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(54) **ALUMINUM AUTOMOTIVE HEAT SHIELDS**

(75) Inventors: **Paul Platek**, Massillon, OH (US); **Zhong Li**, Lexington, KY (US)

Correspondence Address:
ANDREW ALEXANDER & ASSOCIATES
3124 KIPP AVENUE, P.O. BOX 2038
LOWER BURRELL, PA 15068

(73) Assignee: **Commonwealth Industries, Inc.**

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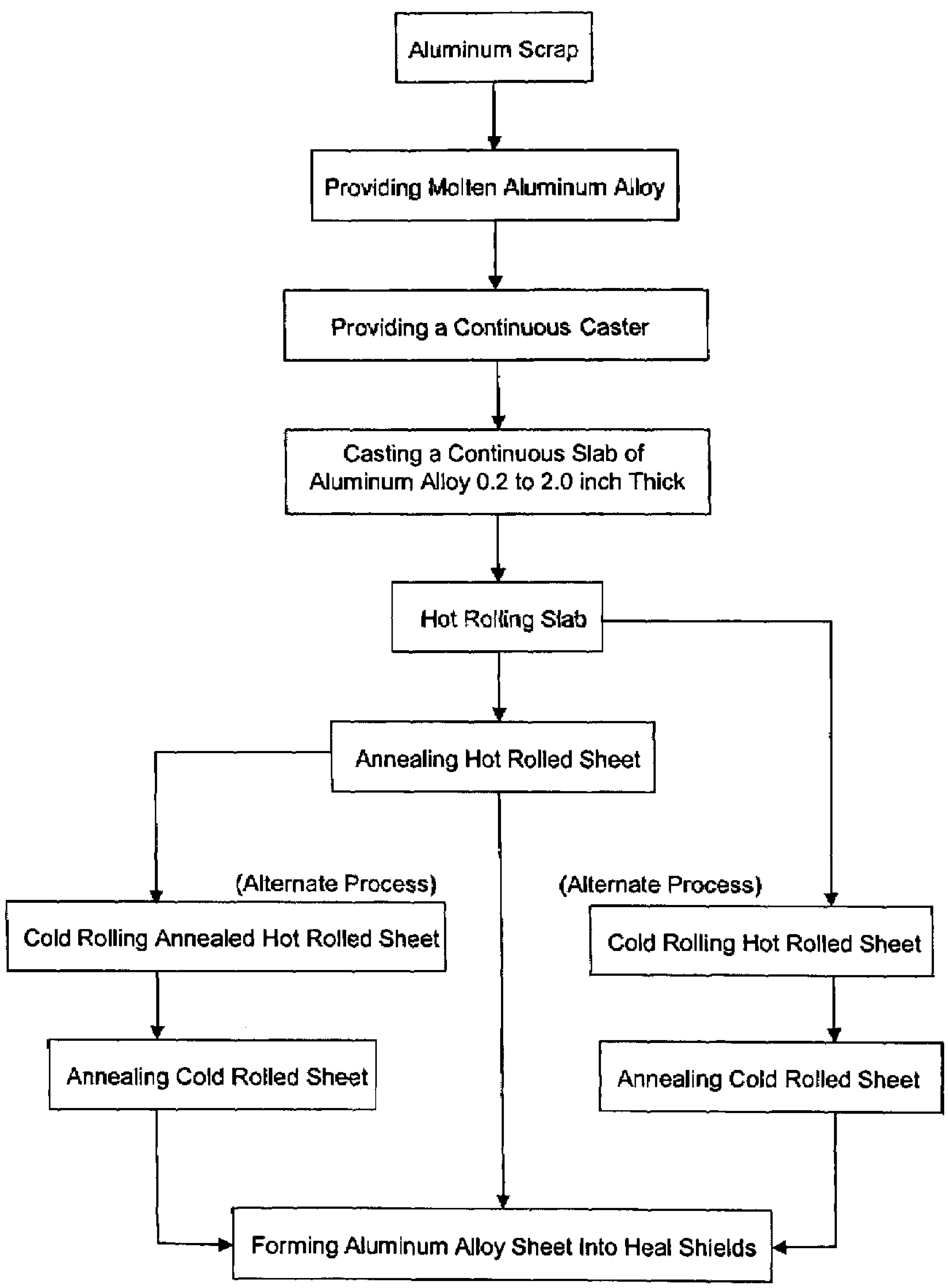
(57) **ABSTRACT**

Disclosed is a method for producing aluminum automotive heat shields or panels such as from scrap derived molten aluminum alloy using a continuous caster to cast the alloy into a slab. The method comprises providing a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities and providing a continuous caster such as a belt caster, block caster or roll caster for continuously casting the molten aluminum alloy. The molten aluminum alloy is cast into a slab which is rolled into a sheet product and then annealed. Thereafter, the sheet product is formed into the automotive heat shield or panel with strength and formability as required by the automotive industry.



