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⑤④ **Bake-hardenable aluminium alloy sheets and process for manufacturing same.**

⑤⑦ A bake-hardenable aluminium alloy sheet for can bodies, ends and/or tabs, containing 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2.0% of Mn and having an average crystal grain width less than 25 microns after cold rolling. There is also disclosed a process for producing such a bake-hardenable aluminium alloy sheet, which comprises: smelting and casting an aluminium alloy containing 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2% of Mn; hot rolling the resulting ingot after a soaking treatment at a temperature higher than 500 °C; heating the hot-rolled alloy or cold rolled alloy after hot rolling to a temperature in the range of 400 to 600 °C at a heating speed higher than 100 °C/min immediately after the heating or after heat retention for a time period shorter than 10 minutes, cooling the alloy at a cooling speed higher than 100 °C/hr while maintaining in solid solution the alloy elements which contribute to the bake-hardening effect; and cold-rolling said alloy at a reduction rate greater than 10%.

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BAKE-HARDENABLE ALUMINIUM ALLOY SHEETS
AND PROCESS FOR MANUFACTURING SAME

This invention relates to a bake-hardenable type aluminium alloy sheets for can bodies, ends and/or tabs and a process for manufacturing same, and more particularly to a process for manufacturing a bake-
5 hardenable type aluminium alloy sheet for can bodies, ends and/or tabs with a fine average grain size, which has excellent formability especially in drawing, ironing, flanging and necking properties and which can be imparted with a high pressure resistance by an
10 outside printing and inside coating stage after formation into can bodies.

The recent development of ironing techniques has made it possible to produce light can bodies on a large
15 scale. Although the aluminium alloy 3004-H19 is widely used as a can body stock, it is desirable to make the can bodies, ends and/or tabs thinner and lighter from the standpoint of economical use of resources and energy. The process for manufacturing
20 such can bodies, usually includes the steps of deep drawing, redrawing, ironing, doming, trimming, pickling, washing, chemical conversion, drying, outside printing, baking (for 1 to 10 minutes at about 200°C), inside coating, baking (for 1 to 10 minutes
25 at about 200°C), necking and flanging. The thin aluminium alloy sheets for can bodies, which have to undergo such a severe process are generally required to have satisfactory properties in the following respects.

- (1) Drawability and redrawability;
- (2) Ironing formability;
- (3) Resistance to scoring (build-up of metal on dies during ironing operation);
- 5 (4) Doming formability;
- (5) Appearance (no scoring on side walls of can bodies);
- (6) Necking formability;
- (7) Flangeability;
- (8) Low earing in deep drawing;
- 10 (9) Pressure resistance;
- (10) Column strength (to endure a charging load in the filling stage); and
- (11) Corrosion resistance.

15 It is to be noted that these properties are all important for can body stock. An improvement in the strength after baking alone which influences pressure resistance and column strength is insufficient to attain a substantial reduction in thickness of the can body

20 materials. A can body stock should also have satisfactory properties in formability such as drawability, ironing formability, necking formability and flangeability and should not wrinkle in the drawing and necking stages.

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Various types of aluminium alloys have thus far been investigated as a can body stock for gaugedown, including Al-Cu alloy, Al-Mg-Si alloy and Al-Zn-Mg alloy. Of these alloys, the Al-Cu alloy which contains

30 more than 1% of Cu for precipitation hardening has extremely inferior corrosion resistance and undergoes precipitation hardening before an ironing stage while it is processed through a number of steps, and for a long time, after solution heat treatment, with degrad-

35 ations in formability and resistance to scoring. The

Al-Mg-Si alloy has a relatively good corrosion resistance but its formability is highly dependent upon the cooling rate after solution treatment (it requires an extremely high cooling rate for good formability) coupled with the drawback that build-up of metal on the dies frequently occurs during an ironing operation due to the Mg content. Further, the Al-Zn-Mg alloy is low in corrosion resistance, owing to the Zn content, and, additionally, has unsatisfactory scoring resistance and is inferior in formability to the other two alloys just mentioned.

