



(86) Date de dépôt PCT/PCT Filing Date: 1999/07/07

(87) Date publication PCT/PCT Publication Date: 2000/01/20

(45) Date de délivrance/Issue Date: 2005/01/04

(85) Entrée phase nationale/National Entry: 2001/01/04

(86) N° demande PCT/PCT Application No.: CA 1999/000618

(87) N° publication PCT/PCT Publication No.: 2000/003052

(30) Priorité/Priority: 1998/07/08 (60/092,051) US

(51) Cl.Int.⁷/Int.Cl.⁷ C22F 1/05, C22F 1/047, C22F 1/043

(72) Inventeurs/Inventors:

GUPTA, ALOK KUMAR, CA;
MAROIS, PIERRE HENRI, CA

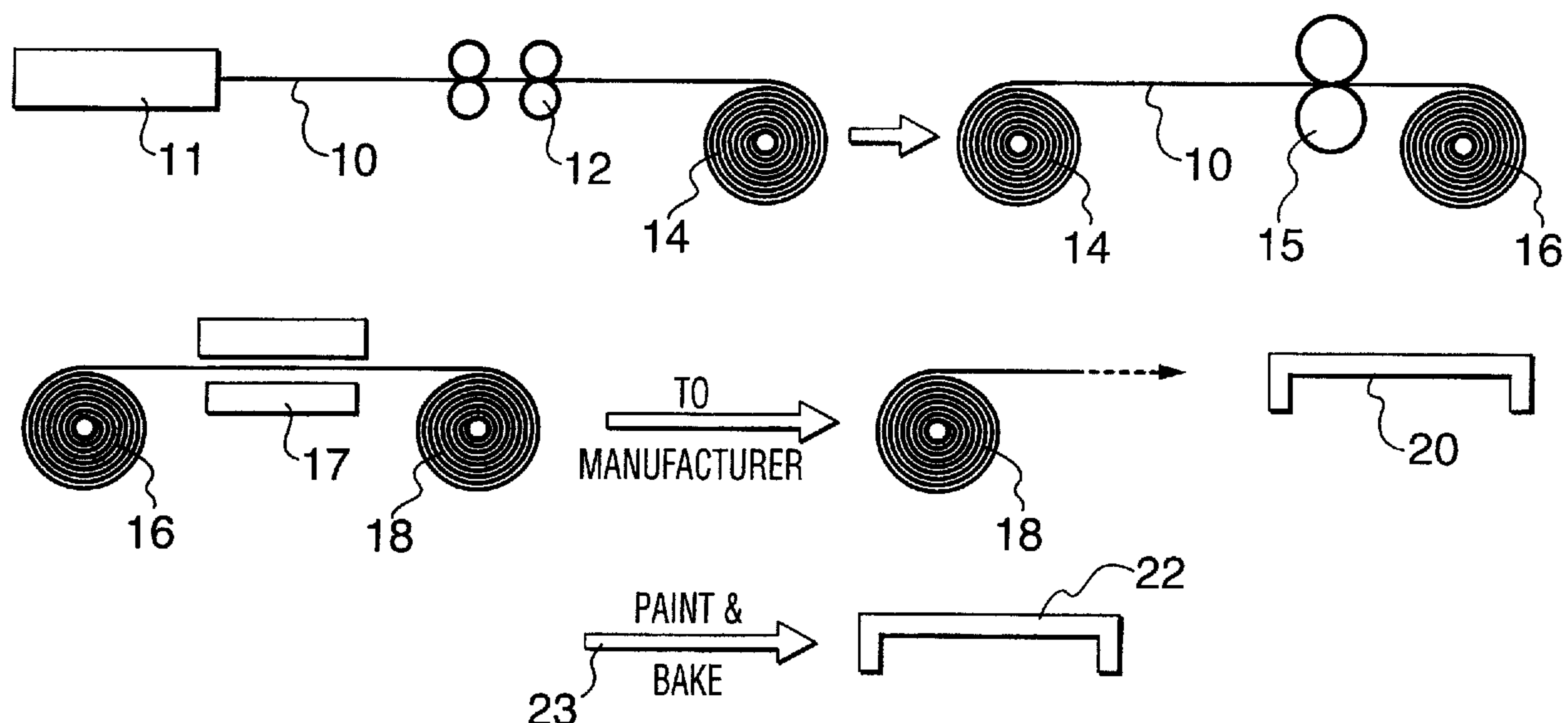
(73) Propriétaire/Owner:

ALCAN INTERNATIONAL LIMITED, CA

(74) Agent: KIRBY EADES GALE BAKER

(54) Titre : PROCEDE DE PRODUCTION D'ARTICLES EN TOLE TRAITABLES A CHAUD

(54) Title: PROCESS FOR PRODUCING HEAT-TREATABLE SHEET ARTICLES



(57) Abrégé/Abstract:

A process of heat treating a sheet article made of a 6000 series aluminum alloy to achieve good "paint-bake response" that is substantially unaffected by natural aging. The process comprises heating the alloy sheet article at a solutionizing temperature followed by cooling the alloy sheet article. The cooling involves the following steps: (1) cooling from said solutionizing temperature to a temperature in the range of 150 - 250 °C at a rate greater than or equal to about 4 °C per second; (2) further cooling the alloy to a temperature in the range of ambient to 100 °C at a rate of 20 to 30 °C (preferably about 25 °C) per minute; and (3) further cooling the alloy sheet article having a temperature of 55 °C or more after step (2) to ambient temperature at a rate of less than 2 °C per hour. Alloy sheet articles suitable for use in the fabrication of automobile skin part can be produced in this way.