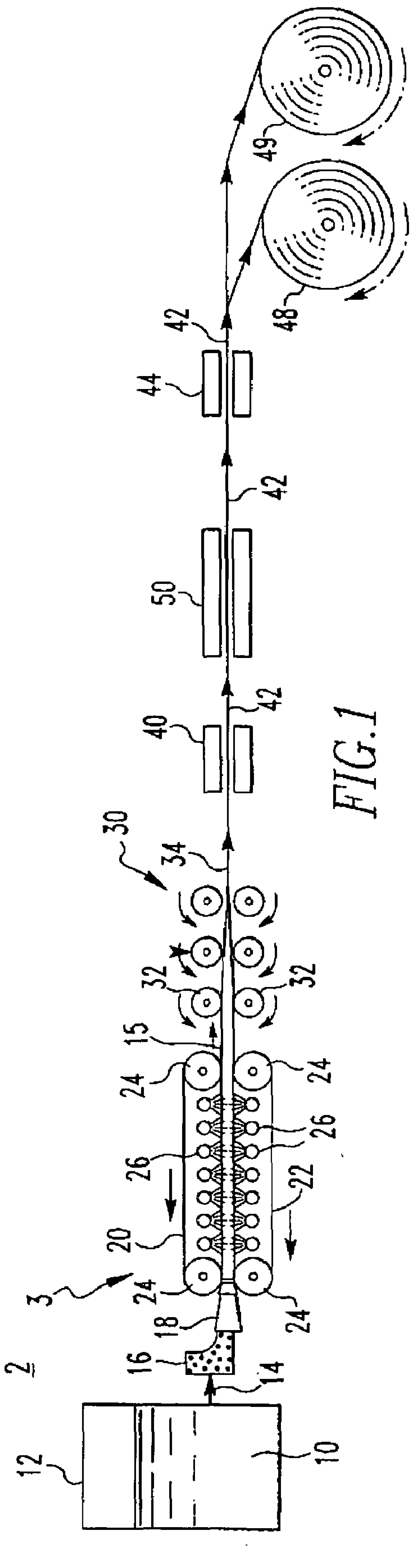


FIG. 1

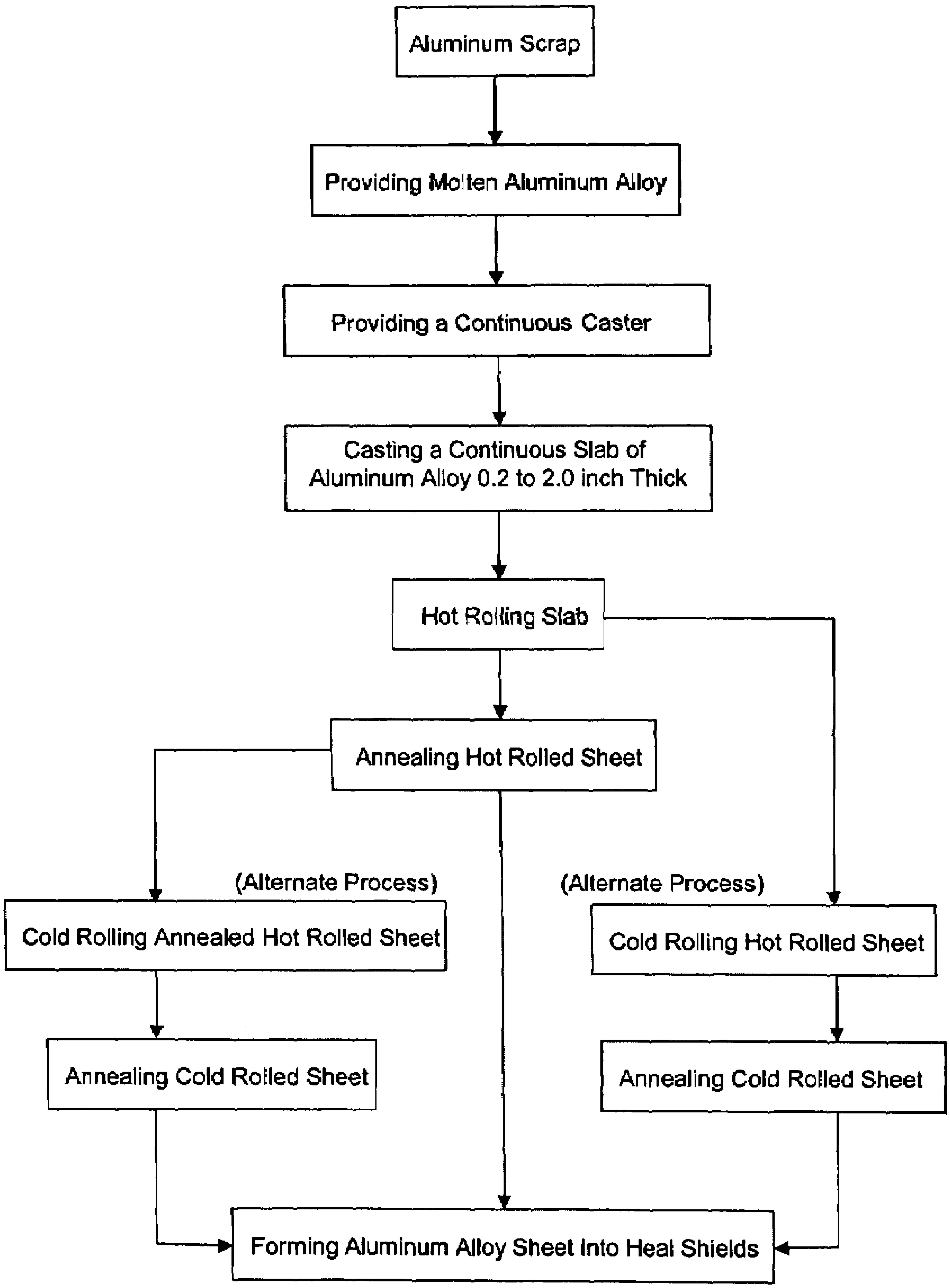

Aluminum Scrap
Providing Molten Aluminum Alloy
Providing a Continuous Caster
Casting a Continuous Slab of Aluminum Alloy 0.2 to 2.0 inch Thick
Hot Rolling Slab
Annealing Hot Rolled Sheet
(Alternate Process)
Cold Rolling Annealed Hot Rolled Sheet
Annealing Cold Rolled Sheet
(Alternate Process)
Cold Rolling Hot Rolled Sheet
Annealing Cold Rolled Sheet
Forming Aluminum Alloy Sheet Into Heat Shields

