(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 August 2024 (29.08.2024)

(10) International Publication Number
WO 2024/176155 A1

(51) International Patent Classification:
C23F 17/00 (2006.01) *C21D 1/00* (2006.01)
B21D 53/88 (2006.01) *C23G 1/02* (2006.01)
B23P 25/00 (2006.01) *C25D 3/22* (2006.01)

(21) International Application Number: PCT/IB2024/051692

(22) International Filing Date: 22 February 2024 (22.02.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/447,611 22 February 2023 (22.02.2023) US

(71) Applicant: MAGNA INTERNATIONAL INC. [CA/CA]; 337 Magna Drive, Aurora, Ontario L4G 7K1 (CA).

(72) Inventors: JOHANNES, Gradinger; Puchberger Strasse 267, 2722 Weikersdorf (AT). SCHLEICHERT, Edward; Kurfürst-Eppstein-Ring 5, 63877 Sailauf, Bavaria (DE). STEPHAN, Kaufhold; Kurfürst-Eppstein-Ring 5, 63877 Sailauf, Bavaria (DE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: METHOD FOR FORMING A MEMBER FOR USE IN AN AUTOMOBILE

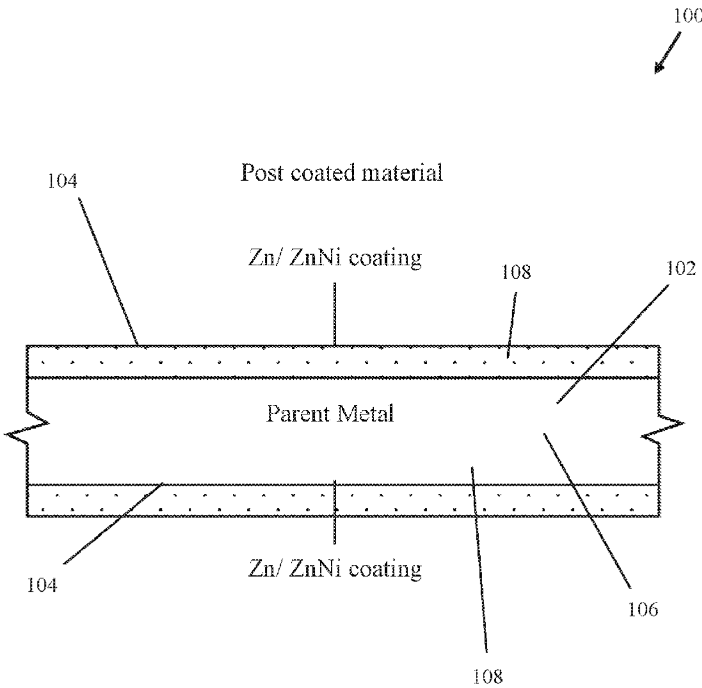

FIG. 1

(57) Abstract: A method for forming a member for use in an automobile is provided. The method comprises providing uncoated steel to a furnace; heating the steel above its austenitization temperature; shaping the steel while cooling it to provide the steel with a desired shape and strength of the member; cutting the steel to further shape it; degreasing the shaped and cut steel; and electrogalvanizing a zinc-based layer on the degreased and shaped steel.

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SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

METHOD FOR FORMING A MEMBER FOR USE IN AN AUTOMOBILE

BACKGROUND

Cross Reference to Related Applications

[0001] This application claims priority of U.S. Provisional Application No. 63/447,611, filed February 22, 2023, which is incorporated herein in its entirety by reference.

Field

[0002] The present patent application relates to a method for forming a member for use in an automobile.

Description of Related Art

[0003] There are high corrosion requirements for the press hardening steels (PHS) that are used in some portions of an automobile. To improve corrosion resistance of the PHS part/components and reduce risk for hydrogen embrittlement, pre-coated raw materials, such as Aluminum silicon (AlSi) coated hardenable steel, Aluminum iron (AlFe) coated hardenable steel, or Zinc Iron (ZnFe) coated hardenable steel may be used. For these pre-coated raw materials, either a direct or an indirect hot forming/stamping procedures/processes may be generally used.

[0004] For example, in the direct hot forming/shaping method, either AlSi or AlFe coated hardenable steel is used as a raw material. The AlSi/AlFe pre-coated hardenable steel is first heated above austenitization temperature. After the heating procedure, the process parts/components are then transferred immediately into a forming and cooling die to rapidly cool down the part/component to an ambient temperature and forming the part/component to achieve a final strength and shape.

[0005] In the indirect hot forming/shaping method, ZnFe coated hardenable steel is used as a raw material. The ZnFe pre-coated hardenable steel is first formed at an ambient temperature into its final shape with a common forming die. The formed part is then heated above austenitization temperature. After heating, the process parts/components are then transferred immediately in a cooling die to rapidly cool down the part/component to an ambient temperature to achieve final strength.

[0006] As the parts/components formed by either the direct or the indirect hot forming/stamping procedures use pre-coated raw materials, these parts/components do not need any additional coating procedures/processes after the final shape and strength are achieved. Some pre-coated materials are not released by the Original Equipment Manufacturers (OEM).

[0007] The present patent application endeavors to provide various improvements over known methods for forming material for use in an automobile.

SUMMARY

[0008] In one embodiment of the present patent application, a method for forming a member for use in an automobile is provided. The method comprises heating uncoated steel above its austenitization temperature; shaping the steel while cooling it to provide the steel with a desired shape and strength of the member; cutting the steel to further shape it; degreasing the shaped and cut steel; and electrogalvanizing a zinc-based layer on the degreased and shaped steel.

[0009] In another embodiment of the present patent application, a member for use in an automobile is provided. The member for use in an automobile, comprises a press-hardened steel structure and a zinc-based layer. The press-hardened steel structure is formed by heating uncoated steel above its austenitization temperature and shaping the uncoated steel while cooling it to obtain a desired shape and strength of the structure. The zinc-based layer is disposed on the press-hardened and shaped steel structure. An interface between the press-hardened/shaped steel structure and the zinc-based layer is devoid of an intermetallic diffusion layer and is devoid of partial or fully inter-crystalline phases.

[0010] In yet another embodiment of the present patent application, a method for forming a member for use in an automobile is provided. The method comprises heating a first portion of uncoated steel above its austenitization temperature and heating a second portion of the uncoated steel below its austenitization temperature; shaping the steel while cooling it to provide the steel with a desired shape and strength of the member; cutting the steel to further shape it; degreasing the shaped and cut steel; and electrogalvanizing a zinc-based layer onto the degreased and shaped steel.

[0011] These and other aspects of the present patent application, as well as the methods of operation and functions of the related elements of structure and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. In one embodiment of the present patent application, the structural components

illustrated herein are drawn to scale. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the present patent application. It shall also be appreciated that the features of one embodiment disclosed herein can be used in other embodiments disclosed herein. As used in the specification and in the claims, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise. In addition, as used in the specification and the claims, the term “or” means “and/or” unless the context clearly dictates otherwise. It should also be appreciated that some of the components and features discussed herein may be discussed in connection with only one (singular) of such components, and that additional like components which may be disclosed herein may not be discussed in detail for the sake of reducing redundancy.

[0012] Other aspects, features, and advantages of the present patent application will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which

[0014] FIG. 1 shows a view of a member formed using a method in accordance with an embodiment of the present patent application, where the member is configured for use in an automobile;

[0015] FIG. 2 shows various methods for forming a member for use in the automobile in accordance with embodiments of the present patent application;

[0016] FIG. 3 shows a method for forming a member for use in the automobile in accordance with one embodiment of the present patent application, wherein the method in FIG. 3 is same as the process route 1 in FIG. 2 and includes, among other things, degreasing procedure, acid pickling procedure, electrolytic degreasing procedure, chemical burring procedure, etc. after cutting procedure and before electrogalvanizing procedure, and the method in FIG. 3 also includes heat treatment procedure after the electrogalvanizing procedure;

[0017] FIG. 4 shows a method for forming a member for use in the automobile in accordance with another embodiment of the present patent application, wherein the method in FIG. 4 is same as the process route 1a in FIG. 2 and includes, among other things, degreasing procedure, acid pickling procedure, electrolytic degreasing procedure, chemical burring procedure, etc. after the cutting procedure and before the electrogalvanizing procedure, but the method in FIG. 4 does not include heat treatment procedure after the electrogalvanizing procedure;

[0018] FIG. 5 shows a method for forming a member for use in the automobile in accordance with yet another embodiment of the present patent application, wherein the method in FIG. 5 is same as process route 2 in FIG. 2 and includes, among other things, shot blasting procedure, degreasing procedure, chemical burring procedure, etc. after the cutting procedure and before the electrogalvanizing procedure, and the method in FIG. 5 also includes heat treatment procedure after the electrogalvanizing procedure;

[0019] FIG. 6 shows a method for forming a member for use in the automobile in accordance with yet another embodiment of the present patent application, wherein the method in FIG. 6 is same as process route 2a in FIG. 2 and includes, among other things, shot blasting procedure, degreasing procedure, chemical burring procedure, etc. after the cutting procedure and before the electrogalvanizing procedure, but the method in FIG. 6 does not include heat treatment procedure after the electrogalvanizing procedure;

[0020] FIG. 7 shows a method for forming a member for use in the automobile in accordance with yet another embodiment of the present patent application, wherein the method in FIG. 7 is same as process route 3 in FIG. 2 and includes, among other things, shot blasting procedure, degreasing procedure, acid pickling procedure, electrolytic degreasing procedure, etc. after the cutting procedure and before the electrogalvanizing procedure, and the method in FIG. 7 also includes heat treatment procedure after the electrogalvanizing procedure;

[0021] FIG. 8 shows a method for forming a member for use in the automobile in accordance with yet another embodiment of the present patent application, wherein the method in FIG. 8 is same as process route 3a in FIG. 2 and includes, among other things, shot blasting procedure, degreasing procedure, acid pickling procedure, electrolytic degreasing procedure, etc. after cutting procedure and before the electrogalvanizing procedure, but the method in FIG. 8 does not include heat treatment procedure after the electrogalvanizing procedure;

[0022] FIG. 9 shows a sectional view of the tool/die in accordance with another embodiment of the present patent application, wherein FIG. 9 shows a heated die segment and a cooled die segment;

[0023] FIG. 10 shows a component in accordance with yet another embodiment of the present patent application, wherein the component includes two strength zones;

[0024] FIG. 11 shows a cross-sectional view of a portion of the member (for use in the automobile and under a microscope) formed using methods in accordance with an embodiment of the present patent application;

[0025] FIG. 12 shows a cross-sectional view of a portion of the member (under the microscope) formed using prior art methods in accordance with an embodiment of the present patent application; and

[0026] FIG. 13 shows a view of a member for use in an automobile formed using prior art methods.

DETAILED DESCRIPTION OF THE DRAWINGS

[0027] The present patent application provides a method (e.g., see methods 300-800 in FIGS. 3-8) for forming a member for use in an automobile. The automobile may be interchangeably referred to as a vehicle. The automobile or vehicle may include any type of passenger or commercial automobile/vehicle such as a car, a truck, a sport utility vehicle, a crossover vehicle, a van, a minivan, a taxi, a bus, etc. The member may interchangeably referred to a component or a part.

