starting ingot for the present method is direct chill cast, the required long-time, high-temperature homogenizing treatment coupled with the hot rolling conditions sometimes causes an unfavorable Mn morphology, and in such cases a Cr addition is helpful in controlling the grain size during solution heat treatment. However, Cr is not needed if the starting ingot is tin-belt cast, because there is no homogenization step and the Mn, being held in solution, can be used alone for grain size control. When not necessary, Cr is not a desired addition because of a potential detrimental effect in the remelt/casting operations.

For can end stock, it is critical that large Fe intermetallic particles be avoided. Casting experience dictates a preference for keeping the Fe higher than the Si content of the alloy, or at least minimizing any excess of Si over Fe. Hence, the Fe maximum for the present invention is set at 0.29%, with a preferred maximum of 0.25%.

In can body stock (sheet from which is drawn and ironed can bodies are produced), it is desirable to have a relatively high volume percent of fairly coarse (e.g. about 2 micron size) intermetallic particles in order to prevent scoring during the ironing operation employed in forming the can body. Although the coarse intermetallics may tend to cause voiding as the metal is formed, the body stock is restricted (in the ironing operation) between die walls so that the metal is effectively pushed back together whenever any voiding starts. Can end stock, however, is not thus restricted during the end-forming operation; hence voiding caused by coarse intermetallics will result in tearing. For this reason, presence of such coarse intermetallics (as would be produced by Fe levels conventional for can body stock) would render can end stock unacceptable in formability, and it is therefore critical to maintain a low Fe content in end stock.

A currently most preferred composition for the practice of the invention consists essentially of about 0.40% Cu, about 1.9% Mg, about 0.40% Mn, about 0.22% Si, about 0.23% Fe, balance essentially Al.

Ingot Preparation

In the practice of the present method, a progressively cast ingot of the above-described alloy composition is provided in hot-rollable condition. For example, the alloy may be cast by a conventional direct chill casting technique to produce a sheet ingot (shaped for convenient production of strip of sheet gauge by succesive hot and cold rolling operations), and homogenized (typically at a temperature of 540-580°C) for a sufficient period of time to substantially remove as-cast Mg_2Si constituents.

Alternatively, the ingot may be a strip ingot produced by continuous strip casting. Continuous strip casting is performed by supplying molten metal to a cavity defined between chilled, moving casting surfaces such as substantially parallel, extended runs of a pair of chilled endless metal belts, thereby to produce a thin (typically less than 25 mm thick) continuous cast strip. Belt-casting apparatus for such casting of strip is described, for example, in U.S. Patents Nos. 4,061,177 and 4,061,178. Each of the belt runs defining the casting space or cavity, in this apparatus, has a surface facing away from the casting space; chilling is effected by direct impingement of coolant on the last-mentioned surfaces of the belt runs.

With continuous strip casting, there is no need for homogenization, since the as-cast ingot has a very fine distribution of Mg_2Si, which is suitable for hot rolling, and may subsequently be readily taken into solution during the solution heat treatment step.

Fabrication Procedure

The hot-rollable ingot, produced as described above, (i.e., either direct chill cast and homogenized, or taken directly from a twin-belt caster), is subjected successively to the following sequence of process steps, all of which may be performed as described in U.S. Patent 4,637,842:

1. Hot rolling of the ingot to produce strip of a conventional "reroll" (final hot-rolled) gauge;

2. Cold rolling of the hot-rolled strip to produce cold-rolled strip of an intermediate gauge that is selected, in relation to the desired final can end stock gauge, so that a reduction of at least about 20% (preferably about 20% to about 80%) is required to reduce the strip from the intermediate gauge to the final gauge;

3. Solution heat treatment of the intermediate-gauge strip, by heating to 540°-585°C followed by quenching (preferably a water quench, though in some instances a rapid air quench may be sufficient), under conditions selected to redissolve and retain the Mg_2Si phase in solid solution;

4. Cold rolling of the solution-heat-treated and quenched strip to further reduce the strip (i.e. by at least about 20%) from the intermediate gauge to the desired final can end stock gauge, e.g. a can end stock gauge of 0.287 mm;

Artificial aging of the final-gauge cold rolled strip by heating the strip to increase its yield strength and formability, this artificial aging step comprising or including the lacquering of the stock followed by lacquer-curing; and

6. Forming portions of the artificially aged can end stock into beverage can ends by conventional drawing and stretching operations. These can ends are the product of the invention.