FIG. 2

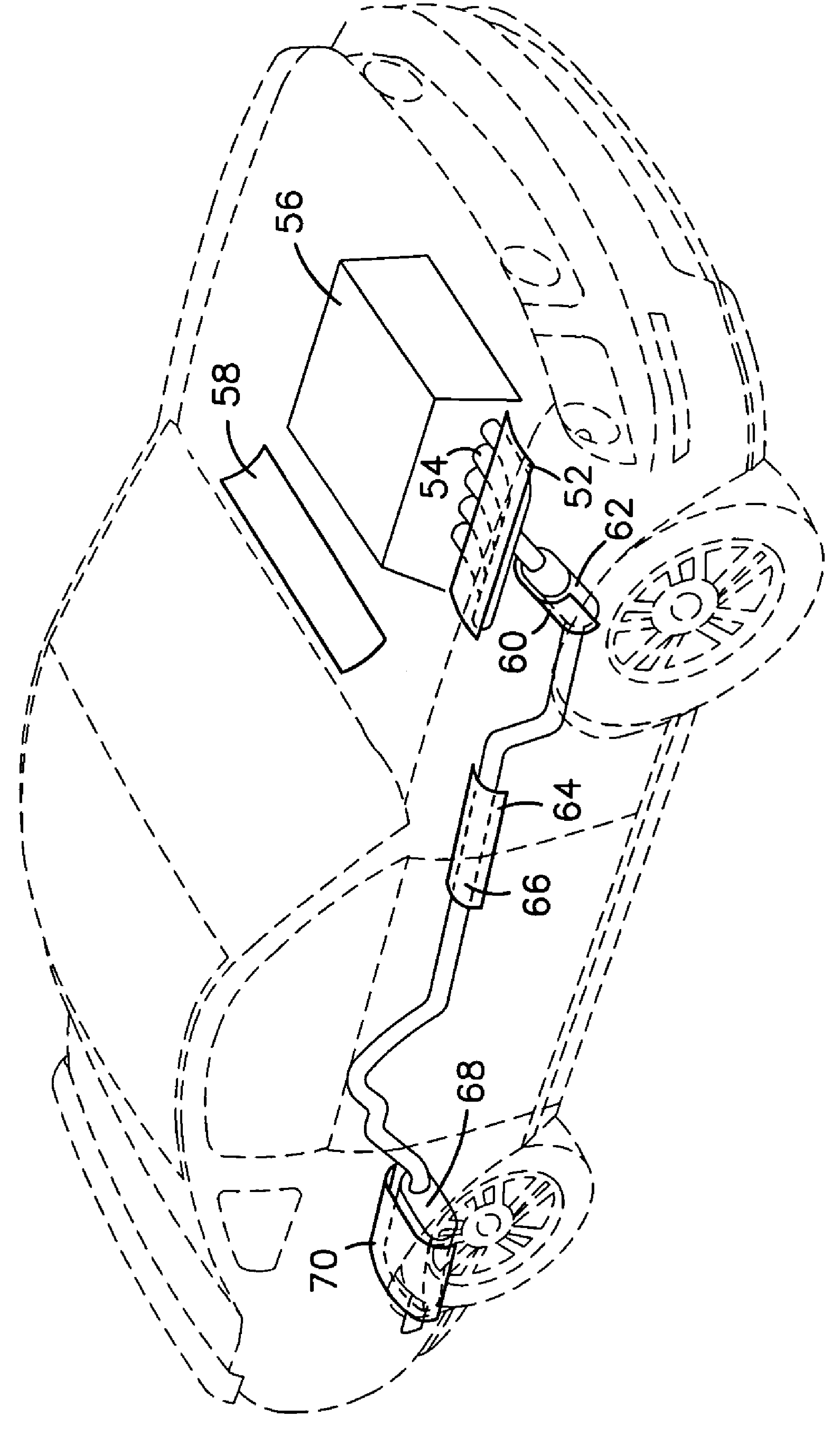


FIG. 3

ALUMINUM AUTOMOTIVE HEAT SHIELDS

BACKGROUND OF THE INVENTION

[0001] This invention relates to aluminum alloy vehicular heat shields or panels made from scrap aluminum and more particularly, it relates to a method of melting scrap aluminum and casting it into sheet having good forming characteristics and to forming the sheet into vehicular heat shields or panels.

[0002] In many instances, continuous casting of molten aluminum into slab utilizing twin belt, twin roll or block casters is favored over DC casting because continuous casting can result in substantial energy savings and total conversion cost savings compared to the DC cast method. In the continuous casting process, molten metal is continuously introduced to an advancing mold and a slab is produced which may be continuously formed into a sheet product which is collected or wound into a coil. However, the continuous casting is not without problems. For example, it has been discovered that the alloy composition and the processing steps must be carefully controlled in order to have the formability level to avoid cracking during forming and yet have the requisite strength properties in the final product. That is, the alloy derived from scrap and the processing thereof must be carefully controlled to provide sheet having the formability suited to the fabricating steps necessary to form the final product or part. If the alloy and processing steps are not controlled, then in the forming steps, fracture can occur and the formed parts have to be scrapped. Thus, there is a great need for selection of an aluminum alloy, continuous casting thereof, and thermal mechanical processing methods which provide a sheet product having forming characteristics and strength properties which permit forming operations such as bending, stamping, deep drawing, stretching or crimping during production of vehicular heat shields or panels while avoiding problems of fracturing or cracking, for example.

[0003] With respect to the use of aluminum scrap, U.S. Pat. Nos. 4,260,419, 4,235,646 and 4,269,632 disclose that consumer scrap is recycled into aluminum sheet and aluminum beverage containers. Aluminum scrap is melted in a heated furnace to form a melt composition. The melt is adjusted to form the present composition, consisting essentially of silicon, 0.1-1.0%; iron 0.1-0.9%; manganese 0.4-1.0%; magnesium 1.3-2.5%; copper 0.05-0.4%; and titanium, 0-0.2%, the balance being essentially aluminum. Aluminum scrap comprising consumer scrap, plant scrap, and can making scrap is heated to form the melt composition, which requires a minimum amount of adjustment to arrive at the present alloy composition. The composition is suitable for fabrication into sheet having strength and formability properties making it suitable for container manufacture.

[0004] U.S. Pat. No. 6,355,090 discloses a method of producing an aluminum alloy for automotive parts, comprising adding a scrap of an aluminum wrought alloy or a pure aluminum ingot to an aluminum alloy casting scrap, melting the mixture to dilute impurities, and if necessary, adjusting elements of the resultant. According to the above method, aluminum alloy casting scraps, which contain large amounts of impurities and have been difficult to recycle into other articles until now, can be converted to an aluminum alloy material that is applicable as a wrought material usable as a higher-grade material.

[0005] U.S. Patent Publication 2004/0213695 discloses recycle friendly aluminum alloys which are variants of AA 3000 and AA 5000 series alloys containing higher than usual amounts of silicon and iron. The alloys contain in percentages by weight, more than 0.6-2.0% silicon, 0.9-2.4% iron, wherein the ratio of the amount of iron to the amount of silicon is in the range of 1.2-1.8:1. Other components of the alloys may include 0-0.4% copper, 0-1.5% manganese, 0-5.0% magnesium, 0-0.5% zinc, 0-3.5% chromium, 0-0.1% titanium and the balance aluminum and incidental impurities.

[0006] U.S. Pat. No. 4,411,707 discloses an aluminum container scrap alloy is processed by a modified chill roll cast process into a highly formable sheet material suitable for use as a container end stock, by employing at least a 60% cold reduction followed by an anneal for about two hours at a temperature of from about 825° F. to about 900° F., followed by cold reduction to final gauge.