[0028] The method of the present patent application generally comprises providing uncoated steel to a furnace; heating the steel above its austenitization temperature; shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting the steel to further shape it; degreasing the shaped and cut steel; and electrogalvanizing a zinc-based layer to the degreased and shaped steel. As will be clear from the discussions below, the method may also include any combination of other procedures including, but not limited to, blanking, shot blasting, descaling, acid pickling, electrolytic degreasing, chemical deburring, post galvanizing heat treatment, etc.

[0029] The present patent application also provides a member 100 for use in an automobile. The member 100 for use in an automobile comprises a press-hardened steel structure 102 and a zinc-based layer 104. The press-hardened steel structure 102 is formed by heating uncoated steel 106 above its austenitization temperature and shaping the uncoated steel 106 while cooling it to obtain a desired shape and strength of the structure 102. The zinc-based layer 104 is disposed on the press-hardened and shaped steel structure 102. An interface 108 between the press-hardened/shaped steel structure 102 and the zinc-based layer 104 is devoid of an intermetallic diffusion layer and is devoid of partial or fully inter-crystalline phases.

[0030] In another embodiment, instead of heating the entire uncoated steel above its austenitization temperature, the method of the present patent application may include heating a first portion of the uncoated steel above its austenitization temperature and heating a second portion of the uncoated steel below its austenitization temperature.

[0031] The uncoated steel grades 22MnB5 and 37MnB5 may be heated in the furnace and the corresponding AC3 temperatures may be achieved in the furnace. The uncoated steel grades 22MnB5 and 37MnB5 may be heated by other heat sources (i.e., not in the furnace) and the corresponding AC3 temperatures may be achieved using other heat sources (not in the furnace). For example, the AC3 temperature range for the uncoated steel grade 22MnB5 may be in the range between 843 and 873 ^{0}C. The AC3 temperature range for the uncoated steel grade 37MnB5 may be in the range between 820 and 850 ^{0}C. The AC3 temperature range for the uncoated steel grade 37MnB5 may be lower than the AC3 temperature range for the uncoated steel grade 22MnB5.

[0032] If a person of ordinary skill in the art (POSITA) compares the zinc-based layer in the present patent application with the prior art ZnFe coated material (e.g., from VoestAlpine). Hot stamped Zn coated material of the prior art ends up as ZnFe coated components after the hot stamping procedure. The ZnFe coating of the prior art does not have an intermetallic layer like the AlSi coated parts but the ZnFe part of the prior art has a partial inter-crystalline phases as shown in FIG. 12. By contrast, the electro galvanized zinc-based layer coated part of the present patent application does not have this characteristic. That is, there are no partial or fully inter-crystalline phases in the electro galvanized zinc-based layer coated parts of the present patent application as shown in FIG. 11.

[0033] By contrast, the post galvanizing procedure of the present patent application does not have this characteristic (i.e., an interface between the press-hardened/shaped steel structure and the zinc-based layer is devoid of an intermetallic diffusion layer and is devoid of partial or fully inter-crystalline phases). This is because only the uncoated steel/material is heated in the furnace above its austenitization temperature. The heated uncoated steel/material is then shaped while cooling it to obtain a desired shape and strength of the structure. The zinc-based layer in the present patent application is applied after the heating and shaping and is disposed on the press-hardened and shaped steel structure (i.e., after the heating and shaping procedures). As the zinc-based layer in the present patent application does not undergo heating and/or shaping procedures along with the base/uncoated steel/material, an interface between the press-hardened/shaped steel structure and the zinc-based layer is devoid of an intermetallic diffusion layer. That is, the present patent application does not have an intermetallic/interdiffusion layer/zone because the zinc-based layer being applied after hot stamping/hot forming. Also, the zinc-based layer in the present patent application has no partial or full inter-crystalline phases or is devoid of partial or full inter-crystalline phases. This is due to the electro galvanic coating procedure (during which the zinc-based layer in the present patent application is formed) occurs at a much lower temperature. For example, under a microscope, the POSITA would readily be able to identify a difference between the material formed by the methods of the present patent application and the material formed by the prior art methods (using the pre-coated raw material) especially in the zone where the coating meets the base material. This can be seen by comparing the member of the present patent application in FIG. 11 with the member of the prior art shown in FIG. 12.

[0034] The present patent application relates to electrogalvanizing of hot forming/hot stamping parts or of the press hardening steel parts. The present patent application relates to an electrogalvanizing procedure that is performed post/after the press hardening procedure of the steel. In the present patent application, the uncoated (e.g., hardenable) steel is used as a raw material. The shaping procedure (i.e., shaping the steel while cooling it to provide the steel with the desired shape and strength) may be interchangeably referred to as press hardening procedure, hot stamping procedure or hot forming procedure.

[0035] After the press hardening procedure, the cutting procedure (i.e., cutting the steel to further shape it) and other surface treatment procedures (e.g., any combination of shot blasting procedure, degreasing procedure (i.e., degreasing the shaped and cut steel), acid pickling procedure, chemical deburring procedure, electrolytic degreasing procedure, etc.), an additional zinc-based surface layer is applied to the shaped uncoated steel part/component by electrogalvanizing. This additional surface layer may include Zinc (Zn) layer, Zinc alloy layer, or Zinc Nickel (ZnNi) layer. Electrogalvanizing the zinc-based layer to the degreased and shaped steel may be interchangeably referred to as electrogalvanizing procedure.

[0036] In one embodiment, the uncoated steel may include boron steel containing manganese. The uncoated steel may include 22MnB5 steel (uncoated ultra high-strength steel that is designed for the hot forming process), 34MnB5 steel (hot-rolled, uncoated steel that is easy to process into relatively complex shapes), etc. The 22MnB5 steel has the characteristics of high strength, good toughness and hardenability, low cost and the like, and is often used for automobile lightweight safety structure stamping parts, such as A columns, B columns, bumpers and the like. In another embodiment, the uncoated steel may include 17Mn B5, 26MnB5, etc.

[0037] In one embodiment, the final and fully zinc-based layer coated component/part (for use in the automobile) of the present patent application may include a high strength in the range between 1000 and 2000 Mega Pascal (MPa). In another embodiment, the final and fully zinc-based layer coated component/part (for use in the automobile) of the present patent application may include a strength in the range between 400 and 1000 MPa. That is, the final and fully zinc-based layer coated component/part of the present patent application may include a lower strength material (hardenable).

[0038] In yet another embodiment, as shown in FIG. 10, the final and fully zinc-based layer coated component/part (for use in the automobile) of the present patent application may include two strength zones. For example, as shown in FIG. 10, one of the two strength zones may have a strength in the range between 400 and 1000 MPa and the other/second of the two strength zones may have a strength in the range between 1000 and 2000 MPa. The strength zone, which has a strength in the range between 400 and 1000 MPa, may be referred to as partial soft zone. Parts or components with varying mechanical properties within a single piece may be achieved by controlled heating and/or cooling (tempering) rates. This allows for different areas of an uncoated steel part to exhibit different hardness, strength, or ductility characteristics. Such parts with different mechanical properties are referred to as having tailored tempered properties (TTP), and often referred to as tailor tempered parts.

[0039] In one embodiment, the final and fully zinc-based layer coated component/part may be used for body structural components of the automobile, including, A-Pillar, A-Pillar reinforcement member, side member, B-Pillar, B-Pillar reinforcement member, hinge pillar, roof rail member, header member, roof bow member, door ring member, double door ring member, front rail member, rear rail member, side reinforcement member, rocker rail member, rocker panel member, fire wall upper member, fire wall lower member, fire wall reinforcement member, tunnel member, tunnel reinforcement member, side impact beam front door member, side impact beam rear door member, etc.

[0040] In one embodiment, the final and fully zinc-based layer coated component/part may be used for body structural components of the automobile, including, standard Electric Vehicle (EV) specific components, Battery-powered Electric Vehicle (BEV) specific components, etc. For example, these EV or BEV specific components may include side member of battery tray, cross member of battery tray, Reinforcement of battery tray, corner reinforcement member, battery tray cover member, battery tray cover reinforcement member, etc.

[0041] The hot formed/stamped component/part (for use in the automobile) of the present patent application that are post coated with zinc-based layer (e.g., pure zinc coating layer or zinc-based coating layer) is configured to provide improved/increased corrosion performance compared to the current or conventional coatings (e.g., that are alloyed with ferrite including AlSi and ZnFe, or AlFe) that are precoated on the materials that are later hot stamped/formed. Thus, the present patent application provides increased corrosion resistance of the hot stamped automotive components.

[0042] Also, the final and fully zinc-based layer coated component/part (for use in the automobile) of the present patent application is configured to have improved weldability compared to the current or conventional coatings (e.g., including AlSi and ZnFe, or AlFe) that are precoated on materials that are later hot stamped/formed.

[0043] The final and fully zinc-based layer coated components/parts (for use in the automobile) of the present patent application may be configured to be welded using Resistance Spot Welding (RSW), projection welding, laser welding, Metal Active Gas (MAG) welding. The final and fully zinc-based layer coated components/parts (for use in the automobile) of the present patent application may be configured to be joined using thermal joining methods/procedures/processes.

[0044] In the present patent application, as the part/component is coated after it is formed/shaped, the part/component of the present patent application is completely coated including trim edges and hole edges.

[0045] The present patent application is configured to keep the microstructure in the form of a small grain size. If a small (fine) grain size is maintained, good hardness & strength may be achieved along with desirable ductility & toughness. The cooling rate, quench rate, and holding time in the press hardening tool do not have an effect on the above described characteristics. The longer the time of the blank in a heating furnace, the bigger the grain size is.

[0046] The methods 300-800 in FIGS. 3-8 may each begin with an uncoiling procedure that includes uncoiling an uncoated steel coil. A steel strip is uncoiled from the uncoated steel coil that may be subjected to cleaning, straightening, and passes over a looper, and a pinch roller into a blanking region.

[0047] The methods 300-800 in FIGS. 3-8 may each include a blanking procedure. The blanking procedure may be laser blanking that is performed by a laser system or on a traditional blanking press line. That is, the uncoated steel coil enters the blanking region, may be cut by a cutting head by way of the blanking process/procedure to form uncoated steel sheets with a required shape (e.g., with waste materials falling down and being conveyed to the outside). The methods 300-800 in FIGS. 3-8 may each include an outputting procedure that includes outputting the uncoated steel sheets. The uncoated steel sheets are received and conveyed by a conveyor, and then carried by means of a manipulator or a robot (e.g., with an external shaft) to a furnace, and then the uncoated steel sheets are placed into the furnace. This procedure may also be referred to as providing the uncoated steel to the furnace procedure.

[0048] In the furnace, the uncoated hardenable steel/raw material is first heated to above austenitization temperature. The uncoated steel is first heated to above the microstructure transformation temperature to an austenitic state, depending on the grade of steel. That is, the uncoated steel may be provided to the furnace in which the uncoated steel may be heated above its austenitization temperature. In one embodiment, the austenitization temperature may be in the range between 800 °C and 950 °C. In one embodiment, the austenitization temperature may be 930 °C.