In the foregoing procedure of the invention, there is no intervening heat treatment after the solution-heat-treatment quench and before or during the subsequent cold rolling to final gauge. Usually or preferably, however, after the quench and before the further cold rolling, the strip is naturally aged by being maintained at ambient (room) temperature for at least about a day.

The cold rolled sheet in final gauge is lacquered, and then subjected to a generally conventional lacquer-curing (heating) operation, before being formed into can ends. In some instances, the heating of the strip for lacquer curing may itself constitute the artificial aging step. Alternatively, and in at least many cases preferably, the artificial aging step includes a separate heat treatment prior to application of the lacquer coat. This treatment is performed by heating the strip to a relatively low predetermined temperature (e.g. 160°C) for a time period (e.g. 3 hours) shorter than that required to achieve the maximum yield strength attainable by artificially aging the same final-gauge strip at that temperature; and the heating is terminated at the end of such time period. Thereby, the aged strip has improved formability (as represented by percent elongation), yet with suitably enhanced yield strength).

Thus, when the final-gauge cold rolled strip is subjected to heating for artificial aging, its % elongation value initially increases to a maximum and then, with continued heating, progressively declines, so that a prolonged aging treatment may result in a value of % elongation lower than that at the start of heating. The yield strength also undergoes an initial increase during aging, and typically reaches a peak value somewhat later than the time at which peak % elongation is attained. To achieve a combination of increased yield strength and increased formability, therefore, the heating of the strip for artificial aging in the method of the present invention is terminated at a time at which both the yield strength and the % elongation are above their respective values at the start of heating. Suitable illustrative procedures for such an artificial aging step (though, as stated, with different alloy compositions) are described in United States Patent 4,637,842.

By way of further illustration of the invention, reference may be made to the following specific examples:

EXAMPLE 1

A series of alloy compositions (respectively designated BRB, BRC, BRD, BRE and BRF) were prepared and cast into ingots under laboratory conditions. Strip of can end stock gauge was produced from these ingots in accordance with the above-described fabrication procedure. After lacquer curing, the five alloy strips, as well as a sample of commercially produced AA5182-H28 can end stock, were tested for mechanical properties (0.2% yield strength, ultimate tensile strength, percent elongation, and work hardening coefficient n). Yield strength was measured at 45° to the rolling direction, as well as in the longitudinal (L) and transverse (T) directions, since the buckle pressure (an important property of can ends) is controlled by the yield strength in the weakest direction, which is usually the 45° direction.

The strips of alloys BRE and BRF did not attain the minimum desired yield strength of 3165 Kg/cm^2 in all test directions and were therefore excluded from further testing. Examination of the microstructure of the final-gauge BRE and BRF samples revealed the presence of some coarse Mg_2Si particles, indicating that these compositions exceed the aforementioned alloy "window." The microstructure of the BRD alloy sample revealed some small Mg_2Si particles indicating that this composition is probably close to the upper permissible limit of Mg and Si.

On a pilot line, can ends were formed from the fully processed (final gauge, aged, lacquered and cured) strips of BRB, BRC and BRD alloys and from the commercially produced AA 5182-H28 can end stock. About 40 to 50 can ends were formed from each alloy sample, and the produced can ends were subjected to various performance tests.