According to the present invention, there is provided a bake-hardenable aluminium alloy sheet for can bodies, ends and/or tabs (which may hereinafter be referred to as "alloy of the invention" for brevity) which contains 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2.0% of Mn and has an average crystalline grain width smaller than 25 microns in terms of crystalline grains as observed on the surface of a rolled alloy sheet.

According to the invention, there is also provided a process for producing a bake-hardenable aluminium alloy sheet for can bodies, comprising:

smelting and casting an aluminium alloy containing 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2% of Mn, the balance being Al and any impurities;

hot rolling the resulting ingot after a soaking treatment at a temperature higher than 500°C;

heating the alloy to a temperature in the range of 400 to 600°C at a heating rate higher than 100°C/min to provide an average crystal grain size in a range smaller than 25 microns;

immediately after the heating or after heat retention for a time period shorter than 10 minutes, cooling said alloy at a cooling rate higher than 100°C/hr to maintain in solid solution the alloy elements which contribute to the bake-hardening effect; and,

cold-rolling said alloy at a reduction rate greater than 10%.

There may thus be provided a bake-hardenable type aluminium alloy sheet for can bodies, ends and/or tabs which is satisfactory in the above-mentioned properties required for the reduction of the sheet thickness and weight of can bodies, ends and/or tabs, namely, an alloy which has not only a high strength but also properties which supplement any reduction in formability caused by an increase in strength and reduction in thickness, and a process for manufacturing such bake-hardening type aluminium alloy sheets.

The above and other features and advantages of the present invention will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings which is a graph showing the tensile and yield strengths of materials of Example 4 in relation to baking temperature.

With regard to the components of the aluminium alloy according to the present invention and their proportions, the element Cu should be present, together with Mg since they remain dissolved in solid solution and contribute to hardening in the baking stage by producing fine Al-Cu-Mg precipitates, enhancing the strength of

the alloy. In order to produce these effects satisfactorily, the Cu content should be greater than 0.05% but no more than 0.5% since a Cu-content in excess of 0.5% will considerably lower the corrosion resistance of the alloy as a can material. Thus, the preferred range of Cu-content is 0.05 to 0.5%.

The element Mg needs to be present together with the Cu since it remains dissolved in solid solution with the latter and induces precipitation hardening in a subsequent stage to impart to the alloy a strength required for a can body material. The Mg-content does not impair the corrosion resistance as much as the Cu content so that it can be contained in a greater amount for the purpose of increasing the strength to permit reductions of the thickness of the ultimate alloy sheet. For this purpose, the Mg-content should be greater than 0.5%. Although a greater Mg-content is reflected by a higher strength, it reduces the formability such as ironing formability and stretch formability and increases the susceptibility to scoring unless the alloy contains Mn which has the effect of improving the alloy's resistance to scoring as will be described hereinafter. Therefore, it is possible to provide a can body with satisfactory properties even with a large Mg-content. However, an Mg-content in excess of 2.5% causes a considerable drop in formability including ironing formability and stretch formability and gives rise to considerable scoring. Consequently, the Mg-content should be in the range of 0.5 to 2.5%.

Differently from Cu and Mg, the element Mn does not contribute to precipitation hardening but it is as important as Mg for imparting strength to the alloy and prevents scoring by crystallising MnAl_6 together with Al. With the Mg, the Mn-content helps to stabilise deep-draw earing by stabilising the recrystallisation texture after a heat treatment. This effect cannot be expected when the Mn-content is less than 0.5%. On the other hand, the amount and size of intermetallic compounds are increased with a greater Mn-content, and primary structures are likely to crystallise if its content exceeds 2%, giving rise to pinholes or tear off in the ironing stage. Therefore, the Mn content should be in the range of 0.5 to 2.0%. The alloy may further contain up to 0.5% of Si, up to 0.7% of Fe, up to 0.05% of Ti, up to 0.05% of B and up to 0.05% of Cr as impurities.