[0049] The heating procedure (i.e., heating the steel above its austenitization temperature) is performed while providing a shielding gas. The atmosphere of the furnace may be expediently inerted by the addition of a shielding gas, in order to prevent scaling of the uncoated steel. Examples of suitable shielding gases include carbon dioxide and nitrogen. In one embodiment, the shielding gas is optional.

[0050] In another embodiment, an anti-scale coating may be used to prevent scaling on the uncoated steel. The anti-scale coating may interchangeably referred to as anti-scaling coating. The anti-scale coating may include an organic coating, a ceramic coating, a metallic coating, etc. The anti-scale coating only serves as a scale protection and can be removed during the shot blast procedure/process. One example of the anti-scaling coating may include Nano-X.

[0051] In one embodiment, the heating procedure (i.e., heating the steel above its austenitization temperature) is performed without providing a shielding gas. In such an embodiment, the uncoated steel/material may include an anti-scale coating to prevent scaling on the uncoated steel.

[0052] In one embodiment, the time at/above austenitization AC3 for the 22MnB5 steel (uncoated ultra high-strength steel that is designed for the hot forming process) is 843°C and 873°C and for the 34MnB5 steel (hot-rolled, uncoated steel that is easy to process into relatively complex shapes) is in the range between 820°C and 850°C. Below these temperatures, no recrystallization takes place.

[0053] After the heating procedure, the heated uncoated steel is shaped while cooling it to provide the uncoated steel with a desired shape and strength. That is, the heated uncoated steel is transferred immediately into a forming and cooling die to form/shape the steel the part/component to achieve the desired strength and shape while rapidly cooling down the uncoated steel to an ambient temperature. The hot forming, the hot shaping or the press hardening may be interchangeably used in this present patent application, they all refer to the procedure of shaping the uncoated steel while cooling it to provide the uncoated steel with the desired shape and strength.

[0054] The forming and cooling die may include a hot forming/hot stamping die set. The die set may include a lower die and an upper die. The lower die may include a die member. The lower die member may include a lower die surface and a plurality of cooling channels. As used herein, the term "die surface" refers to the portion of the exterior surface of a die that forms a hot formed/hot stamped component. Each cooling channel of the lower die member may be offset from the lower die surface. Similarly, the upper die may include a die member. The upper die member also includes an upper die surface and a plurality of cooling channels. Each cooling channel of the upper die member may be offset from the die surface. The die surfaces can cooperate to form a die cavity therebetween. For example, a hot forming/hot stamping die set is shown in and described in U.S. Patent No. 8,215,147, which is incorporated by reference herein in its entirety.

[0055] The heated uncoated steel can be placed in the die cavity between the die surfaces.

The lower and upper dies may be brought together (i.e., closed) in a die action direction via a conventional stamping press to deform the heated uncoated steel so as to form (and optionally trim) a hot-stamped/hot-formed component. Cooling fluid, such as water, gas or other fluid medium, which can be provided by a cooling system (e.g., a cooling system that conventionally includes a reservoir/chiller and a fluid pump) can be continuously circulated through the cooling channels to cool the lower and upper dies. It will be appreciated by a person of ordinary skill in the art that the circulating cooling fluids are configured to cool the lower and upper dies and that the lower and upper dies are configured to quench and cool the hot-stamped/hot-formed component. The stamping press is configured to maintain the lower and upper dies in a closed relationship for a predetermined amount of time to permit the hot-stamped component to be cooled to a desired temperature. The uncoated steel is thus shaped while it is being cooled to provide the uncoated steel with the desired shape and strength.

[0056] Hot stamped components that are heated to different temperatures to create both soft zones and relatively harder zones may be referred to as tailored tempered TTP. Components can have local areas of lower strength, where these can be achieved with different methods: 1) using a heated die section/segment that is heated with heating elements or electric cartridges to avoid martensite when quenching or 2) using a special furnace/heater technology so that a partial area of the blank does not get austenitized and thus not able to transform into martensite. FIG. 9 shows a sectional view of the tool/die with the heated die section/segment with heating elements or cartridges and cooled segment with cooling channels. The tool/die can provide zones with TTP using partial areas of heated blocks. Although the present patent application may refer the component as being "cooled", cooling in the present patent application may include heating but to a lower temperature or may be include heating but to a shorter time (e.g., how long the parts remain at the desired temperature). In one embodiment, the heating of some portions/areas and cooling of other portions/areas in the same component. In one embodiment, maintaining different portions/areas of the same component at different temperatures may be done with a Schwartz thermal printer.

[0057] The heat up time in the roller furnace may depend on the thickness of the sheet. In one embodiment, the heat up time in the roller furnace (i.e., to get to AC3 temperature) may take 150 seconds. In another embodiment, the heat up time in the roller furnace (i.e., to get to AC3 temperature) may take 200 seconds. In yet another embodiment, the heat up time in the roller furnace (i.e., to get to AC3 temperature) may take 250 seconds or even longer (e.g., if there are patches on the part). The hold time above AC3 for the phase transformation may be a minimum of 30 seconds. The typical holding temperature may be 900-930 ^{0}C. The transfer from the oven to the tool and tool closing to start quench may be between 3 and 8 seconds. The quench time in the tool is dependent on the material thickness. This may range between 3 and 20 seconds.

[0058] The Schwartz thermal printer may be configured to create tailored tempered uncoated steel components. The heating in the thermal printer may include local heating, that is, applying heat to specific/desired portions of the uncoated steel components. The heating in the thermal printer may be configured to achieve localized tempering of the uncoated steel components. The heating in the thermal printer may include laser heating, induction heating or heating using other energy sources that are configured to allow for precise control of their intensity and/or their area(s) of application. The thermal printer may be configured to apply thermal energy to targeted/localized/specific areas so as to temper these areas. The application of heat in these targeted/localized/specific areas may change hardness/brittleness of these targeted/localized/specific areas so as to increase ductility and toughness where needed. The application of heat in these targeted/localized/specific areas does not affect the overall structural integrity of the component.

[0059] The thermal printer may further include sensors and a processor. The processor may be connected to the sensors. The processor may also be configured to monitor and adjust the heating procedures continuously (e.g., in real-time) so as to ensure desired material properties can be achieved. The processor may be configured to adjust the intensity of the energy source, the duration of the energy source at a specific location and the spatial area of the energy source. The thermal printer may be configured to create areas with varying/different mechanical properties within a single component. The thermal printer may be configured to create a single components that have areas of high hardness and wear resistance and areas having ductile properties (e.g., configured to absorb impact).

[0060] The thermal printing/printer may be configured to create different temperature zones in the same blank/component. Different/various regions may be subjected to/undergo a selective localized heat treatment based on a differentiation of time-temperature curves. The component may include hard martensitic areas and soft zones. The thermal printing procedure may include small/narrow transition areas between the different hardness zones.

[0061] The method further comprises providing the uncoated steel to a furnace. The heating of first portion of the uncoated steel and the second portion of the uncoated steel are performed in the same furnace. The furnace may be a Schwartz thermal printer. The term "furnace" means anything that is constructed and arranged to heat the steel to a desired temperature for a desired time.

[0062] The press hardened, uncoated steel component/part may then be cut/trim to further shape it. The cutting/trimming of the press hardened uncoated part/component is carried out with the help of a laser cutting process (using a laser system) or the water jet cutting process (using a water jet system), by means of which high-quality trimming of the component/part edges may be achieved.

[0063] The electrogalvanizing reaction/procedure generally occurs on a chemically clean surface. A good quality zinc-based coating may be achieved based on the preparation of the underlying steel surface. That is, the steel surface on which the zinc-based layer is deposited/coated should be free of grease, dirt and scale before electrogalvanizing procedure. These types of contamination are removed by a variety of processes and common practice is to degrease first using an alkaline or acidic solution into which the component is dipped.

[0064] In one embodiment, the degreasing procedure may be performed using aqueous alkaline, and with no current. The degreasing procedure may be performed at a temperature in the range between 60 and 90 °C.

[0065] After hot stamping/forming, scale(s) on surface(s) of the shaped uncoated steel part/component are removed by either shotblasting or chemical descaling. The scales may include hot stamping/forming scales that are formed during the hot stamping/forming process.

The shot blasting is a mechanical process/procedure to remove the hot stamping/forming scales, while chemical descaling is a chemical process/procedure to remove the hot stamping/forming scales. Although FIG. 2 shows using shot blasting procedure to remove the hot stamping/forming scales in the process routes 2, 2a, 3 and 3a, the shot blasting procedure in the process routes 2, 2a, 3 and 3a of FIG. 2 may be replaced with chemical descaling procedure.

[0066] As shown in the process routes 2, 2a, 3 and 3a of FIG. 2, the shaped and cut uncoated steel component/part may be shot blasted to remove scales, any debris or any irregularities from a surface of the hot shaped/formed uncoated steel. The shot blasting procedure is performed after the (laser) cutting procedure and before the degreasing procedure. Shot blasting procedure is a resurfacing process that is used to remove scales, any debris or any irregularities from the surface. The shot blasting process may use a centrifugal blast wheel that shoots media, which varies from steel shot to cut wire to nut shells, onto the surface at high velocity. This knocks the surface free of scales, debris, irregularities or other material. The media loads into a hopper that feeds the blast wheel. The media can blast off the hot stamping/forming scales, debris, irregularities or other material.

[0067] Chemical descaling includes a resurfacing process that is used to remove scales, any debris or any irregularities from the surface of the hot shaped/formed uncoated steel. Removing scales via chemical methods may be generally very thorough. There are several different acidic solutions that may be commonly used to remove scales. Typically, these solutions may be heated to improve quality and efficiency. Regardless of the chemical process being used, the chemical bath's temperature and concentrations may be carefully monitored and controlled by a controller.

[0068] Pretreatment (i.e., before the electrogalvanizing procedure) may include chemical deburring, acid pickling, neutral pickling, or near neutral pickling. For example, the process routes 1 and 1a in FIG. 2 (and also the methods 300 in FIG. 3 and 400 in FIG. 4) use both chemical deburring and acid pickling as the pretreatment procedures (i.e., before the electrogalvanizing procedure), while the process routes 2 and 2a in FIG. 2 (and also the methods 500 in FIG. 5 and 600 in FIG. 6) use just chemical deburring as the pretreatment procedure (i.e., before the electrogalvanizing procedure) and the process routes 3 and 3a in FIG. 2 (and also the methods 700 in FIG. 7 and 800 in FIG. 8) use just acid pickling as the pretreatment procedure (i.e., before the electrogalvanizing procedure). In another embodiment, other pretreatment procedures may be used before the electrogalvanizing procedure.

[0069] Chemical deburring is a process/procedure where burrs and scratches are removed from the surface of the uncoated steel shaped part/component. The part/component may be immersed in a bath to provide a more even exposure of the uncoated steel shaped part/component. The exposure time in the bath may be in the range of approximately 1 minute to approximately 10 minutes at ambient temperature. The material removal during the chemical deburring may be by electrochemical processes.