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : C22F 1/05, 1/047, 1/043	A1	(11) International Publication Number: WO 00/03052 (43) International Publication Date: 20 January 2000 (20.01.00)
---	-----------	--

(21) International Application Number: PCT/CA99/00618
(22) International Filing Date: 7 July 1999 (07.07.99)

(30) Priority Data:
60/092,051 8 July 1998 (08.07.98) US

(71) Applicant (for all designated States except US): ALCAN INTERNATIONAL LIMITED [CA/CA]; 1188 Sherbrooke Street West, Montreal, Quebec H3A 3G2 (CA).

(72) Inventors; and

(75) Inventors/Applicants (for US only): GUPTA, Alok, Kumar [CA/CA]; 24 Seaforth Road, Kingston, Ontario K7M 1E2 (CA). MAROIS, Pierre, Henri [CA/CA]; 38B Crescent Drive, Kingston, Ontario K7M 4J5 (CA).

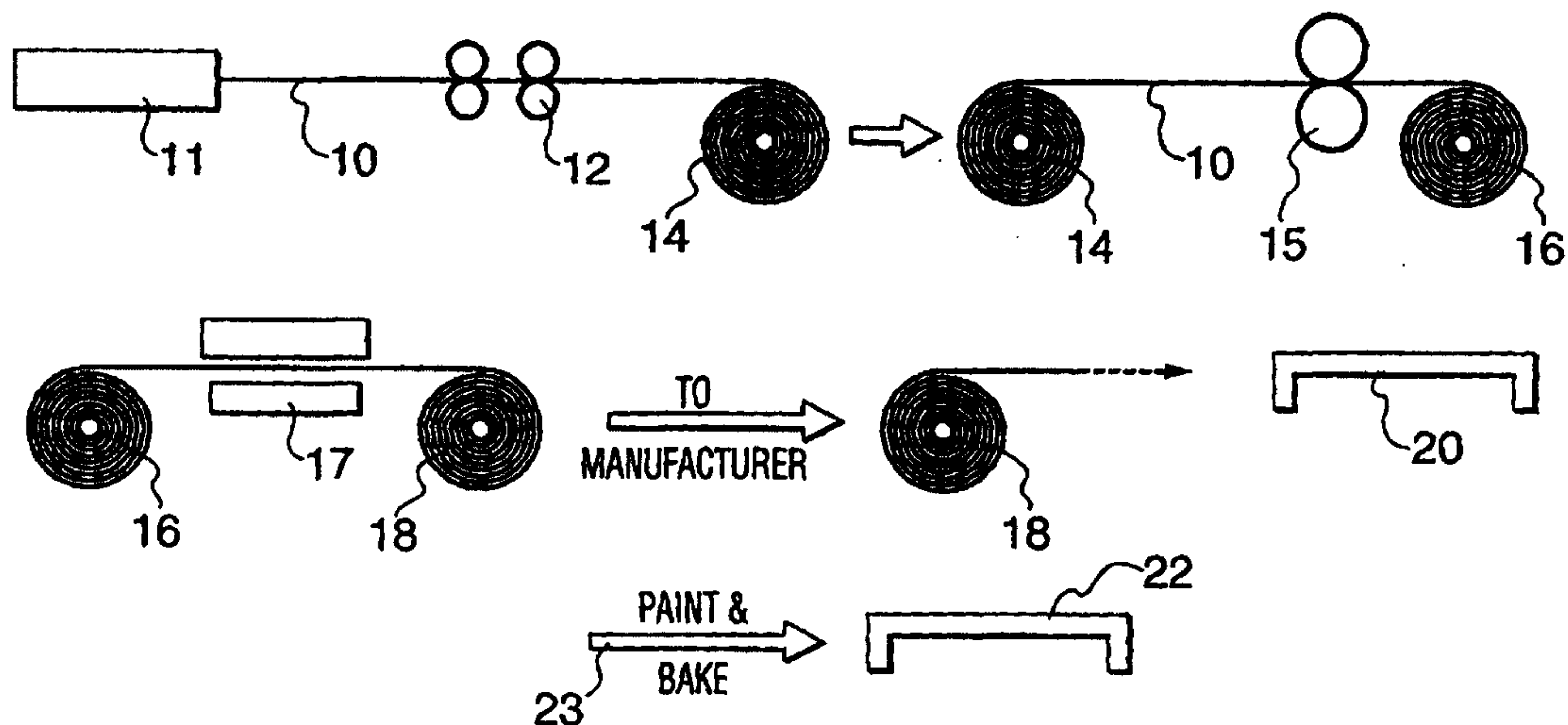
(74) Agents: GALE, Edwin, J. et al.; Kirby, Eades, Gale, Baker, Station D, Box 3432, Ottawa, Ontario K1P 6N9 (CA).

(81) Designated States: BR, CA, JP, NO, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

(54) Title: PROCESS FOR PRODUCING HEAT-TREATABLE SHEET ARTICLES



(57) Abstract

A process of heat treating a sheet article made of a 6000 series aluminum alloy to achieve good "paint-bake response" that is substantially unaffected by natural aging. The process comprises heating the alloy sheet article at a solutionizing temperature followed by cooling the alloy sheet article. The cooling involves the following steps: (1) cooling from said solutionizing temperature to a temperature in the range of 150 – 250 °C at a rate greater than or equal to about 4 °C per second; (2) further cooling the alloy to a temperature in the range of ambient to 100 °C at a rate of 20 to 30 °C (preferably about 25 °C) per minute; and (3) further cooling the alloy sheet article having a temperature of 55 °C or more after step (2) to ambient temperature at a rate of less than 2 °C per hour. Alloy sheet articles suitable for use in the fabrication of automobile skin part can be produced in this way.