Turning now to the processing of the alloy by heat treatment, crystal grain size and cold working according to the present invention, an aluminium alloy of the above-mentioned chemical composition is subjected to a soaking treatment at a temperature above 500°C . If the temperature of the soaking treatment is lower than 500°C , a large quantity of very fine MnAl_6 will precipitate, which tends to suppress grain boundary transformation during recrystallisation of the rolled sheet, raising the recrystallisation temperature and coarsening the crystal grains. Also, due to a change in the recrystallisation texture, earing occurs at an angle of 45° with the rolling direction, coupled with the problem of scoring in the ironing stage. Thus, the soaking temperature should be higher than 500°C .

The hot rolling which follows the soaking treatment involves no control in particular of the hot rolling rate or temperature and may be conducted by an ordinary industrial method. The hot-rolled material is then heated (for annealing) as it is or after cold rolling if necessary.

The heating is effected at a temperature in the range of 400 to 600°C to cause recrystallisation, thereby forming a recrystallisation texture to reduce earing in deep drawing and producing fine and uniform crystal grains, while dissolving Cu in solid solution in order to guarantee the bake-hardening effect by precipitation of Al-Cu-Mg. It is difficult to dissolve Cu in solid solution at a temperature lower than 400°C. Although the temperature in this heating stage should therefore be higher than 400°C, it is preferred to be higher than 430°C in consideration of the Cu content and the heat retention time. However, the growth of recrystallised grains is accelerated at higher temperatures and this tendency becomes pronounced at temperatures above 600°C, making it difficult to control the grain size in a range smaller than 25 microns. Therefore, the heating (annealing) temperature should be in the range of 400°C to 600°C.

In the heating stage, it is necessary to raise the temperature quickly in order to produce fine crystal grains and to reduce the time period of the heat treatment in order to suppress production of MgO on the surface of the alloy sheet. To this end, the heating rate should be higher than 100°C/min.

Further, the control of heat retention time is necessary especially for the purpose of reducing the grain size. Although this can be attained readily in a high temperature treatment even if the retention time is zero, where the treatment employs a relatively low temperature in the above-defined range or for some compositions of the alloy or other conditions of the manufacturing process, the temperature may be retained for a certain time period. As retention of a high temperature over a long time period will encourage growth of recrystallised grains and reduce production of fine crystal grains, the retention time should be 10 minutes or less.

In addition, it is necessary to control the cooling rate in order to secure the subsequent precipitation hardening. More particularly, if the cooling rate is too low, precipitation takes place in the cooling stage, so that there is insufficient precipitation hardening in the baking stage. Also, the fine precipitates which are produced in the low temperature range of the cooling stage increase the strength so that the formability of the alloy is lowered prior to the ironing stage. Thus, the cooling rate should be high enough, ie, higher than 100°C/hr , in order to obtain a satisfactory can body material. Although a higher cooling rate may be employed, it is recommended to use air cooling in the case of a coiled material, in view of the surface quality and flatness of the coil. In the cooling stage, the temperature of the alloy has to be lowered below a predetermined level, more particularly, below a temperature level at which precipitation of Al-Cu-Mg takes place, to prevent premature precipitation before the baking stage.

For this purpose, the alloy should be cooled to a temperature of at least below 150°C and preferably below 100°C where a greater degree of precipitation hardening is desired.

5

The average grain size should be smaller than 25 microns to compensate for the decrease in formability of different types which are involved in the course of reductions of thickness of the can body, as well as deterioration in necking property and flangeability due to an increase in strength after the baking stage, and for increasing the effect of precipitation. Smaller grain sizes are normally reflected by improved formability in stretching flanging and ironing properties. There is no problem with regard to the drawability required for the reductions in thickness, but the same may give rise to a problem of wrinkling. However, the wrinkling barely occurs as long as the average grain size is smaller than 25 microns. On the other hand, if the average grain size exceeds 25 microns, it becomes difficult to obtain a thin can body of high strength which is different from the conventional can body material. Thus, the average grain size should be less than 25 microns.