[0070] Acid pickling is performed on the surfaces of the shaped uncoated steel part/component to remove impurities and prepare the part/component for further processing, including the electrogalvanizing. The acid pickling procedure may be performed after the degreasing procedure and may be performed before the electrogalvanizing procedure.

[0071] For example, various chemical solutions are usually used to clean these impurities from the surfaces of the shaped uncoated steel part/component. Strong acids, such as hydrochloric acid and sulfuric acid may be used, but different applications use various other acids. Also, alkaline solutions may be used for cleaning the surfaces of the shaped uncoated steel part/component. Solutions may usually also contain additives such as wetting agents and corrosion inhibitors. The wetting agents and corrosion inhibitors are optional.

[0072] Referring to the process routes 1 and 1a in FIG. 2 (and also the methods 300 in FIG. 3 and 400 in FIG. 4) in which there is no descaling procedure (e.g., shot blasting or chemical descaling), acid pickling may be referred to as acid cleaning procedure as the acid pickling procedure in the process routes 1 and 1a of FIG. 2 (and also the methods 300 in FIG. 3 and 400 in FIG. 4) is configured to remove both the impurities and the hot forming/stamping scales.

[0073] Referring to the process routes 1 and 1a (and also the methods 300 in FIG. 3 and 400 in FIG. 4) and the process routes 3 and 3a in FIG. 2 (and also the methods 700 in FIG. 7 and 800 in FIG. 8), the acid pickling procedure is generally followed by electrolytic degreasing procedure. That is, the electrolytic degreasing procedure is performed after the acid pickling procedure and before the electrogalvanizing procedure. Acid pickling is configured to remove oxides and/or dirt (e.g., that are difficult to remove) and degreasing is configured to remove oils, grease and/or other lubrications.

[0074] The electrolytic degreasing procedure may be performed using alkaline, anodic current polarization. The electrolytic degreasing procedure may be performed at a temperature in the range between 40 and 60 °C. The electrolytic degreasing procedure may be performed for a duration of minimum 3 minutes.

[0075] The electrolytic degreasing procedure may interchangeable with an ultrasonic degreasing procedure. The ultrasonic degreasing procedure may be performed at a temperature in the range between 20 and 70°C. The ultrasonic degreasing procedure may be performed for a duration of maximum of 4 minutes.

[0076] The methods 300-800 in FIGS. 3-8 or the process routes 1, 1a, 2, 2a, 3, and 3a may include a deoxidation procedure that may be performed after the electrolytic degreasing procedure or the ultrasonic degreasing procedure and that may be performed before electrogalvanizing procedure. The deoxidation procedure may use H_2SO_4 (mass portion of maximum 5%). The deoxidation procedure may be performed for a duration of maximum of 30 seconds. The deoxidation procedure may be optional.

[0077] Chemical deburring procedure is configured to remove imperfections or burrs from the surface of the degreased and shaped uncoated steel. In the chemical deburring procedure, shaped uncoated part/component is immersed in a solution and left in it until the burr on the component/part has dissolved. The chemical deburring procedure may be suitable for small parts or parts with internal burrs.

[0078] As shown in the process routes 1 and 1a (and also the methods 300 in FIG. 3 and 400 in FIG. 4) and 2 and 2a of FIG. 2 (and also the methods 500 in FIG. 5 and 600 in FIG. 6), the chemical deburring procedure is performed after the degreasing procedure and performed before the electrogalvanizing procedure. For example, as shown in the process routes 1 and 1a of FIG. 2 (and also the methods 300 in FIG. 3 and 400 in FIG. 4), the chemical deburring procedure is performed after the degreasing procedure, the acid pickling procedure, and the electrolytic degreasing procedure and the chemical deburring procedure is performed before the electrogalvanizing procedure. As shown in the process routes 2 and 2a of FIG. 2 (and also the methods 500 in FIG. 5 and 600 in FIG. 6), the chemical deburring procedure is performed after the shot blasting procedure and the degreasing procedure and the chemical deburring procedure is performed before the electrogalvanizing procedure.

[0079] After descaling of the hot stamped/formed scales and after pretreatment procedures of the surface, an additional zinc-based surface layer is applied to the shaped uncoated steel part/component by electrogalvanizing. The additional zinc-based surface layer may be interchangeably referred to as a zinc-based coating.

[0080] That is, when the cleaned, shaped uncoated steel component is dipped into the molten zinc (e.g., commonly at around 450 °C), a series of zinc-iron alloy layers are formed on the uncoated steel component by a metallurgical reaction between the iron and zinc. The rate of reaction between the steel and the zinc is generally parabolic with time and so the initial rate of reaction is very rapid. The main thickness of the zinc-based layer is formed during this period. Subsequently, the reaction slows down and the thickness of the zinc-based layer is not increased significantly even if the component/part is in the bath for a longer period of time.

[0081] The electrogalvanizing procedure may use cyanide-free alkaline material. The electrogalvanizing procedure may be performed for a duration of maximum of 90 minutes. The electrogalvanizing procedure may be performed with a current density in the range of 1 – 4 A/dm^2 (e.g., depending on Zinc – coating thickness area).

[0082] The coating or additional surface layer may include Zinc (Zn) layer, Zn based layer, Zn alloy layer, or Zinc Nickel (ZnNi) layer. In one embodiment, the thickness range of zinc coating may vary between 0.005 millimeters (mm) and 0.02mm (e.g., in certain areas).

[0083] The coating is configured to be compatible with typical automotive adhesives and sealants. The coating is configured to be compatible with all painting systems such as electro coating (or e-coat). E-coating is generally known as an immersion wet paint finishing process that uses electrical current to attract the paint product to a metal surface (e.g., zinc-based coating layer of the present patent application). This e-coating process may also be referred to as paint deposition.

[0084] In one embodiment, an additional passivation layer may be applied/coated on top of the zinc coating. Passivation is generally known and used metal finishing process to prevent corrosion. The passivation process may use nitric acid or citric acid to remove free iron from the surface. This chemical treatment leads to a protective oxide layer, or passivation film, that is less likely to chemically react with air and cause corrosion. The additional passivation layer may be optional.

[0085] In one embodiment, the post galvanizing process treatment procedures may include quenching into water or air cooling. In one embodiment, the post galvanizing process treatment procedures may include a brighten procedure, a drying procedure, etc. For example, the methods 300-800 in FIGS. 3-8 may include brighten procedure performed after the electrogalvanizing procedure. The brighten procedure may use HNO_3 (mass portion of maximum 5%). The brighten procedure may be performed for a duration of maximum of 120 seconds. The brighten procedure may be optional. Also, the methods 300-800 in FIGS. 3-8 may include a drying procedure performed after the electrogalvanizing procedure and the brighten procedure. The drying procedure may be performed at a temperature in the range between 60 and 100 °C. The drying procedure may be performed for a duration of maximum time of 15 minutes. The brighten procedure may be optional. The post galvanizing process treatment procedures may be optional.

[0086] The methods 300-800 in FIGS. 3-8 may include applying corrosion protection oils to the product/component. The corrosion protection oils may include anticorit RP4107S (e.g., from Fuchs) or avilub Metacorin 30850 (e.g., from Bantleon). The anticorit RP4107S is a thixotropic corrosion preventative. The corrosion protection oils may have a mass per unit area in the range of between 1.2 and 3.0 g/m^2 distributed evenly over entire component/part. Oil accumulations or oil pockets may not be permissible.

[0087] After the electrogalvanizing procedure, the coated steel component/part may further be heat treated. This heat treatment procedure may be referred to as post galvanizing heat treatment procedure as the heat treatment procedure is performed after the electrogalvanizing procedure. Hydrogen gas may be introduced into the component/part during some procedures such as the press hardening procedure, the electrogalvanizing procedure, the acid pickling procedure, etc. Leaving the hydrogen gas in the component/part may cause ductility issues, cracks, hydrogen embrittlement, etc. The heat treatment procedure is configured to remove the introduced hydrogen gas (e.g., during some of the above-noted processes) out of the component/part.

[0088] The heat treatment procedure may have a temperature that may range between 150 and 250 ^{0}C. The heat treatment procedure may be performed for a predetermined time that may range between 30 and 720 minutes.

[0089] Referring to FIG. 2, the present patent application provides the process routes 1, 1a, 2, 2a, 3, and 3a. For example, the process route 1 in FIG. 2 corresponds to a method 300 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 3, the process route 1a in FIG. 2 corresponds to a method 400 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 4, the process route 2 in FIG. 2 corresponds to a method 500 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 5, the process route 2a in FIG. 2 corresponds to a method 600 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 6, the process route 3 in FIG. 2 corresponds to a method 700 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 7, and the process route 3a in FIG. 2 corresponds to a method 800 for forming a member (e.g., see member 100 in FIG. 1) for use in the automobile in FIG. 8. Each of these process routes will be described with respect to the corresponding methods 300-800 in FIGS. 3-8.

[0090] Referring to FIG. 3, the method 300 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; degreasing the shaped and cut steel; acid pickling the degreased and shaped steel (e.g., to remove impurities from the surface of the degreased and shaped steel); electrolytic degreasing the shaped steel; chemical deburring the degreased and shaped steel (e.g., to remove imperfections or burrs from the surface of the degreased and shaped steel); electrogalvanizing a zinc-based layer on the degreased and shaped steel; and heat treating the electrogalvanized zinc-based layer coated and shaped steel

[0091] Referring to FIG. 4, the method 400 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; degreasing the shaped and cut steel; acid pickling the degreased and shaped steel (e.g., to remove impurities from the surface of the degreased and shaped steel); electrolytic degreasing the shaped steel; chemical deburring the degreased and shaped steel (e.g., to remove imperfections or burrs from the surface of the degreased and shaped steel); and electrogalvanizing a zinc-based layer on the degreased and shaped steel. The process routes 1 (or the method 300) and 1a (or the method 400) are very similar except for the post galvanizing heat treatment in the process route 1 (or the method 300). That is, the process route 1a (or the method 400) does not include the post galvanizing heat treatment.

[0092] Referring to FIG. 5, the method 500 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; shot blasting to remove scales from a surface of the shaped and cut steel; degreasing the shaped steel; chemical deburring the degreased and shaped steel (e.g., to remove imperfections or burrs from a surface of the degreased and shaped steel); electrogalvanizing a zinc-based layer on the degreased and shaped steel; and heat treating the electrogalvanized zinc-based layer coated and shaped steel.

[0093] Referring to FIG. 6, the method 600 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; shot blasting to remove scales from a surface of the shaped and cut steel; degreasing the shaped steel; chemical deburring the degreased and shaped steel (e.g., to remove imperfections or burrs from a surface of the degreased and shaped steel); and electrogalvanizing a zinc-based layer on the degreased and shaped steel. The process routes 2 (or the method 500) and 2a (or the method 600) are very similar except for the post galvanizing heat treatment in the process route 2 (or the method 500). That is, the process route 2a (or the method 600) does not include the post galvanizing heat treatment.

[0094] Referring to FIG. 7, the method 700 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; shot blasting to remove scales from a surface of the shaped and cut steel; degreasing the shaped and cut steel; acid pickling the degreased and shaped steel (e.g., to remove impurities from the surface of the degreased and shaped steel); electrolytic degreasing the shaped steel; electrogalvanizing a zinc-based layer on the degreased and shaped steel; and heat treating the electrogalvanized zinc-based layer coated and shaped steel.