- 1 -

PROCESS FOR PRODUCING HEAT-TREATABLE SHEET ARTICLESTECHNICAL FIELD

This invention relates to sheet articles made of heat-treatable aluminum alloys suitable for the fabrication, for example, of automotive skin panels. More particularly, the invention relates to a method of producing sheet articles of this kind in such a way as to minimize disadvantageous effects caused by natural aging of the articles.

BACKGROUND ART

10 The automotive industry, in order to reduce the weight of automobiles, has increasingly substituted aluminum alloy panels for steel panels. Lighter weight panels, of course, help to reduce automobile weight, which reduces fuel consumption, but the introduction of aluminum alloy panels creates its own set of needs. To be useful in automobile applications, an aluminum alloy sheet product must possess good forming characteristics in the "as-received" (by the automobile manufacturer) T4 temper condition, so that it may be bent or shaped as desired without cracking, tearing or wrinkling. At the same time, the alloy panel, after the painting and baking (paint-bake) carried out by the automobile parts manufacturer, must have sufficient strength to resist dents and withstand other impacts.

25 Several aluminum alloys of the AA (Aluminum Association) 2000 and 6000 series are usually considered for automotive panel applications. The AA6000 series alloys contain magnesium and silicon, both with and

-2-

without copper but, depending upon the Cu content, may be classified as AA2000 series alloys. These alloys are formable in the T4 temper condition and become stronger after painting and baking in the so-called T8X temper
5 (i.e., they exhibit a "paint-bake response" or increase in yield strength). A particularly preferred alloy of this kind is alloy AA6111.

To facilitate understanding, a brief explanation of the terminology used to describe alloy tempers may be in
10 order at this stage. The temper referred to as T4 is well known (see, for example, Aluminum Standards and Data (1984), page 11, published by The Aluminum Association) and refers to alloy produced in the conventional manner (solutionizing followed by quenching and natural aging for
15 48 hours or more). This is the temper in which automotive sheet panels are normally delivered to parts manufacturers for forming into skin panels and the like. For example, the commercial fabrication of conventional AA6111 sheets in the T4 temper involves solutionizing (subjected to a
20 solution heat treatment) the cold-rolled material between 530 and 560°C in a continuous annealing furnace, rapidly cooling the alloy to a temperature between 35 and 45°C and then naturally aging the alloy for two days or more before subjecting the product to the usual finishing operations.
25 Alternatively, the material can be solutionized and coiled between 55 and 85°C and then coil-cooled to room temperature before being subjected to the finishing operations. The material produced in this manner performs similarly to the conventional T4 temper sheet in forming
30 and tensile tests and shows a significant improvement in

WO 00/03052

PCT/CA99/00618

-3-

the paint bake response. Such a material produced by the alternative heat treatment step is internally referred as T4P temper product.

T8 temper designates an alloy that has been solution
5 heat-treated, cold worked and then artificially aged. Artificial aging involves holding the alloy at elevated temperature(s) over a period of time. T8X temper refers to a condition where T4 material has been stretched by 2% and given an artificial aging at 170°C for 20 minutes or
10 177°C for 30 minutes (simulating commercial forming and paint-bake).

An alloy that has only been solution heat-treated and artificially aged to peak strength is said to be in the T6 temper.

15 It has been observed that conventionally-produced 6000 series alloy sheet articles exhibit a good paint-bake response immediately after quenching, but this response declines somewhat upon natural aging. It would therefore be advantageous to produce alloy sheet materials of the
20 6000 series that avoid this decline in the paint bake response and maintain a high yield strength in the T8X temper.

In our US patent no. 5,616,189 issued April 1, 1997, we have described processes for producing aluminum alloy
25 sheet having T4 and potential T8X tempers. These processes involve heat treatments and controlled cooling. However, there is a need for an alternative process, since the disclosed process is not always highly convenient.

- 4 -

DISCLOSURE OF THE INVENTION

An object of the present invention is to produce alloy sheet articles of 6000 series aluminum alloy exhibit a desirable paint bake response and a high yield strength
5 in the T8X temper.

Another object of the invention is to provide a heat treatment process that reduces or avoids the reduction of paint bake response of 6000 series aluminum alloys.

According to one aspect of the invention, there is
10 provided a process of heat treating a sheet article made of a 6000 series aluminum alloy, comprising heating the alloy sheet article at a solutionizing temperature followed by cooling the alloy sheet article; wherein said cooling of the article includes the following steps: (1)
15 cooling from said solutionizing temperature to a temperature in the range of 150 - 250°C at a rate greater than or equal to about 4°C per second (preferably greater than or equal to 225°C per second); (2) further cooling the alloy to a temperature in the range of ambient (room
20 temperature - e.g. about 20°C) to 100°C at a rate of 20 to 30 (preferably about 25°C) per minute; and (3) further cooling the alloy sheet article having a temperature of 55°C or more after step (2) to ambient temperature at a rate of less than 2°C per hour.

25 For step (3) the sheet article would normally be coiled at the indicated temperature following step (2) and allowed to cool at the rate indicated for step (3). This final step (3) brings about an artificial pre-aging of the alloy.

WO 00/03052

PCT/CA99/00618

-5-

If the alloy is solutionized in a continuous annealing line (CAL) involving a heating section and a quenching section, cooling steps (1) and (2) would normally require controlled cooling within a furnace to
5 ensure the required slower cooling rate. Step (3) may be carried out in a conventional storage area of a production facility provided the ambient temperature guarantees the desired slow cooling rate.