[0007] U.S. Pat. No. 4,840,852 discloses Aluminum alloy products particularly for automotive applications, e.g., panel members, may be produced from a body of aluminum base alloy consisting essentially of, by weight, 0.5 to 0.85% Si, 0.25 to 0.55% Mg, 0.05 to 0.4% Fe, 0.75 to 1.1% Cu, the balance essentially aluminum and incidental elements and impurities. The alloy body may be homogenized at a temperature in the range of 900° to 1100° F. and thereafter worked into a wrought product such as sheet which may be continuously solution heat treated and quenched and aged to a T4 condition prior to forming into vehicular panel members, for example.

[0008] U.S. Pat. No. 5,582,660 discloses a process for fabricating an aluminum alloy rolled sheet particularly suitable for use for an automotive body, the process comprising: (a) providing a body of an alloy comprising about 0.8 to about 1.3 wt. % silicon, about 0.2 to about 0.6 wt. % magnesium, about 0.5 to about 1.8 wt. % copper, about 0.01 to about 0.1 wt. % manganese, about 0.01 to about 0.2 wt. % iron, the balance being substantially aluminum and incidental elements and impurities: (b) working the body to produce a sheet; (c) solution heat treating the sheet; and (d) rapidly quenching the sheet. In a preferred embodiment, the solution heat treat is performed at a temperature greater than 840° F. and the sheet is rapidly quenched. The resulting sheet has an improved combination of excellent formability and good strength.

[0009] U.S. Pat. No. 5,641,417 discloses tailored aluminum blanks, such as structural automotive components, formed by gas tungsten arc welding a plurality of aluminum or aluminum-alloy sections. Preferably, a backup plate having a shallow longitudinal groove or a plurality of longitudinal grooves and a beveled electrode are employed. A preferred embodiment comprises the use of a multi-torch assembly for initial cleaning and subsequent smoothing of the resulting weld.

[0010] U.S. Pat. No. 6,086,690 discloses a process of producing an aluminum alloy sheet article of high yield strength and ductility suitable, in particular, for use in manufacturing automotive panels. The process comprises casting a non heat-treatable aluminum alloy to form a cast slab, and subjecting said cast slab to a series of rolling steps to produce a sheet article of final gauge, preferably followed by annealing to cause recrystallization. The rolling steps involve hot and warm rolling the slab to form an intermediate sheet article of intermediate gauge, cooling the intermediate sheet article, and then warm and cold rolling the cooled intermediate sheet to final gauge at a temperature in the range of ambient temperature to 340° C. to form said sheet article. The series of rolling steps is carried out continuously without intermediate coiling or full annealing of the intermediate sheet article. The invention also relates to the alloy sheet article produced by the process.

[0011] U.S. Pat. No. 6,193,818 discloses a process for forming an aluminum alloy strip, including the steps of a) obtaining an aluminum alloy consisting essentially of, by weight, 0.5 to 13% Si, 0 to 2% Mg, 0 to 2% Cu, 0 to 1% Mn, 0 to 2% Fe, other elements less than 0.5% each and less than 2% total, and remainder Al; and b) continuously casting the aluminum alloy between twin cooled rolls having a force applied thereto, to obtain a cast strip of thickness between 1.5 and 5 mm, and optionally cold rolling the cast strip. The force applied to the rolls is maintained below an amount represented by a straight line between a point A and a point B on a graph of specific applied force (y-axis) vs. cast width (x-axis), where point A is (1.5 mm, 750 tons/meter at cast width) and point B is (5 mm, 500 tons/meter of cast width).

[0012] U.S. Pat. No. 6,207,299 discloses a coating layer for sheet metal that is comprised of an aluminum-silicon alloy having low emissivity. The coated sheet metal may be used as heat shield material, particularly for heat sources having temperatures greater than 500° C., which sources may be, e.g., the hotter parts of the conduits of automotive exhaust systems. The sheet metal may be sheet steel coated on at least one of its principal surfaces with a layer of a coating comprised of an alloy of silicon in the amount of 7-11 wt. % and aluminum in the amount of 87-93 wt. %. The coated surface of the sheet has a monochromatic emissivity less than 0.15 for all wavelengths in the range of 1.5-15 microns.

[0013] U.S. Pat. No. 6,267,922 discloses an aluminum alloy containing the following elements in the stated amounts: $0.6 \leqq Mg \leqq 0.9$; $0.25 \leqq Si \leqq 0.6$; $0.25 \leqq Cu \leqq 0.9$; $Fe \leqq 0.4$; $Mn \leqq 0.4$; the total of the amounts of Cu, Si and Mg being, in atomic weight percent, more than 1.2% and less than 1.8%. These alloys may be subjected to homogenization at about 470 to 560° C. for more than four hours, hot rolling at a temperature in the range of 400 to 580° C., cold rolling, solutionizing at a temperature in the range of 470 to 580° C., and natural aging at ambient temperature. The alloys may then be used as structural components for all aluminum vehicles and may be recycled with other aluminum alloys used in such vehicles.

[0014] U.S. Pat. No. 6,280,543 discloses an invention directed to a continuous casting of flat rolled sheets selected from automotive sheet, can body sheet, and endstock which exhibits properties comparable to the same products made from World Class Ingot. A preferable embodiment for the continuous caster is a vertical continuous caster.

[0015] U.S. Pat. No. 5,993,573 discloses a process for continuously casting aluminum alloys and improved aluminum alloy compositions. The process includes the steps of (a) heating the cast strip before, during or after hot rolling to a temperature in excess of the output temperature of the cast strip from the chill blocks and (b) stabilization or back annealing in an induction heater of cold rolled strip produced from the cast strip.

[0016] U.S. Pat. No. 5,514,228 discloses a method for manufacturing aluminum sheet stock which includes hot rolling an aluminum alloy sheet stock, annealing and solution heat treating it without substantial intermediate cooling and rapid quenching.

[0017] U.S. Pat. No. 5,833,775 discloses an aluminum alloy sheet and a method for producing an aluminum alloy sheet. The aluminum alloy sheet is useful for forming into drawn and ironed container bodies. The sheet preferably has an after-bake yield strength of at least about 37 ksi and an elongation of at least about 2 percent. Preferably the sheet also has earing of less than about 2 percent.

[0018] The continuous casting of molten aluminum and rolling slab produced therefrom into a sheet product is disclosed in various patents. For example, U.S. Pat. No. 5,976,279 discloses a process for continuously casting aluminum alloys and improved aluminum alloy compositions. The process includes the steps of continuously annealing the cold rolled strip in an intermediate anneal using an induction heater and/or continuously annealing the hot rolled strip in an induction heater. The alloy composition has mechanical properties that can be varied selectively by varying the time and temperature of a stabilizing anneal.