Results of the tests of strip mechanical properties, and formed can end buckle pressure are set forth in Table I below; compositions and processing conditions for the various samples are given in the notes following Table I. As shown in the table, the three experimental alloys afford differing balances between yield strength (especially in the transverse and 45° directions), and work hardening ability (as represented by the work-hardening coefficient n). All three of these alloys performed well, with no manufacturing difficulties, and met all can end performance requirements such as score depth, rivet strength, and "pop and tear" tests, as well as buckle pressure (for which the results are given in the table). All samples were at a nominal gauge of 0.335 mm.

Generally superior results were achieved with the BRC alloy sample, which is an embodiment of the present invention. The overall results indicate that a preferred composition would be found between compositions embodied by alloys BRC and BRD.

The composition notes following Table I additionally set forth estimates, for each alloy, of the maximum possible amount (%) of Mg_2Si and the resulting amount (%) of excess Mg (above that stoichiometrically required to form Mg_2Si).

TABLE I

Sample	Test Direction	0.2% Yield Strength (x 1000 Kg/cm^2)	Ult. Tens. Strength (x 1000 Kg/cm^2)	Elong. (%)	"n"	Buckle Pressure (Kg/cm^2)
BRB	L	3.59	3.98	6.8	0.082	6.61-7.38
	T	3.33	3.87	8.5	0.088	
	45°	3.29	3.81	7.5	0.085	
BRC	L	3.70	4.15	7.3	0.080	7.45-7.66
	T	3.58	4.03	7.5	0.069	
	45°	3.51	3.91	5.3	0.056	
BRD	L	3.52	4.04	8.3	0.092	6.75-7.59
	T	3.26	3.85	8.5	0.093	
	45°	3.21	3.83	9.0	0.092	
Control	L	3.32	3.87	8.3	0.104	6.89-7.17
	T	3.39	3.92	15.0	0.099	
	45°	3.26	3.80	11.0	0.098	
BRE		below 3.16 minimum				
BRF		below 3.16 minimum				

TABLE 1 -- ALLOYS AND PROCESSING

Alloy	Composition (%)								
	Cu	Fe	Mg	Mn	Si	Cr	Ti	Mg_2Si*	Excess Mg**
BRB	.43	.20	1.05	.25	.40	.12	.017	1.09	.36
BRC	.41	.18	1.56	.23	.23	.11	.016	0.63	1.14
BRD	.49	.23	2.37	.27	.45	.13	.018	1.23	1.59
BRE	.54	.24	3.27	.30	.47	.14	.020	1.28	2.46
BRF	.53	.22	3.90	.27	.46	.14	.020	1.25	3.10

(control is AA 5182, meeting the Aluminum Association composition limits for that alloy)
(balance aluminum in each composition)
*stoichiometric composition Mg:Si ratio 1.73 assuming sufficient solubility at elevated temperatures and all Si as Mg_2Si.
**Excess Mg over that to form Mg_2Si.

Fabrication Schedules

All alloys BRB, BRC, BRD, BRE and BRF were direct chill cast in the laboratory as 9.5 cm × 22.9 cm ingots. The ingots of BRB, BRC and BRD were homogenized 6 hrs. at 580°C; the ingots of BRE and BRF were homogenized 6 hours at 590°C. Thereafter, the ingots of all five alloys were processed as follows: cooled to 520°C., hot rolled to 2.29 mm gauge, cold rolled to 0.63 mm gauge, solution heat treated and water quenched, final cold rolled to 0.335 mm gauge, aged for three hours at 160°C, and then lacquer coated and subjected to a lacquer curing treatment.

The control material was AA 5182 alloy sheet, commercially produced, in H28 temper; it was not subjected to an aging heat treatment but simply lacquer-cured.

EXAMPLE 2

Three alloys within the composition limits of the invention (respectively designated A, B and C below) were cast, fabricated into can end stock and formed into beverage can ends, all in accordance with the invention, in a production-scale operation, with 200-500 satisfactory can ends made in each case. The test also included, as a control, commercial AA 5182-H28 can end stock. Pertinent properties are given in Table II below. Compositions and processing conditions are identified by the code letters in the table; the meanings of the code letters are set forth in the notes following the table.