25

With regard to the crystal grains in the aluminium alloy according to the present invention which is formed into a hard sheet by cold rolling subsequent to the recrystallisation as mentioned hereinbefore, the crystal grains are stretched in the rolling direction and flattened by the cold rolling but the width (average width) of the individual grains as seen on the surface of the rolled sheet remain sub-

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stantially the same as long as the average grain size at the time of recrystallisation is smaller than 25 microns. This is the reason why the average width of crystal grains on the surface of the rolled alloy sheet is defined as being smaller than 25 microns in the present invention.

The cold rolling operation subsequent to the above-mentioned heat treatment is necessary to impart a required strength to the alloy as a can body material and is effected at a reduction rate which is determined depending upon the contents of Cu, Mg and Mn taken in conjunction with the required strength. As a matter of fact, an insufficient effect is produced at a reduction rate smaller than 10%, and it is preferred to be greater than 30%. However, a sufficient reduction of can wall thickness is possible if the reduction rate is in the range of 10% to 30%, depending upon the internal pressure and shape of the can body. After the cold rolling operation, the alloy material should be maintained at a temperature below 150°C, preferably below 100°C to prevent premature precipitation hardening before the ironing operation. This is also necessary for improving the resistance to scoring since the production of MgO on the surface of the alloy sheet from the final cold rolling stage is increased by a heat treatment prior to the ironing operation.

A bake-hardenable type can body aluminium alloy sheet of excellent properties can be obtained by the process described above, which is also applicable to can lids, tabs or the like, or to other purposes involving a printing or paint-coating operation.

The bake-hardenable can body aluminium alloy sheet of the present invention is illustrated more particularly by the following examples.

5 EXAMPLE 1

An aluminium alloy consisting of 0.22% of Cu, 1.07% of Mn, 1.21% of Mg and the balance of aluminium and impurities was smelted and cast into a 500 mm thick
10 ingot, which was then hot-rolled into a thickness of 3 mm after a soaking treatment at 580°C. Thereafter, the work was formed into a 1.0 mm thick sheet by cold rolling and heating at a heating rate of 500°C/min, and different workpieces (1) to (4) were then treated
15 according to the procedures listed below:

(1) A treatment in which, after terminating the heating at 500°C and without heat retention, the work was air-cooled to 80°C at a cooling rate of 6000°C/hr;
20

(2) A treatment in which, after terminating the heating at 420°C and heat retention of 8 minutes, the work was air-cooled to 80°C at a cooling rate of 1000°C/hr;
25

(3) A treatment in which, after terminating the heating at 500°C and heat retention of 3 minutes, the work was air-cooled to 100°C at a cooling rate of 40°C/hr;
30

(4) A treatment in which after terminating the heating at 360°C and heat retention of 1 hour, the work was air-cooled to 80°C at a cooling rate of 12000°C/hr.
35

The workpieces were formed into a 0.34 mm thick sheet in the cases of workpiece (1) and (2) and into a 0.4 mm thick sheet in the cases of workpiece (3) and (4) by final cold rolling. Thus, the alloy sheets of workpieces
5 (1) and (2) were produced according to the process of the present invention, while the alloy sheets of workpieces (3) and (4) were produced by the conventional process.

10 The mechanical properties of aluminium alloy sheets of workpieces (1) to (4) were measured with regard to plain blank sheets and baked specimens which has undergone baking of 200°C x 20 minutes. Further, the plain blank sheets were subjected to baking after
15 ironing and trimming, and to necking and flanging to measure their pressure resistance and column strength. The grain size after annealing and earring of blank sheets in workpieces (1) to (4) were also measured.