[0019] U.S. Pat. No. 6,264,765 discloses a method and apparatus for casting, hot rolling and annealing non-heat treatment aluminum alloys. The method and apparatus comprises continuous casting, hot rolling and in-line inductively heating the aluminum sheet to obtain the mechanical properties within the specification tolerance of the hot rolled product.

[0020] U.S. Pat. No. 5,985,058 discloses a process for continuously casting aluminum alloys and improved aluminum alloy compositions. The process includes the step of heating the cast strip before, during or after hot rolling to a temperature in excess of the output temperature of the cast strip from the chill blocks. The alloy composition has a relatively low magnesium content yet possesses superior strength properties.

[0021] In spite of these disclosures, there is a great need for selection of aluminum alloy derived from aluminum scrap and method for-producing vehicular heat shield parts or members utilizing a continuous caster, optimized thermal mechanical processing, to provide good strength and levels of formability which permit ease of forming into intricate parts without cracking.

[0022] The term "formability" when used herein is used to describe the ease with which a sheet of metal can be shaped through plastic deformation. Formability of a metal can be evaluated by measuring strength, ductility, and the amount of deformation to cause failure.

[0023] The term "aluminum" when used herein is meant to include aluminum and its alloys.

[0024] The term "automotive" or "automobile" as used herein is meant to include automobile and other vehicles and other transport parts or members having similar construction. The term "heat shield" as used herein is meant a shield made from aluminum and used to deflect heat on an automobile or other vehicle.

SUMMARY OF THE INVENTION

[0025] It is an object of the invention to provide an improved, low cost process utilizing aluminum scrap including continuous casting and rolling to continuously produce aluminum sheet product having consistent levels of formability.

[0026] It is another object of the invention to provide a process including continuously casting a slab from a melt derived from aluminum scrap and rolling the slab into a sheet product suitable for use in producing vehicular parts such as heat shields.

[0027] It is still another object of the invention to provide a process employing continuous casting of molten aluminum derived from aluminum scrap into slab and rolling the slab into sheet product for meeting the forming requirements, such as bending, stamping, stretching or deep drawing of heat shields.

[0028] And yet it is another object of the invention to provide an improved process for producing aluminum sheet product employing a continuous caster to produce slab, continuously rolling the slab to produce a sheet product and annealing the sheet product for forming into vehicular heat shields or panels.

[0029] It is yet another object of the invention to provide a process for producing vehicular formed exhaust heat shields, which includes melting aluminum scrap to form an alloy, continuously casting the aluminum alloy into a slab, rolling the slab to a sheet product and annealing the sheet product to provide good levels of formability, and thereafter forming the sheet product into a panel.

[0030] And yet it is another object of the invention to provide a process for casting an aluminum scrap derived molten alloy preferably comprising 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3, wt. % Mn, 0.2 to 2.8, wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities, casting the alloy into a slab which is hot rolled and annealed to provide a sheet product suitable for forming into a heat shield suitable for an automobile such as an exhaust or engine heat shield.

[0031] In accordance with these objects, there is provided a process for producing aluminum vehicular heat shields or members from molten aluminum alloy made from aluminum scrap, the process using a continuous caster, e.g., a belt caster, to cast the alloy into a slab. The method comprises providing a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05, preferably 0.3, to 1.3 wt. % Mn, 0.2, preferably 0.3, to 2.5 or 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities and providing a continuous caster such as a belt caster for continuously casting the molten aluminum alloy. Thereafter, the sheet product is formed into heat shields such as automotive exhaust shields to direct heat away from automotive body.

[0032] Alternatively, the hot rolled sheet may be cold rolled after hot rolling, and then annealed prior to the forming steps. In yet another embodiment, the hot rolled sheet may be annealed or even homogenized and then cold rolled to a cold rolled sheet product. The cold rolled product can be annealed to provide a product suited to the various forming steps.

[0033] These and other objects will become apparent from a reading of the specification and claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. 1 is a schematic of a continuous caster, hot rolling mill and rolls of sheet material.

[0035] FIG. 2 is a flow chart showing steps in the invention.

[0036] FIG. 3 is a schematic showing typical heat shields as used on an automobile.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0037] The automotive heat shields of the invention are comprised of an aluminum base alloy derived from aluminum scrap, the alloy containing controlled amounts of magnesium, iron, silicon and manganese for the required strength and formability in the sheet product produced by the casting and thermomechanical process. The total amounts of the alloying elements are required to be controlled to meet the strength requirement without causing casting difficulty in the process. Further, the amount of alloying elements also is required to be controlled to meet the formability requirements, especially the amount of iron, manganese and silicon.

[0038] Accordingly, the aluminum base alloy consists essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3, wt. % Mn, 0.2 to 2.8, wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities. Preferably, magnesium is maintained in the range of 0.3 to 2.5 wt. % and manganese is preferably maintained in the range of 0.07 to 0.8 or 1.2 wt. %. Further, preferably iron is maintained in the range of 0.25 or 0.3 to 0.85 wt. %, typically 0.3 to 0.8 wt. % and silicon is maintained in the range of 0.15 to 0.65 wt. %. Impurities are preferably limited to not more than 0.05 wt. % each and the combination of impurities should not be greater than 0.15 wt. % total.

[0039] Thus, it will be understood that to use an alloy of the above composition derived from aluminum scrap in the process of the invention to form automotive heat shields having the requisite properties requires careful control of the elements in the alloy and the casting thereof to avoid forming intermetallic particle structures adverse to the forming operation. That is, it will be appreciated that in the present process, there is great difficulty in balancing all the constituents in the alloy for strength and procedural steps necessary to forming a sheet product having desirable properties for forming into the final product while avoiding undesirable properties which leads to fracture or cracking, for example, during the forming process.

[0040] Not only is it important to have alloying elements and impurities in the controlled amounts as herein described, but the slab produced by continuous casting, the sheet formed from the slab and automotive heat shields fabricated from the sheet must be prepared in accordance with specific method steps in order to produce sheet and automotive heat shields therefrom having the desirable characteristics.

[0041] Thus, referring now to FIG. **1**, there is shown a schematic illustration of a belt caster and rolling mill **2** for producing sheet suitable for forming into automotive heat shields in accordance with the invention.