The process of the invention may form part of a
10 process for the continuous production of alloy sheet article involving casting, homogenizing and hot and cold rolling prior to the indicated solutionizing and multi-step cooling.

The alloy may be any AA6000 series aluminum alloy and
15 is most preferably an alloy having the following composition by weight:

	Cu	0 to 1.0%
	Mg	0.4 to 1.1%
	Si	0.3 to 1.4%
20	Fe	0.1 to 0.4%
	Mn	0 to 0.45%
	Al	balance.

Optionally, the preferred alloy may also contain small amounts of Zr, Cr and/or Ti not exceeding 0.15% in
25 total.

The most preferred alloy is alloy AA 6111 which has the following composition by weight (Al forms the balance):

WO 00/03052

PCT/CA99/00618

-6-

	Cu	Fe	Mg	Mn	Si	Ti	Cr
Max	0.9	0.40	1.0	0.45	1.1	0.10	0.10
Min	0.5	0.1	0.5	0	0.6	-	-

The process of the present invention creates a sheet article that exhibits an improved paint-bake response (increase in yield strength from the T4 temper following painting and baking) compared to an identical alloy produced by the conventional solutionizing, rapid quenching and natural aging procedure, by reducing the tendency of natural aging to reduce this response.

10 The exact mechanism explaining why the required controlled cooling works is not yet clear. However, without wishing to be bound to any particular theory, it is currently believed that the controlled cooling of steps (1) and (2) allows the formation of stable nuclei which promote the precipitation of fine coherent particles, homogeneously distributed in the alloy matrix, during the artificial aging (pre-aging) step. In conventional material, the nuclei formed during natural aging become unstable and dissolve during subsequent aging at high temperature. As a result, particle distribution in the matrix is coarse and this causes reduced strengthening in the T8X temper compared with that expected from the material produced according to the method of the present invention.

- 7 -

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is schematic illustration of steps carried out according to a preferred embodiment of the process of the present invention;

5 Fig. 2 is a chart showing heating and cooling curves of samples as explained in the following Example 1; and

Fig. 3 is a chart showing variations of yield strength as a function of intermediate cooling temperature of samples as explained in the following Example 1.

10 BEST MODES FOR CARRYING OUT THE INVENTION

According to a preferred embodiment of the present invention, the alloy is direct chill cast, scalped, homogenized between 480 and 580°C for less than 48 hours, hot/cold rolled to an intermediate gauge, cold rolled to
15 the final gauge, solution heat treated between 480 and 580°C in a continuous heat treatment (CASH) furnace, rapidly cooled in the required controlled manner, coiled at a temperature of less than about 85°C, and is then cooled to room temperature. The material is then normally
20 subjected to various finishing operations including leveling to obtain a flat sheet for forming into parts. Panels formed from the material of this invention will acquire higher strength during the paint cure than conventional AA6111-T4 alloy sheet material. Alloys of
25 the resulting temper are referred to internally as T4CC.

The processing may also include an inter annealing operation between the hot rolling and the final cold rolling operation to produce roping-free high strength sheet products (for example, as described in co-pending
30 PCT Application Serial No. PCT/CA98/00109 filed

-8-

February 17, 1998, published on August 27, 1998 as WO 98/37251.

An alternative preferred process according to the present invention, involving twin-belt casting, is shown in simplified schematic form in Fig. 1 of the accompanying drawings. Continuous metal strip 10 of series 6000 alloy (preferably AA6111) is cast in a twin belt caster 11 and subjected to hot rolling at rolling station 12. During this rolling step, some precipitates form. The hot rolled product is coiled to form coil 14. The hot rolled strip 10 is then unwound from coil 14, subjected to cold rolling in cold roll mill 15 and coiled to form coil 16. The cold rolled strip 10 is then unwound from coil 16 and subjected to a continuous solution heat treatment and controlled quenching at station 17 to re-solutionize and precipitate constituent particles, and is then coiled at to form coil 18.

The solution heat treatment, by means of which precipitated alloying ingredients are re-dissolved in the alloy, generally involves heating the alloy sheet material to a temperature of between about 500°C and about 570°C (preferably about 560°C). The improved quenching or cooling process of the invention is then carried out. The coiled strip 18 is in T4 temper and may be sold to an automobile manufacturer or parts manufacturer for fabrication by forming panels 20 from the strip by deformation followed by painting and baking the panels to form painted panels 22 in T8X temper.

- 9 -

According to the present invention, materials having the properties of the known T4P product can also be produced by controlling the cooling conditions immediately after solutionizing in the indicated way. In fact, the
5 aging response is significantly improved when controlled cooling is combined with warm coiling between 55 and 80°C.

As noted above, the controlled cooling from the solutionizing temperature is performed in two stages, which are referred to as steps (1) and (2) or as the
10 primary and secondary cooling steps. During primary cooling, the material is cooled to an intermediate temperature between 150 and 250°C at rates typically used in a commercial continuous heat treatment line. In the secondary stage, the material is then naturally cooled to
15 below 85°C, and optionally coiled and then coil-cooled to room temperature.

It should be noted that the use of heat treatment process of this invention can be readily carried out in long continuous annealing furnaces so that the material
20 can be solutionized, cooled to an intermediate temperature between 150 and 250°C and further cooled slowly to allow formation of stable nuclei.

The invention is illustrated in more detail by the following Examples, which are not intended to limit the
25 scope of the present invention.