20 The results are shown in Tables 1 and 2.

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Table 1

No.	Thick- ness (mm)	Mechanical Properties (plain sheets)			Mechanical Properties (AB)			Earing (%)	Grain size after annealing (μ)
		$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)		
1	0.34	30.9	31.3	2.8	28.6	33.0	7.0	2.7	20
2	0.34	29.6	30.8	3.0	26.5	31.0	7.3	2.9	18
3	0.40	29.0	30.0	3.0	24.8	29.0	6.9	2.6	21
4	0.40	28.6	29.9	2.9	24.7	29.1	5.4	2.8	24

Table 2

No.	Thick- ness (mm)	Can Formability (plain)		Can Formability (AB)		Pressure proofing (kg/cm ²)	Column strength (kg)	Scoring
		Drawing	Ironing	Necking	Flanging			
1	0.34	0	0	0	0	9.1	204	◎
2	0.34	0	0	0	0	8.5	195	◎
3	0.40	0	0	0	0	9.0	203	0
4	0.40	0	0	0	0	9.0	202	0

As seen in Table 1, the aluminium alloy sheets of workpieces nos. 1 and 2 have a higher after-baking (AB) strength as compared with the alloys sheets of workpieces 3 and 4 due to differences in heating conditions and cooling speed. It will be seen that higher heating temperatures and cooling rates give better results. The alloy sheets of workpieces nos. 3 and 4 exhibit a drop in strength upon baking owing to the use of deficient cooling rate and heating temperature.

Table 2 shows the properties of ironed cans, from which it will be understood that the thin blank sheets of workpieces nos. 1 and 2 according to the process of the present invention, especially, the blank sheet in workpiece 1 has properties comparable to the 0.4 mm thick alloy sheets of workpieces nos. 3 and 4 in can formability as well as in pressure proofing and buckling strength in spite of its reduced thickness. The improvement of the can formability is attributable to a finer crystal grain size, while the improvements in pressure resistance and buckling strength are ascribed to the improvement of strength after baking. The annealing time periods for the alloy sheets nos. 1 to 4 are shorter than in the batch system, and above all the alloy sheets nos. 1 and 2 give good results with only an extremely small amount of scoring on the can walls notwithstanding the heating, heat retention and the short time periods of cooling.

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In Table 2 and in the following tables, the results are rated by "◎" (very good), "O" (no distinctive change), "⊙" (a little inferior), and "Δ" (inferior).

EXAMPLE 2

400 mm thick ingots were prepared by smelting and casting (1) an aluminium alloy consisting of 0.15% of Cu, 1.05% of Mn, 1.13% of Mg and the balance of aluminium and impurities (in the range of the present invention), and (2) an aluminium alloy consisting of 0.03% of Cu, 1.0% of Mn, 1.2% of Mg and the balance of aluminium and impurities (outside the range of the present invention). The ingots of aluminium alloy thus obtained were hot-rolled into a thickness of 4mm after a soaking treatment at 540°C, and then cold-rolled into a 1.0 mm thick sheet, followed by a heat treatment employing a heating rate of either

- (A) 10°C/min or
- (B) 400°C/min

After raising the temperature to 480°C at the heating rate (A) or (B) and retaining that temperature for 2 minutes, the work was cooled at a cooling rate of 1000°C/hr and then cold-rolled into a 0.4 mm thick sheet. The resulting sheets were subjected to the same measurements of mechanical properties and forming tests as in Example 1. The results are shown in Table 3 and 4.

Table 3

No.	Thick- ness (mm)	Mechanical Properties (plain sheets)		Mechanical Properties (AB)		Earing (%)	Grain size after annealing (μ)
		$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)
1-A	0.40	29.2	30.5	2.8	28.0	32.0	7.1
							2.3
							29
1-B	0.40	29.4	30.8	3.0	28.2	32.2	7.0
							2.4
							16
2-A	0.40	28.0	29.5	3.4	23.9	26.9	6.2
							2.7
							30
2-B	0.40	28.3	29.6	3.4	24.1	27.0	6.5
							2.8
							17