[0042] In FIG. **1**, molten aluminum **10** obtained from aluminum scrap is provided in a furnace or reservoir **12**. The aluminum scrap can be almost all types of non-heat treatable and 6xxx series heat treatable aluminum scrap such as aluminum building and construction materials, used beverage containers, food containers, truck trailer siding, and auto parts, for example. Molten aluminum from reservoir **12** is typically passed through a filter and degasser (not shown) and is then directed along line **14** to a tundish **16** from where it is metered through a nozzle **18** into an advancing mold created by revolving belts **20** and **22** and side dam blocks (not shown). Belts **20** and **22** are turned by means of rolls **24**. Molten metal, e.g., molten aluminum, is solidified to form a continuous slab **15** between belts **20** and **22** which are chilled using coolant spray **26**. The belt caster is described in U.S. Pat. Nos. 3,864,973; 3,921,697; 4,648,438; 4,940,076 and 4,972,900, incorporated herein by reference as if specifically set forth. Improved nozzles for a belt caster are set forth in U.S. Pat. No. 5,452,827, incorporated herein by reference.

[0043] From FIG. **2**, it will be seen that molten aluminum **10** is derived from aluminum scrap. Minor adjustments may be made to the alloy composition by adding prime aluminum when necessary. However, it is desired to use very small amounts of prime aluminum to favor economics of the process. Further, preferably, the aluminum scrap is comprised of non-heat treatable and heat treatable aluminum alloys such as, for example, Aluminum Association (AA) alloys 1050, 1100, 3003, 3004, 3105, 5052, 5754, 5182, 6061 and 6111, whose compositions are included herein as if specifically set forth. By "scrap derived" as used herein is meant that most of the alloy used in the process comes from scrap, and primary aluminum is only used when it necessary to adjust the alloy within the composition ranges provided herein. FIG. **2** is a flow chart showing manufacturing steps of the invention.

[0044] Another casting apparatus that may be used in the present invention is a block caster wherein the blocks are connected to function as belts and is included herein as a belt caster. As described with respect to belt caster **3**, a tundish and nozzle are provided to transfer molten metal to the blocks of the block caster wherein solidification occurs to provide a solidified slab **15** and the blocks are chilled to aid in solidification of the molten metal.

[0045] Yet another apparatus that may be utilized to cast a continuous strip or slab **15** is a roll caster which includes two rolls which rotate to provide the continuously advancing mold. As in the belt caster, a tundish and nozzle are used to transfer molten aluminum to the mold defined by the two rolls. Again, the rolls are normally chilled to aid in solidification of the molten metal into a strip or slab. The different casters are described in U.S. Pat. No. 5,452,827. By the use of the term "continuous caster" is meant to include all these casters.

[0046] Molten aluminum alloy of the invention is introduced to the caster in a temperature range of about 1230° to 1350° F., typically 1250° to 1300° F., and exits the caster at a temperature in the range of 750° to 1150° F., typically 860° to 1050° F. In addition, typically the continuous slab exiting the continuous caster has a thickness in the range of 0.2 to 2 inches, for example, 0.25 to 1 inch. A typical slab thickness for the belt caster is about 0.5 to 1 inch. Belt casting speed can range from 10 to 40 ft/min, depending on the thickness of the slab. It is important to adhere to these casting conditions in order to achieve the volume and quality required for the end product. Thus, the present invention provides continuous cast slab for forming into sheet material with high cost savings and yet retains the desirable properties such as formability.

[0047] After exiting the caster, the slab **15** is directed to rolling mill **30** where it is rolled to form a rolled strip or flat product **34** using preferably a hot mill. Hot mill **30** is comprised of one or more pairs of oppositely opposed rolls **32** which reduces the thickness of the slab a controlled amount as it passes between each stand of rolls. Three sets of hot mill stands or rolls are illustrated in FIG. **1**. For example, slab **15** having a thickness of about 0.2 to 1 inch would be reduced to a sheet product having a thickness of about 0.01 to 0.1 inch. Typically, for automotive heat shields the sheet product would have a thickness in the range of 0.015 to 0.04 or 0.08 inch, for example, depending on the application. The temperature of the slab entering hot mill **30** would typically be in the range of about 700° to 1050° F., if no heat is added. Typically, temperature of sheet product exiting mill **30** would be in the range of 350° to 700° F. In another aspect of the invention, the slab from caster **3** may be heated prior to hot rolling (not shown in FIG. **1**) to a temperature of 800° to 1100° F. to increase the rolling temperature prior to hot rolling. Thus, slab entering the hot mill can have temperatures of about 700° to 1100° F.

[0048] Hot mill **30** can reduce the thickness of the slab about 60 to 98% of its original thickness, with a typical reduction being 75 to 95%. Depending on the end use of the sheet product, heat may be applied to the strip or slab between hot stands in addition to or instead of heating prior to the hot mill.

[0049] The temperature of the aluminum alloy sheet exiting the hot mill can be in the range of about 350° to 825° F., depending on whether there was heat input before or during hot rolling.

[0050] After hot rolling, hot rolled strip **34** can have a deformation texture and deformed grain structure. The hot rolled strip can have a partially or fully recrystallized grain structure with an optimum texture depending on previous heat input and rolling reduction. If the structure remains deformed and a recrystallized grain structure is necessary for the end product, then annealing of the hot rolled strip **34** can be applied to promote recrystallization of the deformed structures. For example, it is important for automotive application using the aluminum alloy of the invention to have a fine, fully recrystallized grain structure with random texture for the purpose of forming automotive heat shields in accordance with the invention. Thus, in the present invention, it is preferred that the hot rolled sheet be fully annealed to O-temper in annealer **40**. If the hot rolled strip is already recrystallized with an optimum texture, then annealing is not required. Hot rolled sheet in the fully annealed condition can have a tensile strength in the range of 12 to 35 ksi, a yield strength in the range of 5 to 20 ksi and an elongation greater than 15%.

[0051] Referring to FIG. **1**, it will be seen in the embodiment illustrated that the hot rolled sheet product is directed to a continuous annealer **40**, using a heater such as an infrared, solenoidal or transverse flux induction heater. While any continuous heater may be used, an induction heater is preferred. Continuous anneal may also be required if cold rolling (not shown in FIG. **1**) of the hot rolled strip is necessary. Thus, the hot or cold rolled strip may be continuously annealed in annealer **40** in a temperature range of 600° to 1100° F. in time periods from 0.3 to 60 seconds in order to effect fully recrystallized sheet having fine grains and highly desired formability properties. However, care is required that the sheet product is not over annealed to the point where secondary recrystallization occurs. Secondary recrystallization is the growth of fine grains into undesirable coarse grains which are detrimental to formability.