-10-

EXAMPLE 1 - Laboratory Study

Commercially-produced AA6111 alloy sheets containing (by weight): 0.74% Cu, 0.24% Fe, 0.79% Mg, 0.13% Mn, 0.60% Si, 0.06% Ti, 0.05% Cr and balance Al were used in the following laboratory study.

The alloy had previously been solutionized at 560°C in a continuous annealing and solution heat treatment (CASH) line, quenched in cold water and stored at room temperature. Several samples prepared from this material were re-solutionized by heating to 558°C in a fluidized bed, and then cooled in forced air in two stages to simulate the primary and secondary cooling operations (first and second cooling steps) of the present invention.

The primary cooling conditions, to obtain different intermediate cooling temperatures (ICTs), were determined by performing several calibration runs. A tensile sample having a thickness of 1.0 mm, with an embedded thermocouple, was heated in a fluidized bed (sand bed) to 558°C, held for 30 seconds and cooled in forced air to room temperature (RT). Figure 2 shows the heating and cooling characteristics of the sample. Such experiments were repeated several times and the heating and cooling curves of the sample were found to be highly reproducible. The cooling curve in Figure 2 was used to determine the time to reach various ICTs. The secondary cooling conditions were simulated by cooling from the ICT to room temperature or a pre-aging temperature in still air.

To study the effect of the primary cooling conditions on tensile properties, a number of samples were cooled to

-11-

a variety of ICTs ranging from 100 to 250°C and then naturally cooled to room temperature (secondary cooling). The samples were solutionized at 560°C and cooled in forced air, for a predetermined period of time, to obtain
5 the desired ICT and further cooled to room temperature in still air. The samples took a maximum of 8 minutes to cool down to room temperature.

Additional heat treatments were also performed to determine the combined effect of controlled cooling and
10 warm coiling temperatures. Samples were solutionized, cooled to the intermediate cooling temperature between 150 and 250°C and then cooled in still air. The samples were then subjected to a simulated pre-aging treatment by heat treating at 60, 80 or 100°C for 5 hours.

15 One week later, duplicate tensile tests were performed in the T4 and T8X (2% stretch plus 30 minutes at 177°C) tempers. Similar results were also obtained without prior natural aging to examine the stability of the tensile properties. The properties of the material of
20 this invention were then compared with those of the conventionally produced material.

Results

Effects of Primary cooling to Intermediate Cooling Temperature (ICT)

25 Table 1 below summarizes the average tensile properties of AA6111 in different tempers.

In the Table:

U.T.S. means "ultimate tensile strength";

WO 00/03052

PCT/CA99/00618

-12-

Y.S. means "yield strength";
%El. means percentage elongation;
ksi means kilopounds per square inch; and
MPa means megapascals.

Table 1

Tensile properties of AA-6111 alloy, resolution heat-treated at 560°C in a sand bed for 1 minute, forced air-cooled to an intermediate temperature, further cooled in still air and pre-aged.

Intermediate Temperature (°C)		Preaging Temperature (°C) -5h		Now*										1 Week Later		
		T4				T8X				T4				T8X		
		U.T.S. MPa (ksi)	Y.S. MPa (ksi)	% El.	U.T.S. MPa (ksi)	Y.S. MPa (ksi)	% El.	U.T.S. MPa (ksi)	Y.S. MPa (ksi)	% El.	U.T.S. MPa (ksi)	Y.S. MPa (ksi)	% El.	U.T.S. MPa (ksi)	Y.S. MPa (ksi)	% El.
Conventional		--	74.5 (10.8)	--	351.6 (51.0)	276.5 (40.1)	19.5	276.5 (40.1)	133.1 (19.3)	27.4	295.1 (42.8)	206.8 (30.0)	22.6			
250	None	219.3 (31.8)	91.0 (13.2)	25.4	355.1 (51.5)	299.9 (43.5)	14.6	274.4 (39.8)	137.2 (19.9)	24.8	324.7 (47.1)	256.5 (37.2)	14.9			
	100	--	--	--	--	--	--	282.0 (40.9)	150.3 (21.8)	25.3	360.6 (52.3)	299.2 (43.4)	16.9			
	80	--	--	--	--	--	--	263.4 (38.2)	126.2 (18.3)	24.4	352.3 (51.1)	286.8 (41.6)	18.0			
	60	--	--	--	--	--	--	262.7 (38.1)	126.9 (18.4)	26.7	346.8 (50.3)	282.7 (41.0)	15.9			
200	None	--	--	--	--	--	--	273.7 (39.7)	135.8 (19.7)	26.2	315.1 (45.7)	237.2 (34.4)	19.0			
150	None	217.9 (31.6)	84.8 (12.3)	24.1	340.6 (49.4)	273.0 (39.6)	16.2	273.0 (39.6)	132.4 (19.2)	26.5	308.9 (44.8)	227.5 (33.0)	20.2			
	100	--	--	--	--	--	--	268.9 (39.0)	131.7 (19.1)	25.3	347.5 (50.4)	277.2 (40.2)	19.3			
	80	--	--	--	--	--	--	255.8 (37.1)	115.8 (16.8)	27.8	339.9 (49.3)	267.5 (38.8)	18.4			
	60	--	--	--	--	--	--	257.2 (37.3)	117.9 (17.1)	26.9	327.5 (47.5)	248.9 (36.1)	20.3			
100	None	--	--	--	--	--	--	275.8 (40.0)	132.4 (19.2)	27.5	297.9 (43.2)	210.3 (30.5)	22.7			

* Tested immediately after the heat treatment.