As demonstrated by the measured properties and the production of satisfactory can ends on production scale, the alloys of the invention, in conjunction with the specified fabricating schedule, provide can end material having very favorable properties in respect of strength, formability, and low anisotropy.

TABLE II

Code	0.2% Yield Strength (x 1000 Kg/cm^2)			Ult. Tens. Strength (x 1000 Kg/cm^2)			Elongation (%)		
	L	T	45°	L	T	45°	L	T	45°
A D F J M	3.71	3.53	3.38	4.14	4.06	3.94	6.7	9.3	9.3
A D F J N	3.79	3.61	3.47	4.22	4.16	4.04	5.5	9.0	8.8
A D F K N	3.75	3.53	3.45	4.18	4.13	4.00	7.2	8.5	9.5
A D G J M	3.41	3.28	3.18	3.86	3.79	3.70	7.5	10.2	9.3
A D G J N	3.41	3.29	3.21	3.86	3.80	3.72	8.2	9.8	9.3
A D G K N	3.34	3.23	3.17	3.79	3.75	3.66	8.0	10.0	9.3
B D F J M	3.73	3.62	3.50	4.12	4.08	3.97	6.8	9.0	8.0
B D F J N	3.76	3.63	3.51	4.14	4.10	3.99	6.8	9.3	8.0
B D F K N	3.72	3.58	3.49	4.08	4.07	3.96	6.7	8.8	8.3
B D G J M	3.42	3.24	3.17	3.91	3.78	3.71	7.8	10.3	9.3
B D G J N	3.47	3.29	3.21	3.94	3.82	3.75	7.8	9.3	9.8
B D G K N	3.42	3.24	3.18	3.89	3.77	3.72	8.2	9.8	10.3
C E F x M	3.61	3.46	3.31	4.04	3.93	3.83	7.3	7.8	9.0
C E F x N	3.65	3.48	3.35	4.08	3.98	3.86	7.3	9.8	9.0
C E H x M	3.74	3.56	3.37	4.15	4.08	3.92	5.8	9.3	9.2
C E H x N	3.71	3.55	3.39	4.11	4.05	3.90	6.7	8.8	9.8
Control	3.39	3.35	3.18	4.01	4.02	3.80	7.8	12.3	10.8

TABLE II --CodesA - alloy composition: 0.37% Cu, 0.22% Fe, 1.76% Mg, 0.25% Mn, 0.24% Si, 0.024% Ti, 0.10% Cr, balance Al

B - alloy composition: 0.43% Cu, 0.20% Fe, 2.09% Mg, 0.24% Mn, 0.25% Si, 0.036% Ti, 0.10% Cr, balance Al

C - alloy composition: 0.38% Cu, 0.21% Fe, 1.91% Mg, 0.28% Mn, 0.23% Si, balance Al

D - fabrication schedule: direct chill case, homogenized, hot rolled to 3.2 mm. gauge, initial cold rolled to code F or code G gauge (see below), solution heat treated and water quenched, final cold rolled to 0.287 mm. gauge, aged 2 hrs. at 170°C. and lacquer-cured at a peak metal temperature of 230°C. max.

E - fabrication schedule: twin belt cast, directly hot rolled (from caster exit) to 3 mm. gauge, initial cold rolled to code F or code H gauge (see below), solution heat treated and water quenched, final cold rolled to 0.287 mm. gauge, aged 2 hrs. at 170°C. and lacquered-cured at a peak metal temperature of 230°C. max.
F - initial cold rolled to 1.00 mm. gauge (71% cold reduction in final cold roll)
G - initial cold rolled to 0.64 mm. gauge (55% cold reduction in final cold roll)
H - initial cold rolled to 1.3 mm. gauge (78% cold reduction in final cold roll)
J - sample from outside of coil
K - sample from inside of coil
x - location of sample (outside or inside) unspecified
M - sample taken at edge of coil (across width)
N - sample taken at center of coil (across width)
Control - AA 5182 alloy in H28 temper, final cold rolled gauge 0.287 mm.