[0095] Referring to FIG. 8, the method 800 includes blanking a sheet of uncoated steel (i.e., before it is provided to a furnace); providing uncoated steel to a furnace; heating the steel above its austenitization temperature (e.g., with or without the shielding gas); shaping the steel while cooling it to provide the steel with a desired shape and strength; cutting (e.g., laser cutting) the steel to further shape it; shot blasting to remove scales from a surface of the shaped and cut steel; degreasing the shaped and cut steel; acid pickling the degreased and shaped steel (e.g., to remove impurities from the surface of the degreased and shaped steel); electrolytic degreasing the shaped steel; and electrogalvanizing a zinc-based layer on the degreased and shaped steel. The process routes 3 (or the method 700) and 3a (or the method 800) are very similar except for the post galvanizing heat treatment in the process route 3 (or the method 700). That is, the process route 3a (or the method 800) does not include the post galvanizing heat treatment.

[0096] The methods 300-800 in FIGS. 3-8 may include other procedures such as die polishing procedure for reducing the scoring (scratches) on the components/parts. The methods 300-800 in FIGS. 3-8 may include chemical deburring procedure and anti-scale coating (e.g., nano-X) application procedure for reducing the scoring (scratches) on the components.

[0097] Uncoated material may typically cause high abrasion on the forming (or press-hardening) tool due to scale(s) on the surface of the uncoated material sheet. That is, the die wear (tool wear) is higher for the uncoated material than that of AlSi coated material. Because the electrogalvanizing procedure is sensitive to scratches on the finished product, additional tool maintenance and additional polishing of the forming sections may need to be performed to try and reduce the scratches. If a forming tool would typically be polished every 4000 strokes, in the case of electrogalvanizing, the forming tool may need to be polished for every 1000 to 2000 strokes.

[0098] The present patent application and its various embodiments as described above uniquely address the observed, noted and researched findings and improve on the prior and current state of the art systems. The listed products, features and embodiments as described in the present patent application should not be considered as limiting in any way.

[0099] Although the present patent application has been described in detail for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that the present patent application is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements that are within the spirit and scope of the appended claims. In addition, it is to be understood that the present patent application contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

[00100] The illustration of the embodiments of the present patent application should not be taken as restrictive in any way since a myriad of configurations and methods utilizing the present patent application can be realized from what has been disclosed or revealed in the present patent application. The systems, features and embodiments described in the present patent application should not be considered as limiting in any way. The illustrations are representative of possible construction and mechanical embodiments and methods to obtain the desired features. The location and/or the form of any minor design detail or the material specified in the present patent application can be changed and doing so will not be considered new material since the present patent application covers those executions in the broadest form.

[00101] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an,” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[00102] When an element or layer is referred to as being "on," "engaged to," "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[00103] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[00104] Terms of degree such as "generally," "substantially," "approximately," and "about" may be used herein when describing the relative positions, sizes, dimensions, or values of various elements, components, regions, layers and/or sections. These terms mean that such relative positions, sizes, dimensions, or values are within the defined range or comparison (e.g., equal or close to equal) with sufficient precision as would be understood by one of ordinary skill in the art in the context of the various elements, components, regions, layers and/or sections being described.

[00105] The foregoing illustrated embodiments have been provided to illustrate the structural and functional principles of the present patent application and are not intended to be limiting. To the contrary, the present patent application is intended to encompass all modifications, alterations and substitutions within the spirit and scope of the appended claims.

What is claimed is:

1. A method for forming a member for use in an automobile, comprising:

heating uncoated steel above its austenitization temperature;

shaping the steel while cooling it to provide the steel with a desired shape and strength of the member;

cutting the steel to further shape it;

degreasing the shaped and cut steel; and

electrogalvanizing a zinc-based layer on the degreased and shaped steel.

2. The method of claim 1, wherein the heating includes heating the steel above its austenitization temperature while providing a shielding gas.

3. The method of claim 1, wherein the uncoated steel includes an anti-scale coating, and wherein heating the steel above its austenitization temperature without providing a shielding gas.

4. The method of claim 1, wherein the cutting the steel comprises laser cutting.

5. The method of claim 1, further comprises providing the uncoated to a furnace and blanking a sheet of the uncoated steel before it is provided to the furnace.

6. The method of claim 1, further comprises acid pickling to remove impurities from a surface of the degreased and shaped steel,

wherein the acid pickling is performed after the degreasing and before the electrogalvanizing.

7. The method of claim 6, further comprises electrolytic degreasing,

wherein the electrolytic degreasing is performed after the acid pickling and before the electrogalvanizing.

8. The method of claim 7, further comprises chemical deburring to remove imperfections or burrs from a surface of the degreased and shaped steel,

wherein the chemical deburring is performed after the electrolytic degreasing and before the electrogalvanizing.

9. The method of claim 1, further comprising shot blasting to remove scales from a surface of the shaped and cut steel,

wherein the shot blasting is performed after the cutting and before the degreasing.

10. The method of claim 1, further comprises chemical deburring to remove imperfections or burrs from a surface of the degreased and shaped steel,

wherein the chemical deburring is performed after the degreasing and before the electrogalvanizing.

11. The method of claim 1, further comprises heat treating the electrogalvanized zinc-based layer coated and shaped steel,

wherein the heat treatment is performed after the electrogalvanizing.

12. The method of claim 1, wherein the desired strength is in the range between 1000 and 2000 MPa.

13. The method of claim 1, wherein the desired strength is in the range between 400 and 1000 MPa.

14. The method of claim 1, wherein the thickness of the zinc-based layer is in the range between 0.005 and 0.02 mm.

15. The method of claim 1, wherein the zinc-based layer comprises a pure zinc layer, a zinc alloy layer, or a zinc-nickel layer.

16. The method of claim 1, further comprises depositing an additional passivation layer on top of the zinc-based layer.

17. The method of claim 1, wherein the zinc-based layer is configured to be welded using Resistance Spot Welding (RSW), projection welding, laser welding, or Metal Active Gas (MAG) welding.

18. The method of claim 1, wherein the zinc-based layer is configured to be compatible with automotive sealants, automotive adhesives, and automotive painting systems.

19. A member for use in an automobile, comprising:

a press-hardened steel structure formed by heating uncoated steel above its austenitization temperature and shaping the uncoated steel while cooling it to obtain a desired shape and strength of the structure; and

a zinc-based layer disposed on the press-hardened and shaped steel structure;

wherein an interface between the press-hardened/shaped steel structure and the zinc-based layer is devoid of an intermetallic diffusion layer and is devoid of partial or fully inter-crystalline phases.

20. A method for forming a member for use in an automobile, comprising:

heating a first portion of uncoated steel above its austenitization temperature and heating a second portion of the uncoated steel below its austenitization temperature;

shaping the steel while cooling it to provide the steel with a desired shape and strength of the member;

cutting the steel to further shape it;

degreasing the shaped and cut steel; and

electrogalvanizing a zinc-based layer on the degreased and shaped steel.

21. The method of claim 20, further comprising providing the uncoated steel to a furnace;

wherein the heating of first portion of the uncoated steel and the second portion of the uncoated steel are performed in the same furnace.

22. The method of claim 21, wherein the furnace is a Schwartz thermal printer.

23. The method of claim 20, wherein the desired strength of one of the first portion or the second portion is in the range between 1000 and 2000 MPa.

24. The method of claim 23, wherein the desired strength of the other of the first portion or the second portion is in the range between 400 and 1000 MPa.

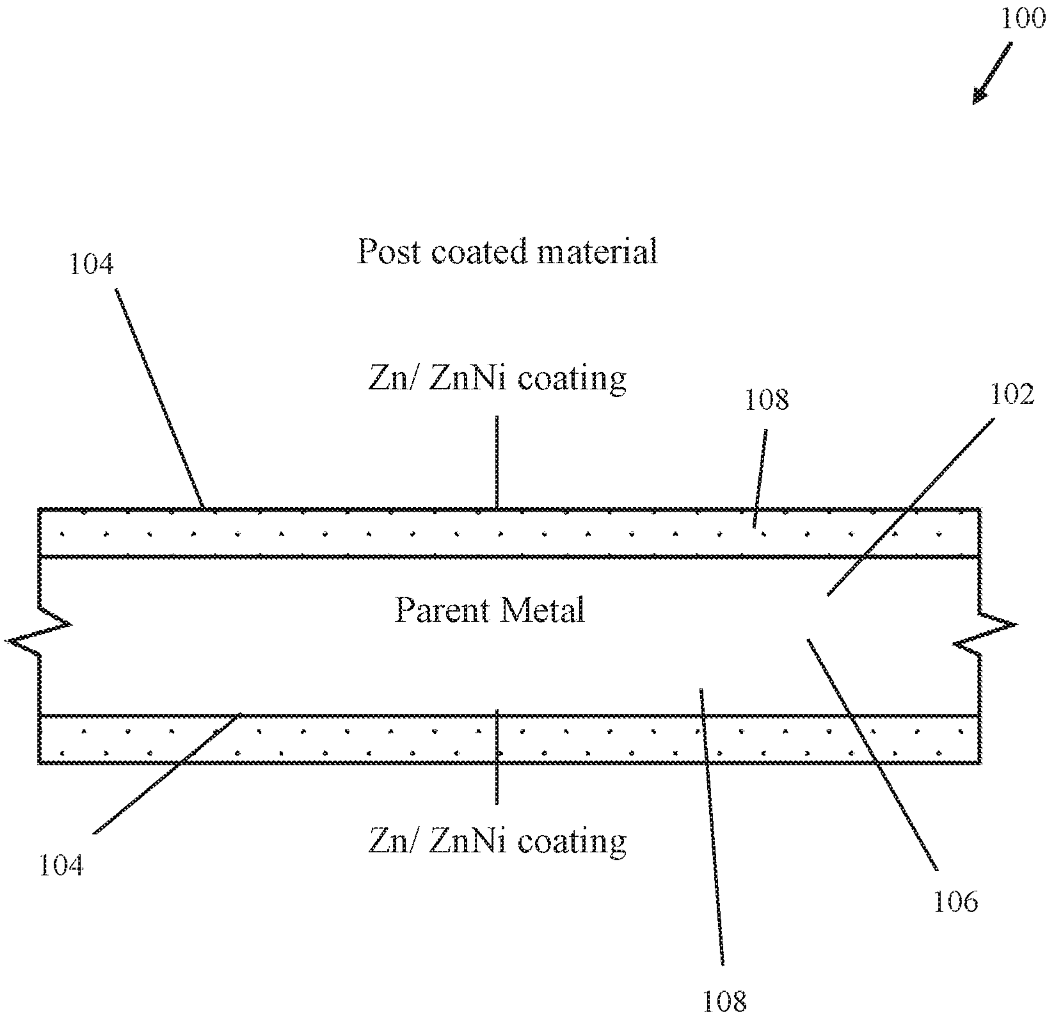

100
104
Post coated material
Zn/ ZnNi coating
108
102
Parent Metal
104
Zn/ ZnNi coating
106
108