-14-

Figure 3 shows the variation in yield strength (YS) as a function of intermediate cooling temperature. In the Figure:

Curve (a) shows the yield strength values after cooling;

Curve (b) shows the yield strength values after one week at room temperature;

Curve (c) shows the yield strength values after one week at room temperature in the T8X temper; and

Curve (d) shows the yield strength values after cooling in the T8X temper.

From the Figure, the following observations can be made:

- (i) The yield strength of the alloy immediately after the heat treatment is ~82.7 to 89.6 MPa (~12 to 13 ksi). These values are close to that of as-quenched conventional material.
- (ii) The yield strength in the T4 temper does not vary with the changes in ICT, Figure 3, Curve (a).
- (iii) The Yield strength in the T8X temper, Figure 3, Curve (d), immediately after cooling shows a significantly different aging behavior. The conventionally cooled material shows ~275.8 MPa

-15-

(~40 ksi) yield strength at ICT's below 150°C. Beyond this temperature, the yield strength increases and reaches a value close to 299.9 MPa (43.5 ksi) at 250°C.

- 5 (iv) After one week of natural aging, the yield strength of the material is ~132.4 MPa (~19.2 ksi), Curve (b) in Figure 3. Like Curve (a), the yield strength in the T4 temper is independent of the ICT.
- 10 (v) As expected, natural aging causes a loss in yield strength in the T8X temper. The loss of strength is related to the ICT. For example, the material shows 206.8 MPa (30 ksi) yield strength when primary cooling is carried out to
- 15 <150°C. Higher values are achieved provided the ICT is increased to a maximum of 250°C. At this temperature, the material shows 256.5 MPa (37.2 ksi) yield strength, which is close to 25% higher than the conventionally produced material
- 20 (Table 1).

Relationship Between ICT and Pre-aging Conditions:

25 The Yield strength of the material is increased significantly when controlled cooling is followed by a pre-aging step (Figure 3). Generally, a lower ICT gives lower strength in both tempers. The strength is increased slightly with an increase in the pre-aging temperature and

WO 00/03052

PCT/CA99/00618

-16-

the absolute T8X Yield strength is increased by up to 20.7 MPa (3 ksi) for the material which was cooled to 250°C (Table 1). These data clearly suggest that the higher pre-aging temperatures are generally better to achieve high strength, especially for the ICT of 250°C. It should be noted that the choice of higher pre-aging temperature between 60 and 100°C has only a minor influence on the T8X properties, Curve (d) in Figure 3 and Table 1.

Summary

Clearly, there is considerable gain in the paint-bake response if the material is cooled between 150 and 250°C in primary cooling and then very slowly cooled to a temperature less than 100°C.

-17-

CLAIMS:

1. A process of heat treating a sheet article made of a 6000 series aluminum alloy, in which the alloy sheet article is heated at a solutionizing temperature, and then cooled;

5 characterized in that the cooling of the article includes the following steps:

(1) cooling from said solutionizing temperature to a temperature in the range of 150 - 250°C at a rate greater than or equal to 4°C per second;

10 (2) further cooling the alloy to a temperature in the range of ambient to 100°C at a rate in the range of about 20 to 30°C per minute; and

(3) further cooling the alloy sheet article having a temperature of 55°C or more after step (2) to ambient
15 temperature at a rate of less than 2°C per hour.

2. A process according to claim 1, characterized in that said cooling step (1) is carried out at a rate greater than or equal to 225°C per second.

20 3. A process according to claim 1, characterized in that said cooling step (2) is carried out at a rate of about 25°C per minute.

4. A process according to claim 1, characterized in that said alloy sheet article is coiled at said temperature following step (2) prior to said cooling of step (3).

-18-

5. A process according to claim 1, characterized in that the process is carried out on an alloy having the following composition by weight:

5 Mg 0.4 to 1.1%
 Si 0.3 to 1.4%
 Fe 0.1 to 0.4%
 Al balance.

10 6. A process according to claim 1, characterized in that the process is carried out on an alloy having the following composition by weight:

15 Cu up to 1.0%
 Mg 0.4 to 1.1%
 Si 0.3 to 1.4%
 Fe 0.1 to 0.4%
 Mn up to 0.4%
 Zr }
 Cr } up to 0.15% in total
 Ti }
 Al balance.

20 7. A process according to claim 1, characterized in that the process is carried out on an alloy having the following composition by weight:

	Cu	Fe	Mg	Si
Max	0.9	0.40	1.0	1.1
Min	0.5	0.1	0.5	0.6

8. A process according to claim 1, characterized in that the process is carried out on an alloy having the following composition by weight:

-19-

5 Cu 0.5 to 0.9%
 Fe 0.1 to 0.4%
 Mg 0.5 to 1.0%
 Mn up to 0.45%
 Si 0.6 to 1.1%
 Ti up to 0.10%
 Cr up to 0.10%
 Al balance.

10 9. A process according to claim 1, characterized in that
the process is carried out on alloy AA6111.

15 10. A process according to claim 1, characterized in that
said alloy sheet article subjected to said solutionizing is
produced by casting an ingot, scalping said ingot,
homogenizing said ingot at a temperature in the range of
480 to 580°C, hot/cold rolling the ingot to form a sheet
article of intermediate gauge, and cold rolling the sheet
article of intermediate gauge to final gauge.

20 11. A process according to claim 10, characterized in that
said intermediate gauge sheet article is subjected to an
inter annealing operation.