Table 4

No.	Thick- ness (mm)	Can Formability (plain)		Can Formability (AB)		Pressure proofing (kg/cm ²)	Column strength (kg)	Scaling
		Drawing	Ironing	Stretching	Necking	Flanging		
1-A	0.40	0	0	0	0	0	239	0
1-B	0.40	0	⊙	⊙	⊙	⊙	242	⊙
2-A	0.40	0	0	0	0	0	196	0
2-B	0.40	0	⊙	⊙	⊙	⊙	199	⊙

Note: (1-B : invention)

It will be seen from the after-baking (AB) strength of the sheet nos. 1 and 2 shown in Tables 3 and 4 that the Cu-content is necessary for the bake-hardening effect and that the difference between the heating speeds (A) and (B) is reflected by a difference in grain size after baking, which has a great influence on the can formability. The aluminium alloy sheet no. 1-B according to the present invention provides good can formability along with high pressure resistance and column strength.

EXAMPLE 3

(1) An aluminium alloy containing 0.20% of Cu, 1.0% of Mn and the balance of aluminium and impurities (outside the range of the present invention), and (2) an aluminium alloy containing 0.17% of Cu, 0.95% of Mn, 1.1% of Mg and the balance of aluminium and impurities (in the range of the present invention) were smelted and cast into 500 mm thick ingots. Each ingot was hot-rolled to a thickness of 3 mm after a soaking treatment at 590°C and then cold-rolled into a 1 mm thick sheet. After heating to 515°C at a heating speed of 500°C/min, the alloy sheet was immediately cooled to 90°C at a cooling rate of 500°C/min and cold-rolled into a thickness of 0.4 mm, followed by the same measurements and forming tests as in the foregoing examples.

The results are shown in Tables 5 and 6.

Table 5

	Mechanical Properties (plain sheets)		Mechanical Properties (AB)			Earing (%)	Grain size after annealing (μ)
	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)		
1	19.9	21.0	3.0	18.6	20.5	4.1	4.0
2	28.8	29.9	3.1	27.8	31.2	7.0	2.2
							16

Table 6

	Can Formability (plain)		Can Formability (AB)		Pressure proofing (kg/cm ²)	Column strength (kg)	Scaling
	Drawing	Ironing	Stretching	Necking	Flanging		
1	0	0	Ⓐ	Ⓐ	0	6.4	164
2	0	⊙	⊙	⊙	⊙	9.6	231

As seen in the foregoing Tables 5 and 6, no hardening by baking is observed in the alloy sheet no 1 which is outside the range of the present invention, indicating the necessity of the Mg-content. The lack
5 of the Mg-content results in a lower strength and a coarse grain size after annealing in spite of application of optimum annealing conditions, and thus in inferior formability, pressure resistance and column strength.

10

In contrast, the alloy sheet no. 2 according to the process of the present invention is far superior to the sheet no 1 in overall properties.

15 EXAMPLE 4

(1) An aluminium alloy containing 0.23% of Cu, 1.03% of Mn, 1.24% of Mg and the balance of aluminium and impurities, and (2) an aluminium alloy containing
20 0.18% of Cu, 1.00% of Mn, 1.12% of Mg, and the balance of aluminium and impurities were smelted and cast into 500 mm thick ingots, which were then hot-rolled into a thickness of 4 mm after a soaking treatment at 590°C. The aluminium alloy of No. 1 was cold-rolled into (A)
25 a 0.8 mm thick sheet and (B) a 0.67 mm thick sheet, followed by a heat treatment in which, immediately after heating to 500°C at a heating rate of 500°C/min, the respective sheets were air-cooled to 90°C at a cooling rate of 500°C/min. On the other hand, the
30 aluminium alloy of no 2 was reduced to a thickness of 4 mm and then cold-rolled to a thickness of 1 mm and annealed by the conventional batch system, heating the alloy sheet to 360°C with heating and cooling rates of

40°C/hr. Thereafter, the alloy sheets nos. 1 and 2 were cold-rolled to a thickness of 0.4 mm, followed by the same measurements and forming tests as in Example 1 except for the baking at 230°C for 10 min.