FIG. 1

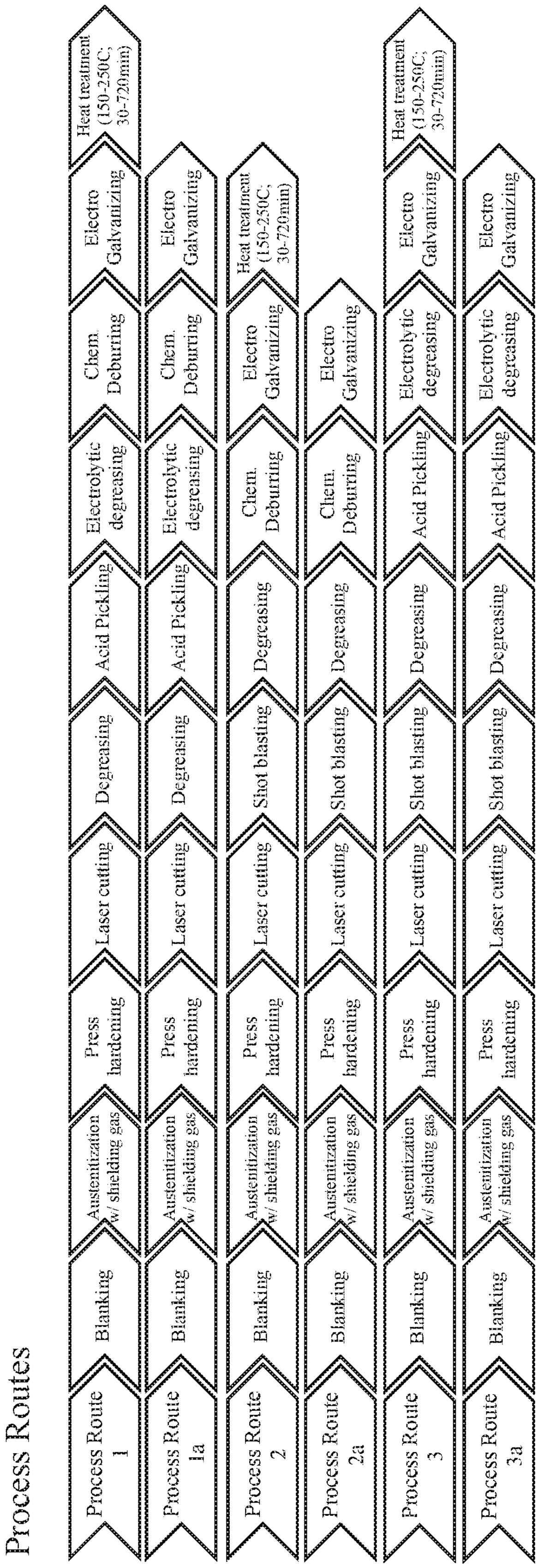

Process Routes
Process Route 1
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Degreasing
Acid Pickling
Electrolytic degreasing
Chem. Deburring
Electro Galvanizing
Heat treatment (150-250C; 30-720min)
Process Route 1a
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Degreasing
Acid Pickling
Electrolytic degreasing
Chem. Deburring
Electro Galvanizing
Process Route 2
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Shot blasting
Degreasing
Chem. Deburring
Electro Galvanizing
Heat treatment (150-250C; 30-720min)
Process Route 2a
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Shot blasting
Degreasing
Chem. Deburring
Electro Galvanizing
Process Route 3
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Shot blasting
Degreasing
Acid Pickling
Electrolytic degreasing
Electro Galvanizing
Heat treatment (150-250C; 30-720min)
Process Route 3a
Blanking
Austenitization w/ shielding gas
Press hardening
Laser cutting
Shot blasting
Degreasing
Acid Pickling
Electrolytic degreasing
Electro Galvanizing

FIG. 2

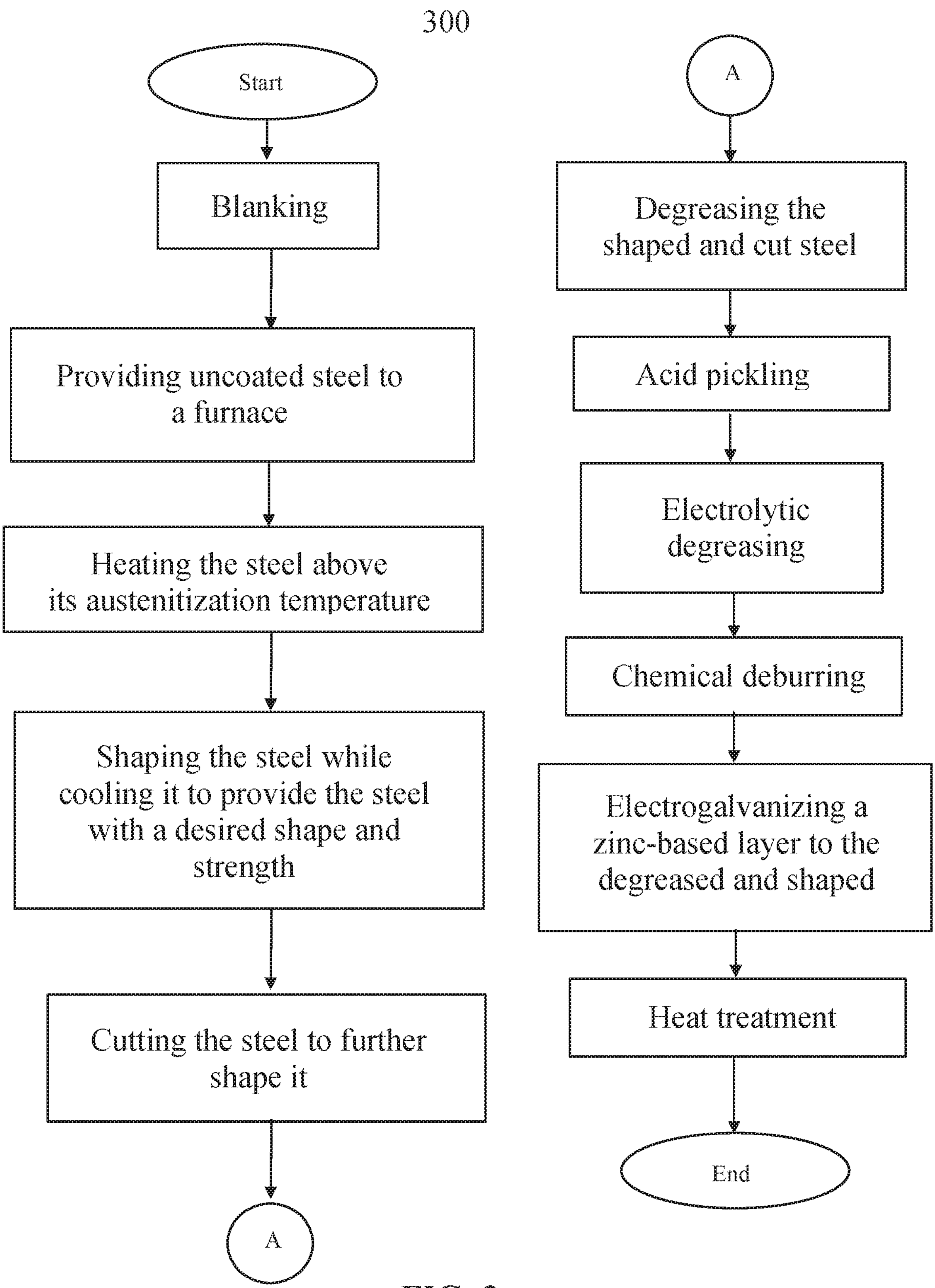

300
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
A
A
Degreasing the shaped and cut steel
Acid pickling
Electrolytic degreasing
Chemical deburring
Electrogalvanizing a zinc-based layer to the degreased and shaped
Heat treatment
End

FIG. 3

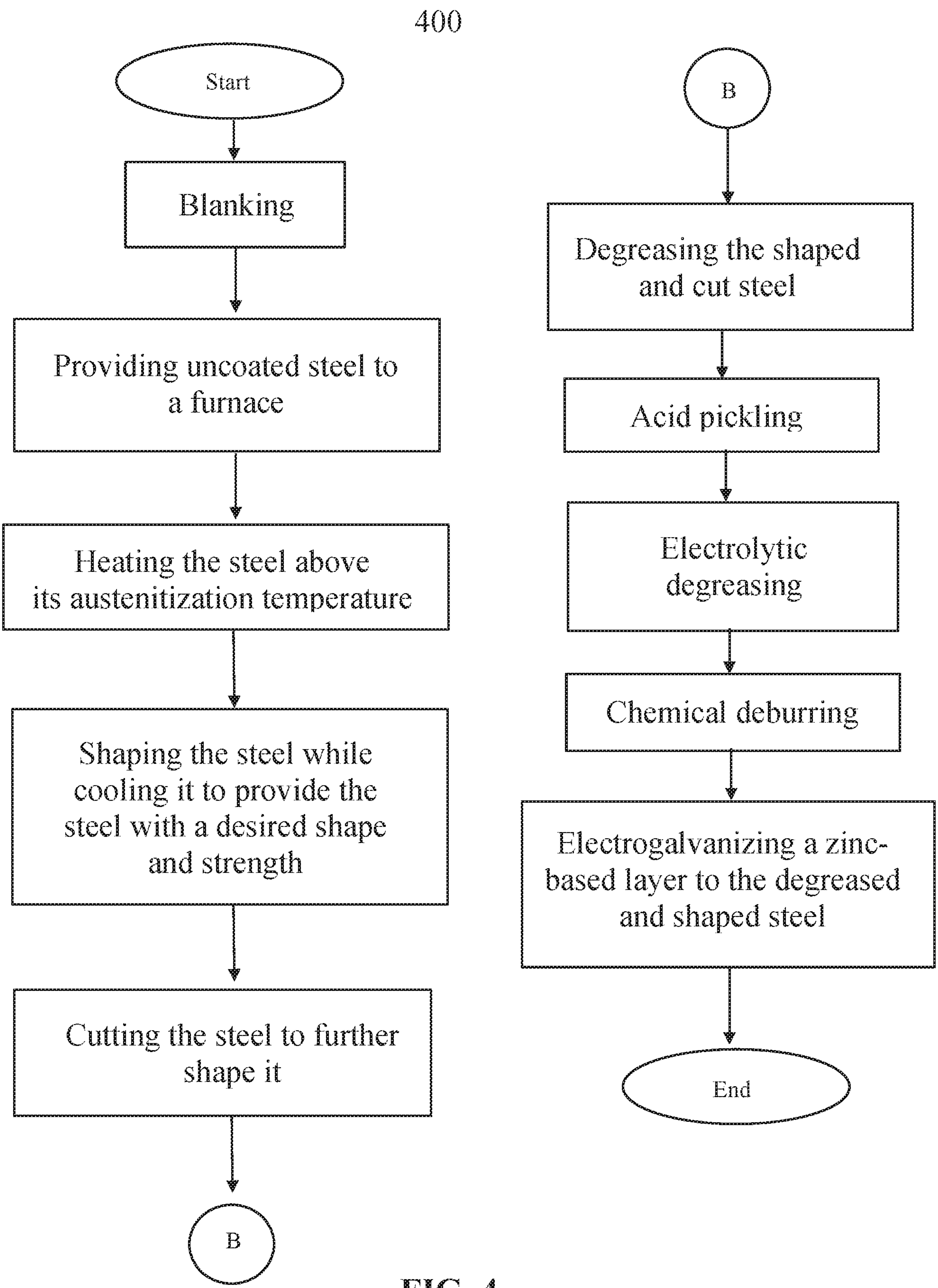

400
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
B
B
Degreasing the shaped and cut steel
Acid pickling
Electrolytic degreasing
Chemical deburring
Electrogalvanizing a zinc-based layer to the degreased and shaped steel
End