[0052] Instead of continuous annealing, the hot rolled sheet may be batch annealed. That is, hot rolled sheet **42** is wound into coils **48** or **49**. These coils are then placed in a furnace and soaked in a temperature range of 600° to 1000° F. for 2 to 10 hours to provide the rolled sheet in a fully annealed or **0**-temper condition. If the slab has been hot rolled to a gauge suitable for forming, then no further thermal mechanical processing is necessary and the sheet is in condition for the forming steps. If the slab has been hot rolled to an intermediate gauge, then after annealing, the annealed material is subjected to cold rolling followed by further annealing to provide sheet in the O-temper for forming operations.

[0053] After hot rolling, the hot rolled sheet or flat product may be allowed to cool prior to other operations. For example, after hot rolling, with or without annealing and cooling, the resulting strip **42** may be cold rolled (not shown in FIG. **1**) to a sheet product having a final gauge. The cold rolling may be performed by passing strip **42** through several pairs or stands comprising a cold mill to provide the cold rolling required to produce the final gauge. Cold rolling can reduce the thickness of strip **42** by 20% to 80% or 90%. Final gauge can range from 0.01 to 0.04 or even 0.1 inch, typically 0.015 to 0.08 inch, for automotive heat shield applications. It will be appreciated that the cold rolling, which is rolling at lower than 350° F., can be performed in a cold rolling line separate from the subject continuous casting and rolling line.

[0054] After cold rolling to final gauge, the sheet product is subject to further anneal to ensure the required crystallographic texture and grain structure necessary for forming into the final automotive product.

[0055] After hot rolling or annealing sheet **42** may be subject to a continuous rapid quenching such as cold water quench **50** prior to further operations. Quench **50**, if used and shown after anneal, can be located at different locations in the process.

[0056] Referring to FIG. **2**, it will be seen that in an alternate process annealed hot rolled sheet may subject to cold rolling followed by further annealing prior to forming. In a further embodiment or alternate process, after hot rolling, the sheet may be directly cold rolled followed by annealing of the cold rolled sheet prior to being formed into heat shields or members. The cold rolled and annealed sheet, along the rolling direction, can have a tensile strength in the range of 12 to 35 ksi, a yield strength in the range of 5 to 20 ksi and an elongation greater than 15%. Further, the finish gage coils may go through one or a combination of steps before the forming process, such as tension leveling, slitting, surface pretreatment, lubrication or cut-to-length.

[0057] All ranges provided herein are meant to include all the numbers within the range as if specifically set forth, e.g., 1 to 5 would include 1.1, 1.2, 1.3, etc., or e.g., 2, 3, 4.

[0058] FIG. **3** is a schematic of an automobile illustrating examples of typical uses of heat shields on automobiles. The automobile is shown in outline form. For example, in FIG. **3**, there is shown a heat shield **52** which is often used to shield plug wires and water hoses from exhaust heat emanating from exhaust pipe **54** of engine **56**. Directing heat away from these components greatly extends their useful life.

[0059] Another shield that is sometimes employed is located on the firewall and is identified by the reference number **58**. This is useful in directing heat from engine **56** away from the inside of the automobile.

[0060] And yet another use is shield **60** which is used to direct heat from catalytic converter **62** downwards and away from the automobile body. This use or shield is particularly important because the catalytic converter can become very hot as it burns pollutants in the exhaust stream.

[0061] Next in the exhaust system there is shown heat shield **64** which is used to direct downwardly the exhaust heat emanating from pipe **66**. Also, exhaust muffler **68** is provided with a shield **70** to direct heat away from the automobile bottom and gas tank. Thus, this shield is important from a safety standpoint.

[0062] The following example is further illustrative of the invention.

EXAMPLE

[0063] Aluminum scrap was melted to provide an aluminum base alloy containing 0.23 wt. % Si, 0.54 wt. % Fe, 0.16 wt. % Cu, 1.0 wt. % of Mn, 0.91 wt. % Mg, 0.03 wt. % Cr, 0.05 wt. % Zn, 0.013 wt. % Ti, and incidental elements and impurities. The melt was fed to a twin belt caster at a temperature of 1280° F. and solidified to produce a 0.875 inch thick slab existing the caster at a temperature of 1020° F. The slab was directly fed into a three stand hot rolling mills and rolled to a gauge of 0.90 inch. The temperature of introducing the slab to the hot rolling mill was at about 950° F. and the temperature of exiting the mill was at about 475° F. The hot rolled sheet was wound into a coil. The coil was cold rolled to a final gauge of 0.035 inch and annealed in an anneal furnace at 850° F. for four hours. The annealed coil was tension leveled and slit into the required width. The material had properties in the rolling direction before forming into automotive heat shields of: ultimate tensile strength of 28.7 ksi, yield strength of 13.2 ksi, elongation of 16.3%. The material was formed into heat shields. Thus, the scrap based alloy can be cast in a twin belt caster, rolled into a sheet product, stamped or shaped into an automotive heat shields with sufficient strength and formability.

[0064] It will be seen that the continuous caster can be used to produce a slab which can be thermomechanically treated to form a sheet product having the properties for forming into vehicular parts or heat shields.

[0065] Having described the presently preferred embodiments, it is to be understood that the invention may be otherwise embodied within the scope of the appended claims.

What is claimed is:

1. In the production of an aluminum automotive heat shields from a molten: aluminum alloy using a continuous caster to cast the alloy into a slab, the method comprising:

(a) melting aluminum scrap to provide a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cup 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities;

(b) providing a continuous caster for continuously casting said molten aluminum alloy;

(c) casting said molten aluminum alloy into a slab having a 0.2 to 2 inch thickness;

(d) rolling said slab into a sheet product;

(e) annealing said sheet product to an O-temper condition; and

(f) forming said sheet in said O-temper into said automotive heat shield.

2. In the production of the aluminum heat shield in accordance with claim **1** wherein manganese is maintained in the range of 0.07 to 1.2 wt. %.

3. In the production of the aluminum heat shield in accordance with claim **1** wherein magnesium is maintained in the range of 0.3 to 2.5 wt. %.

4. In the production of the aluminum heat shield in accordance with claim **1** wherein iron is maintained in the range of 0.3 to 0.85 wt. %.