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The results are shown in Tables 7 and 8.

Table 7

	Mechanical Properties (plain sheets)		Mechanical Properties (AB)		Earing (%)	Grain size after annealing (μ)
	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)	$\sigma_{0.2}$ (kg/mm ²)	σ_B (kg/mm ²)	σ (%)
1-A	28.3	29.2	2.5	25.7	30.5	6.7
1-B	26.2	27.0	3.2	24.0	29.0	8.4
2	27.8	29.7	4.8	22.3	25.8	7.2
						2.5
						28

Table 8

	Can Formability (plain)		Can Formability (AB)		Pressure proofing (kg/cm ²)	Column strength (kg)	Scoring
	Drawing	Ironing	Stretching	Necking	Flanging		
1-A	0	0	0	0	0	212	0
1-B	0	0	0	0	8.7	196	0
2	0	0	0	0	8.2	180	0

In Tables 7 and 8, the aluminium alloy sheets nos. 1-A and 1-B according to the process of the present invention were produced with smaller reduction rates in cold rolling (ie with reduction rates of 50% and 40%, respectively, as compared with 60% in Examples 1 to 3 and a higher baking temperature.

More particularly, the blank sheet 2 had a strength intermediate between the sheets nos. 1-A and 1-B but exhibited an after-baking (AB) strength far lower than the sheets nos. 1-A and 1-B, with inferior formability due to a greater grain size.

Plotted in Figure 1 are softening curves of the alloy sheets 1-A and 2, showing the baking temperature in relation with the tensile strength σ_B and yield strength $\sigma_{0.2}$, in which the alloy sheets no. 1-A (0.4 mm thick) and no. 2 (0.4 mm thick) are indicated by "O" and " Δ ", respectively.

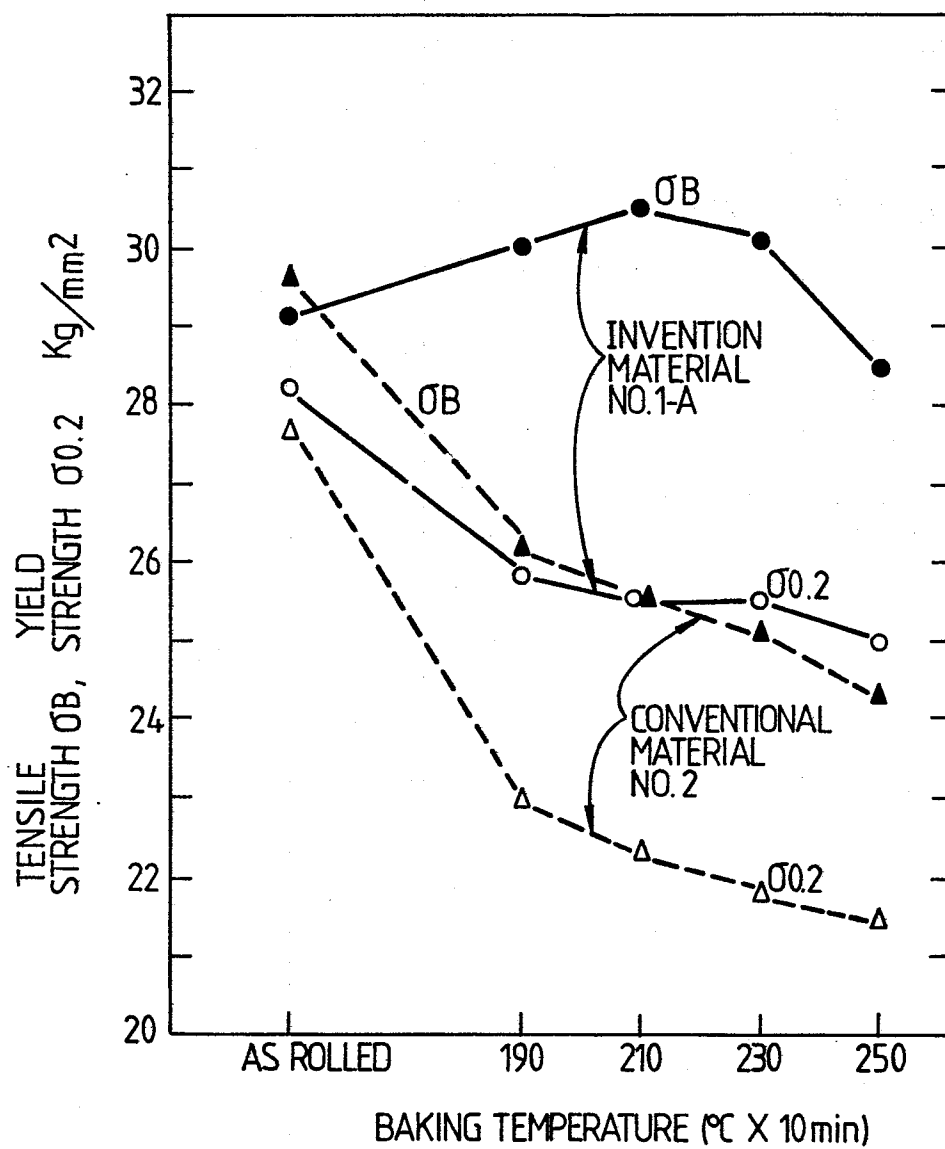
Thus an aluminium alloy sheet which is produced according to the above-described process of the present invention has improved formability in stretching, ironing and flanging properties and the like owing to the fine grain size and provides a high pressure resistance by hardening in a printing and coating stage subsequent to the drawing and ironing operations.