FIG. 4

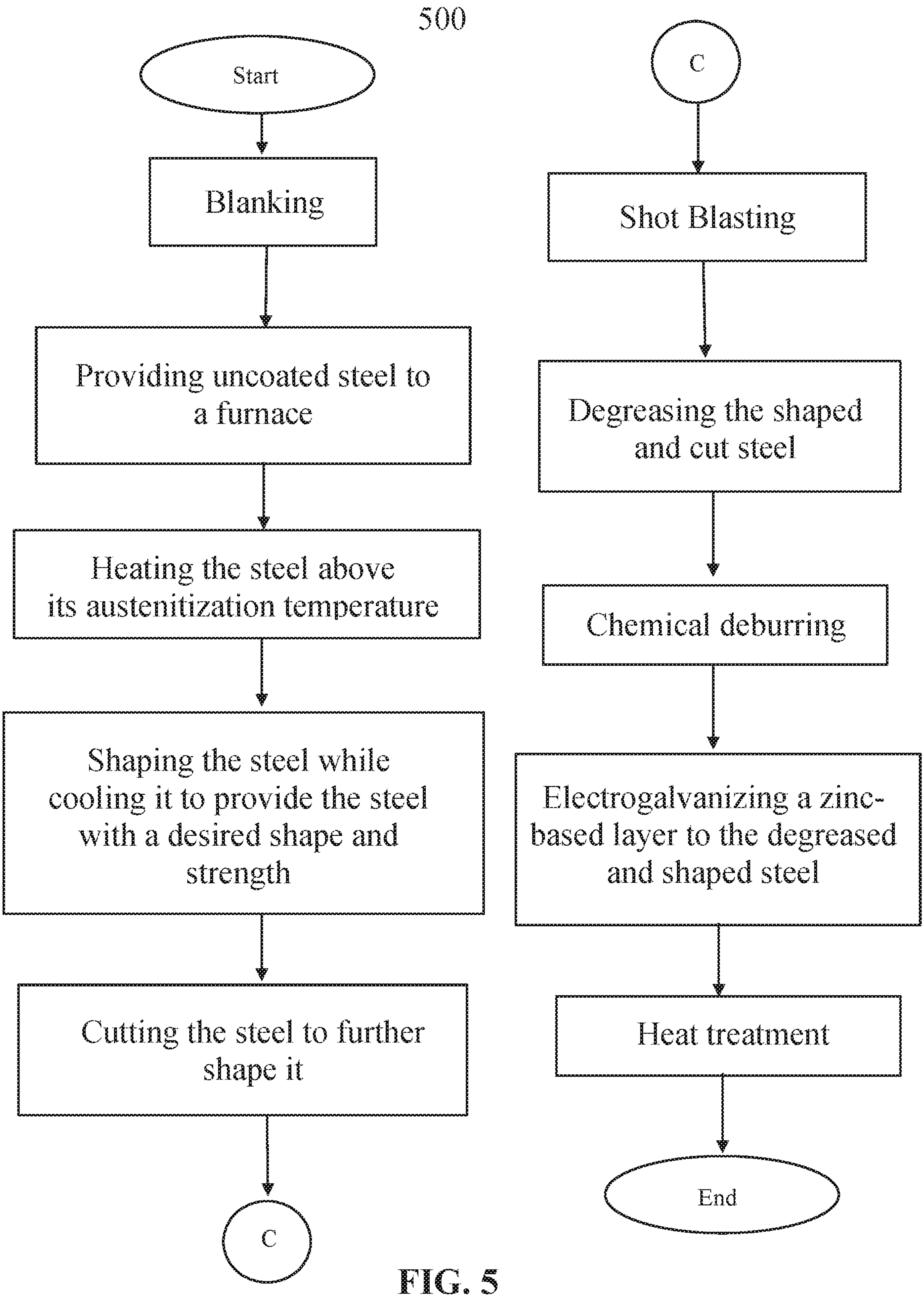

500
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
C
C
Shot Blasting
Degreasing the shaped and cut steel
Chemical deburring
Electrogalvanizing a zinc-based layer to the degreased and shaped steel
Heat treatment
End

FIG. 5

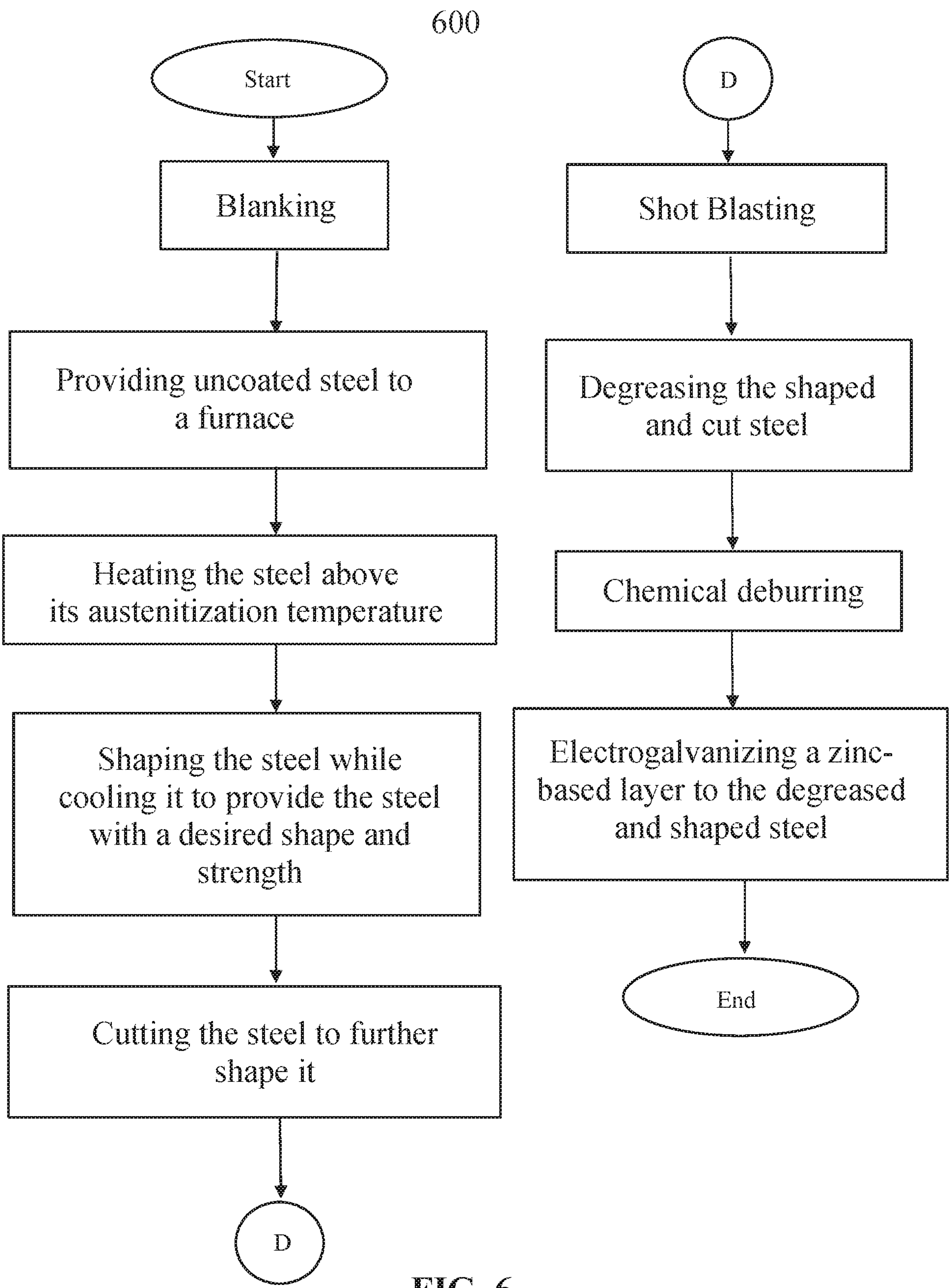

600
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
D
D
Shot Blasting
Degreasing the shaped and cut steel
Chemical deburring
Electrogalvanizing a zinc-based layer to the degreased and shaped steel
End