Can end stock produced in accordance with the invention, though being of a gauge and having properties and microstructure (including absence of coarse intermetallics) especially suitable for formation of can ends, also has utility for formation of other articles such as food can bodies that are produced by drawing and redrawing with at most a small amount of ironing restricted to the upper portion of the can wall. Thus, reference herein to can end stock is descriptive of the attributes but not restrictive as to the actual end use of the alloy strip so designated.

It is to be understood that the invention is not limited to the features and embodiments hereinabove specifically set forth but may be carried out in other ways without departure from its spirit.

Claims

1. A method of making aluminum alloy can ends, comprising:

(a) providing a progressively cast hot-rollable ingot of an aluminum alloy consisting essentially of 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al;

(b) hot rolling the ingot to produce hot-rolled strip;

(c) cold rolling the hot-rolled strip to an intermediate gauge from which a reduction of at least about 20% is required to achieve a predetermined final gauge;

(d) solution-heat-treating the strip at said intermediate gauge by successively heating and quenching the strip;

(e) after quenching, and without intervening heat treatment, cold rolling the strip to said final gauge;

(f) artificially aging the cold-rolled strip at said final gauge by heating the strip for increasing the yield strength and formability thereof; and

(g) forming portions of the artificially aged strip into can ends.

2. A method according to claim 1, wherein step (f) comprises applying lacquer to the strip at final gauge and then heating the strip for curing the applied lacquer.

3. A method according to claim 1, wherein step (f) comprises heating the strip to a predetermined temperature for a time period shorter than that required to achieve the maximum yield strength attainable by artificially aging said final gauge strip at said temperature, and terminating the heating at the end of said time period.

4. A method according to claim 3, wherein step (f) further comprises applying lacquer to the strip after terminating the heating at the end of said time period, and then again heating the strip for curing the applied lacquer.

5. A method according to claims 1-4, wherein the strip is subjected to a cold reduction of about 20% to about 80% in step (e).

6. A method according to claims 1-5, wherein the alloy contains not more than 0.25% Fe.

7. A method according to claims 1-6, wherein the alloy contains not more than 2.1% Mg.

8. A can end formed of an aluminum alloy consisting essentially of 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al.

9. A method of making aluminum alloy can end stock, comprising:

(a) providing a progressively cast hot-rollable ingot of an aluminum alloy consisting essentially of 0.25-0.60% Cu, 1.5-2.4% Mg, 0.15-0.50% Mn, 0.15-0.40% Si, up to 0.29% Fe, up to 0.20% Cr, other elements up to 0.05% each, up to 0.15% total, balance Al;

(b) hot rolling the ingot to produce hot-rolled strip;

(c) cold rolling the hot-rolled strip to an intermediate gauge from which a reduction of at least about 20% is required to achieve a predetermined final gauge;

(d) solution-heat-treating the strip at said intermediate gauge by successively heating and quenching the strip;

(e) after quenching, and without intervening heat treatment, cold rolling the strip to said final gauge; and

(f) artificially aging the cold-rolled strip at said final gauge by heating the strip for increasing the yield strength and formability thereof.

10. A method according to claim 9, wherein step (f) comprises heating the strip to a predetermind temperature for a time period shorter than that required to achieve the maximum yield strength attainable by artificially aging said final gauge strip at said temperature, and terminating the heating at the end of said time period.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 1074

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A,D	US-A-4 637 842 (JEFFREY et al.) * Claims 1,15 *	1,6-8	C 22 C 21/14 C 22 C 21/16 C 22 F 1/05
A,D	* Claims 6-9,11-13,16 *	1,9	
A	GB-A-2 027 744 (COORS CONTAINER CO.) * Claims 1,3,5 *	1	
A	EP-A-0 097 319 (SUMITOMO LIGHT METAL INDUSTRIES) * Claims 1-4; page 28, table 14, example no. 7 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

C 22 C 21
C 22 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22-06-1988	LIPPENS M.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document