CLAIMS

1. A bake-hardenable aluminium alloy sheet for can bodies, ends and/or tabs, containing 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2.0% of Mn, the balance being Al and any impurities, and having an average crystal grain width of smaller than 25 microns after cold rolling.
2. A bake-hardenable type aluminium alloy sheet as claimed in claim 1, wherein said alloy contains as impurities up to 0.5% of Si, 0.7% of Fe, 0.05% of Ti, 0.05% of B or 0.05% of Cr.
3. A process for producing a bake-hardenable aluminium alloy sheet for can bodies, comprising:
 - smelting and casting an aluminium alloy containing 0.05 to 0.5% of Cu, 0.5 to 2.5% of Mg and 0.5 to 2% of Mn, the balance being Al and any impurities;
hot-rolling the resulting ingot after a soaking treatment at a temperature higher than 500°C;
 - heating the alloy to a temperature in the range of 400 to 600°C at a heating rate higher than 100°C/min to provide an average crystal grain size in a range smaller than 25 microns;
immediately after the heating or after heat retention for a time period shorter than 10 minutes, cooling said alloy at a cooling rate higher than 100°C/hr to maintain in solid solution the alloy elements which contribute to the bake-hardening effect; and
 - cold rolling said alloy at a reduction rate greater than 10%.

4. A process as claimed in claim 3 wherein said aluminium alloy is cold rolled after said hot rolling step and before said heating step.
- 5 5. A process as claimed in claim 3 or 4, wherein said aluminium alloy is cooled to a temperature below 150°C in the cooling stage.
- 10 6. A process as claimed in claim 3, 4 or 5, wherein said aluminium alloy is worked at a reduction rate greater than 30% in the final cold rolling stage.

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*Fig. 1.*



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. ³)
X	FR-A-2 432 555 (COORS CONTAINER CY.) * Claims 1-4 *	1,2	C 22 C 21/06
X	* Claims 5,9-11 *	3,6	
X	--- FR-A-2 432 556 (ALUMINIUM SUISSE) * Claim 1; page 9, lines 28-36 *	1,2	
X	* Claims 2,5,7 *	3	
A	--- US-A-3 787 248 (SETZER et al.) * Claims 1,11 *	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	* Claims 1,5,6 *	3	C 22 C 21 C 22 F 1/04

The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14-12-1983	Examiner 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	