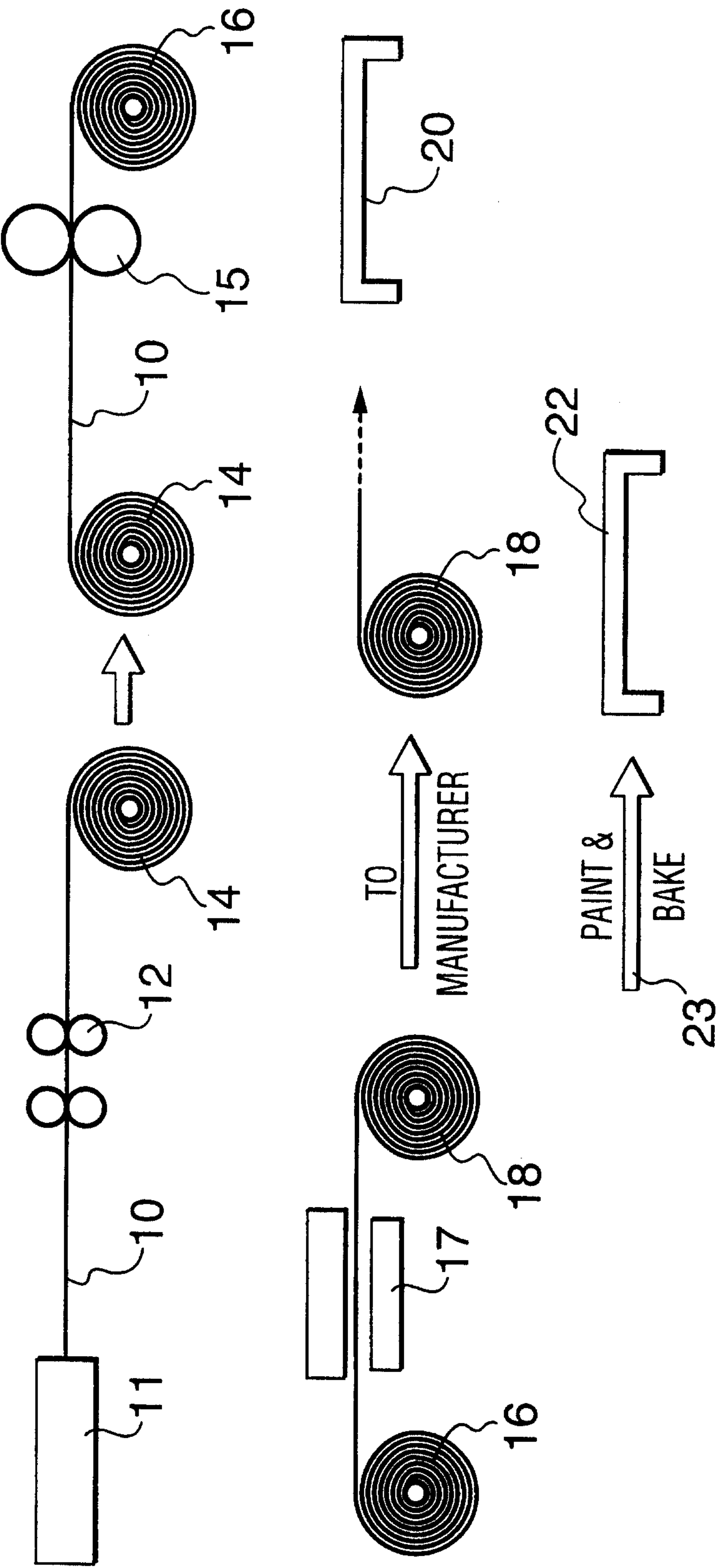
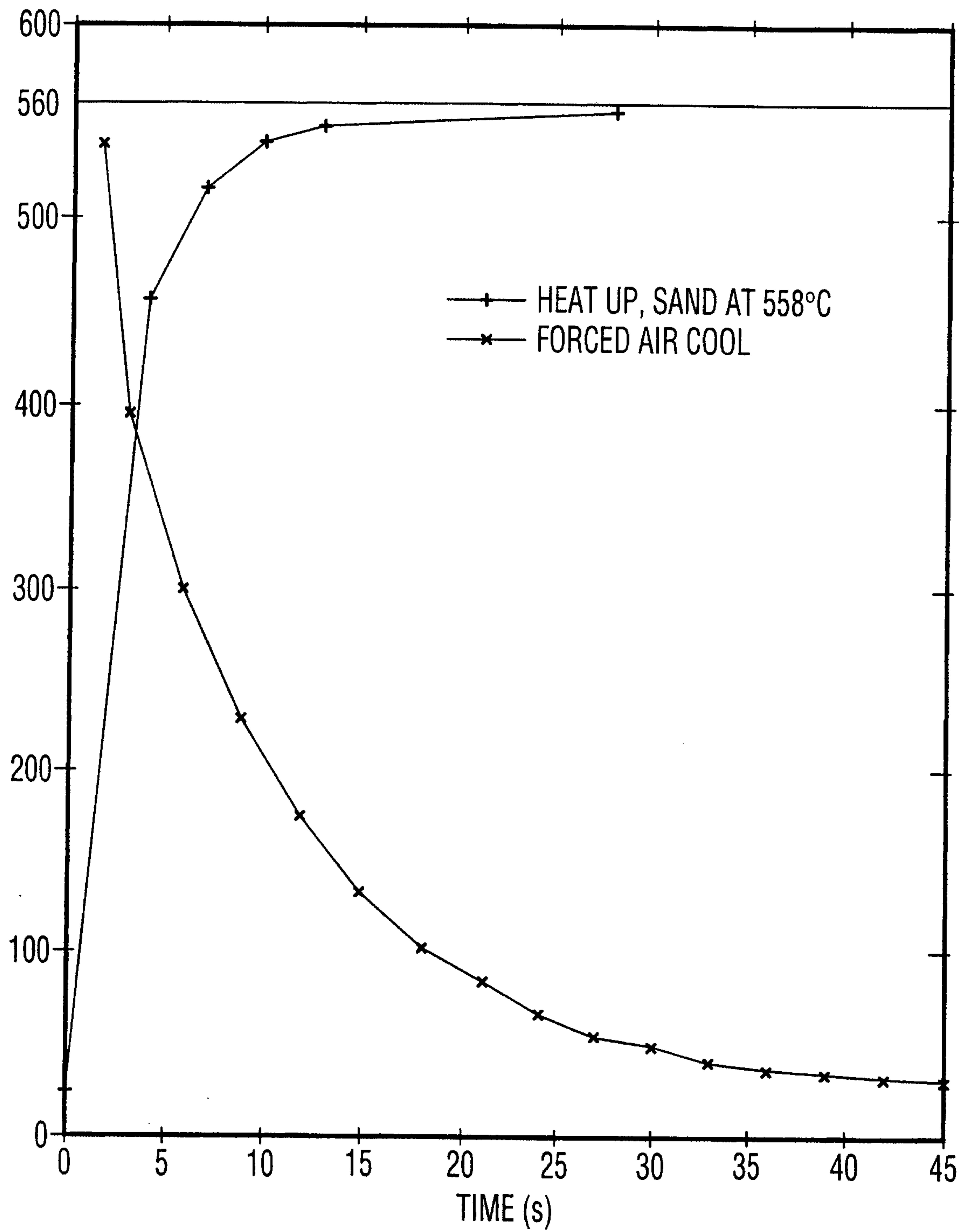