5. In the production of the aluminum heat shield in accordance with claim **1** wherein said continuous caster is a belt caster, a block caster or a roll caster.

6. In the production of the aluminum heat shield or member in accordance with claim **1** including annealing said sheet product in a temperature range of 600° to 1100° F.

7. In the production of the aluminum heat shield in accordance with claim **1** including annealing said sheet product in a temperature range of 650° to 950° F.

8. In the production of the aluminum heat shield in accordance with claim **7** including annealing for about 2 to 10 hours.

9. In the production of the aluminum heat shield in accordance with claim **1** including continuously annealing said sheet product.

10. In the production of the aluminum heat shield in accordance with claim **1** including hot rolling said slab to a hot rolled sheet product.

11. In the production of the aluminum heat shield in accordance with claim **1** including hot rolling said slab to a hot rolled sheet product followed by cold rolling.

12. In the production of the aluminum heat shield in accordance with claim **11** wherein said cold rolling provides a 20 to 90% gauge reduction.

13. In the production of the aluminum heat shield in accordance with claim **11** including annealing said cold rolled sheet product.

14. In the production of the aluminum heat shield in accordance with claim **13** wherein said cold rolled sheet product is annealed in a temperature range of 600° to 1000° F.

15. In the production of the aluminum heat shield in accordance with claim **1** wherein primary aluminum is added to bring said alloy into said range.

16. In a method for the production of an aluminum automotive heat shield from molten aluminum alloy using a continuous caster to cast the alloy into a slab, the method comprising:

(a) melting aluminum scrap to provide a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities;

(b) providing a continuous caster for continuously casting said molten aluminum alloy;

(c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.2 inch to 2 inches;

(d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 700° to 1100° F. and ending in a temperature of 400° to 825° F.;

(e) annealing said hot rolled sheet product to an O-temper condition, said hot rolled sheet product in said condition having a tensile strength in the range of 12 to 35 ksi, a yield strength in the range of 5 to 20 ksi, and an elongation greater than 15%; and

(f) forming said sheet product in said O-temper condition into said heat shield.

17. The method in accordance with claim **16** wherein magnesium is maintained in the range of 0.3 to 2.5 wt. %.

18. The method in accordance with claim **16** wherein iron is maintained in the range of 0.3 to 0.85 wt. %.

19. The method in accordance with claim **16** including annealing said hot rolled sheet in a temperature range of 600° to 1100° F.

20. The method in accordance with claim **16** including annealing said hot rolled sheet in a temperature range of 700° to 950° F.

21. The method in accordance with claim **19** including annealing for about 2 to 10 hours.

22. The method in accordance with claim **16** including continuously annealing said sheet product.

23. A method for producing an aluminum automotive heat shield from molten aluminum alloy using a continuous caster to cast the alloy into a slab, the method comprising:

(a) melting aluminum scrap to provide a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities;

(b) providing a continuous caster for continuously casting said molten aluminum alloy;

(c) casting said molten aluminum alloy into a slab using said caster, the slab having a thickness in the range of 0.2 to 2 inches thick;

(d) hot rolling said slab into a hot rolled sheet product;

(e) cold rolling said hot rolled sheet product to a thickness in the range of 0.01 inch to 0.1 inch to provide a cold rolled sheet product;

(f) annealing said cold rolled sheet product to provide an annealed sheet product, said annealed sheet product having a tensile strength in the range of 12 to 35 ksi, a yield strength in the range of 5 to 20 ksi and an elongation greater than 15%; and

(g) forming said annealed sheet product into said automotive heat shield.

24. The method in accordance with claim **23** including annealing said cold rolled product to an O-temper.

25. The method in accordance with claim **23** including annealing in a temperature range of 600° to 1000° F.

26. The method in accordance with claim **23** including annealing for about 2 to 10 hours.

27. The method in accordance with claim **23** including continuously annealing said sheet product.

28. The method in accordance with claim **23** wherein said cold rolling provides a 20 to 90% gauge reduction.

29. A method for producing aluminum automotive heat shield from molten aluminum alloy using a continuous caster to cast the alloy into a slab, the method comprising:

(a) providing a molten aluminum alloy consisting essentially of 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities;

(b) providing a continuous caster for continuously casting said molten aluminum alloy;

(c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.2 to 2 inches;
(d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 700° F. to 1100° F. and ending in a temperature range of 400° to 825° F.;
(e) annealing said hot rolled sheet product to provide an annealed sheet product;
(f) cold rolling said annealed sheet product to a thickness in the range of 0.01 inch to 0.1 inch to provide a cold rolled sheet product;
(g) annealing said cold rolled sheet product to provide a sheet product having a tensile strength in the range of 12 to 35 ksi, a yield strength in the range of 5 to 20 ksi and an elongation of greater than 15%; and
(h) forming said annealed sheet product into said automotive heat shield.

30. The method in accordance with claim **29** including batch annealing said hot rolled sheet product.

31. The method in accordance with claim **29** including continuous annealing said hot rolled sheet product.

32. The method in accordance with claim **29** including annealing said hot rolled sheet product in a temperature range of 650° to 1000° F.

33. The method in accordance with claim **29** including annealing in a temperature range of 650° to 950° F.

34. The method in accordance with claim **29** wherein said cold rolling provides a 25 to 80% gauge reduction.

35. The method in accordance with claim **29** wherein said annealing cold rolled sheet provides a 25 to 80% gauge reduction.

36. The method in accordance with claim **29** wherein manganese is maintained in the range of 0.07 to 1.2 wt. %.

37. The method in accordance with claim **29** wherein magnesium is maintained in the range of 0.3 to 2.5 wt. %.

38. The method in accordance with claim **29** wherein iron is maintained in the range of 0.3 to 0.85 wt. %.

39. The method in accordance with claim **29** wherein said cold rolled sheet product has a thickness in the range of 0.01 inch to 0.1 inch.

40. In an automobile, an aluminum heat shield comprised of an alloy containing 0.1 to 0.7 wt. % Si, 0.2 to 0.9 wt. % Fe, 0.05 to 0.5 wt. % Cu, 0.05 to 1.3 wt. % Mn, 0.2 to 2.8 wt. % Mg, 0.3 wt. % max. Cr, 0.3 wt. % max. Zn, 0.2 wt. % max. Ti, the remainder aluminum, incidental elements and impurities, the alloy being derived from aluminum scrap.

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