FIG. 1

2/3

**FIG. 2**

3/3

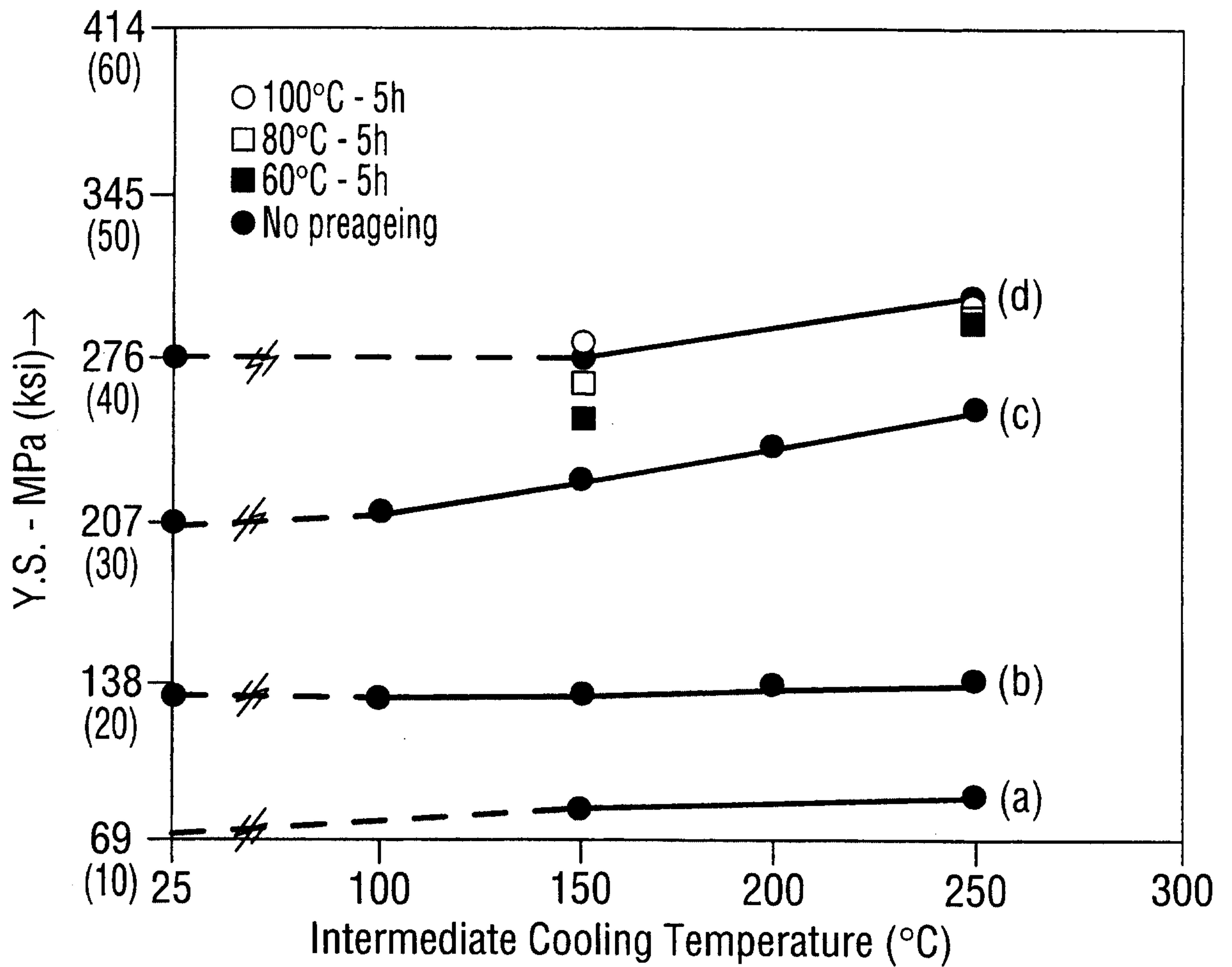


FIG. 3