FIG. 6

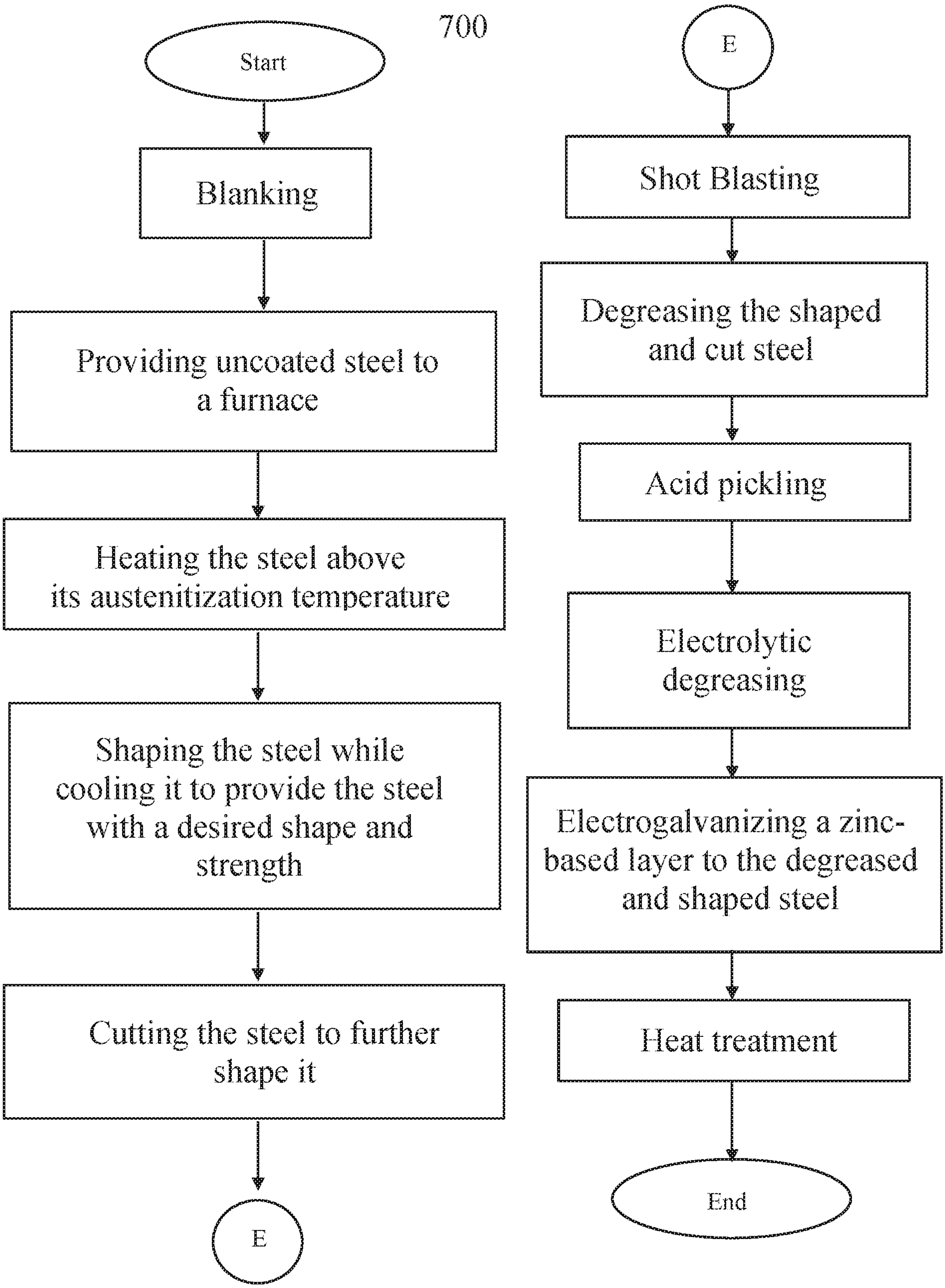

700
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
E
E
Shot Blasting
Degreasing the shaped and cut steel
Acid pickling
Electrolytic degreasing
Electrogalvanizing a zinc-based layer to the degreased and shaped steel
Heat treatment
End

FIG. 7

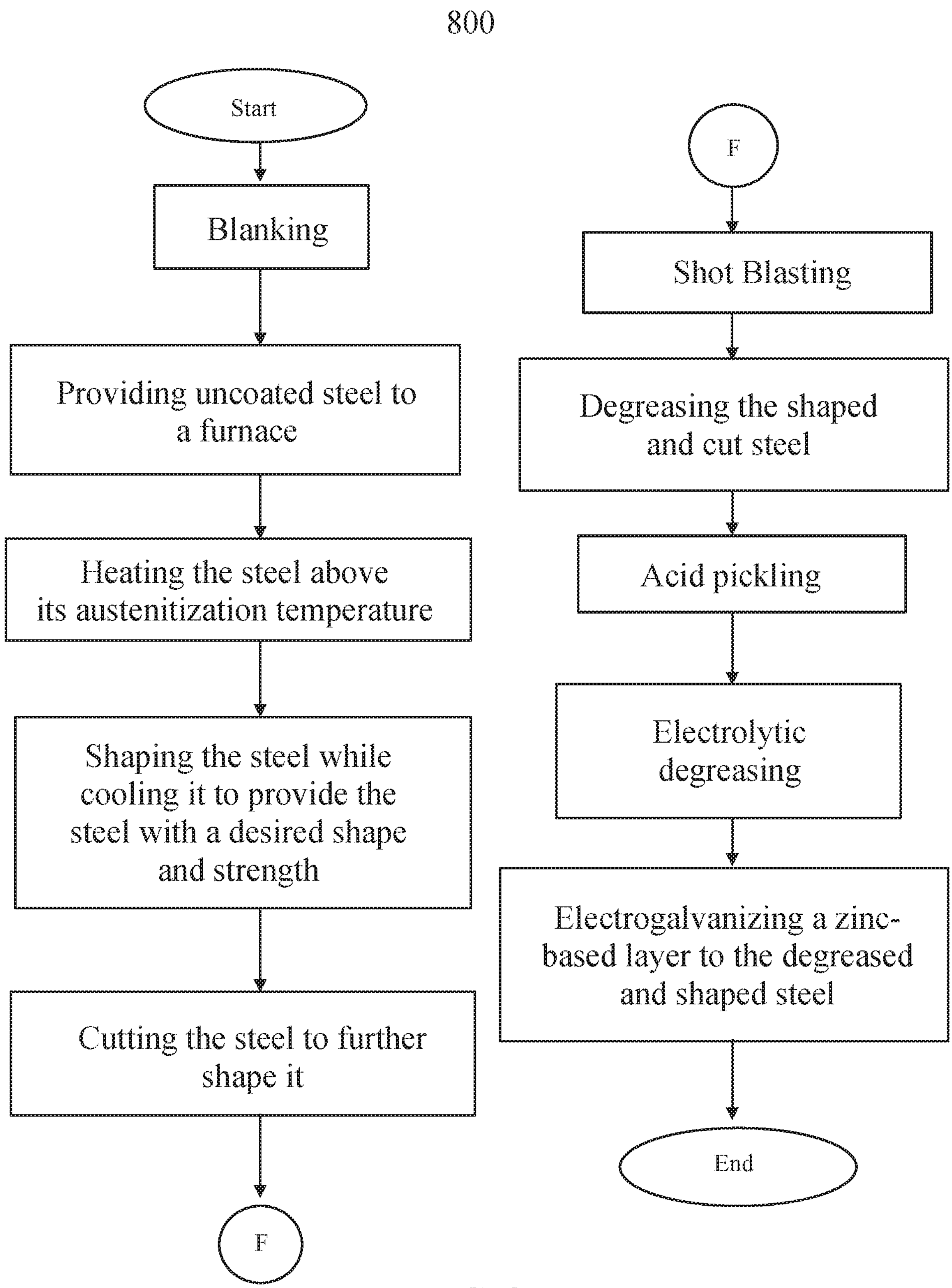

800
Start
Blanking
Providing uncoated steel to a furnace
Heating the steel above its austenitization temperature
Shaping the steel while cooling it to provide the steel with a desired shape and strength
Cutting the steel to further shape it
F
F
Shot Blasting
Degreasing the shaped and cut steel
Acid pickling
Electrolytic degreasing
Electrogalvanizing a zinc-based layer to the degreased and shaped steel
End

FIG. 8

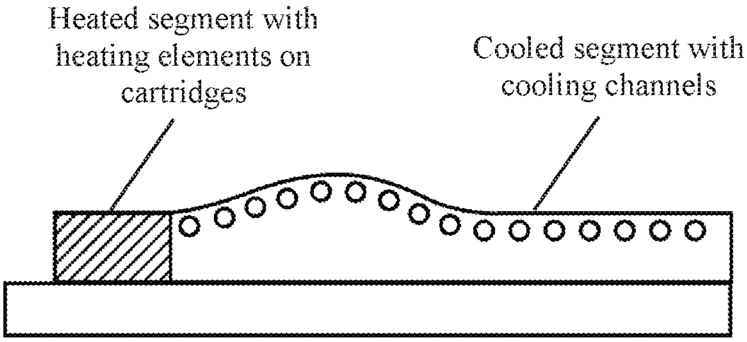

Heated segment with
heating elements on
cartridges
Cooled segment with
cooling channels

FIG. 9

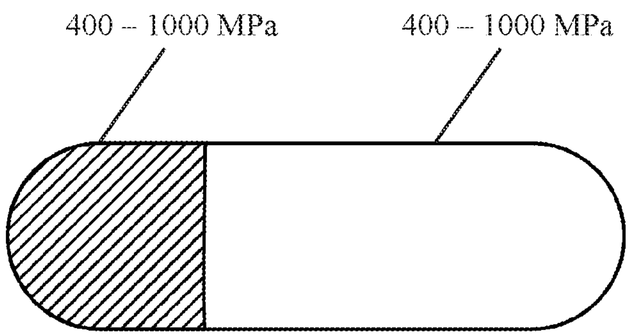
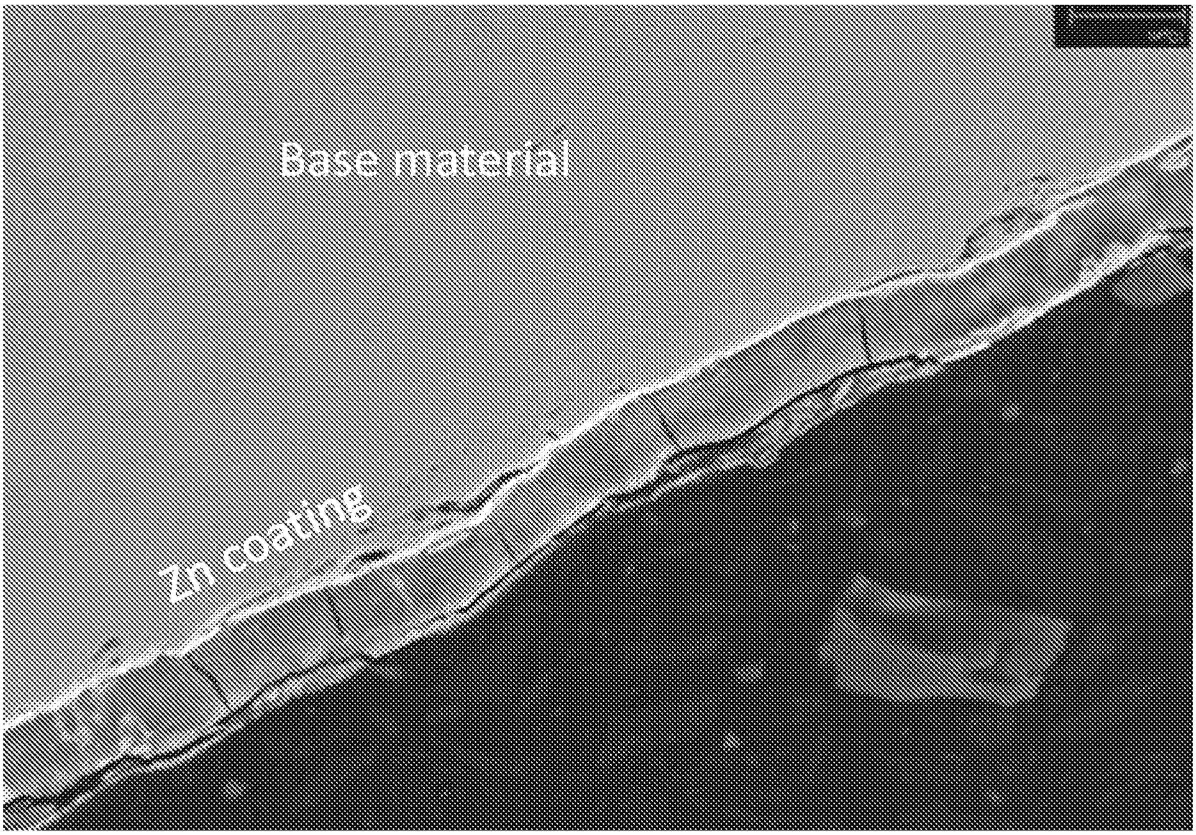


FIG. 10

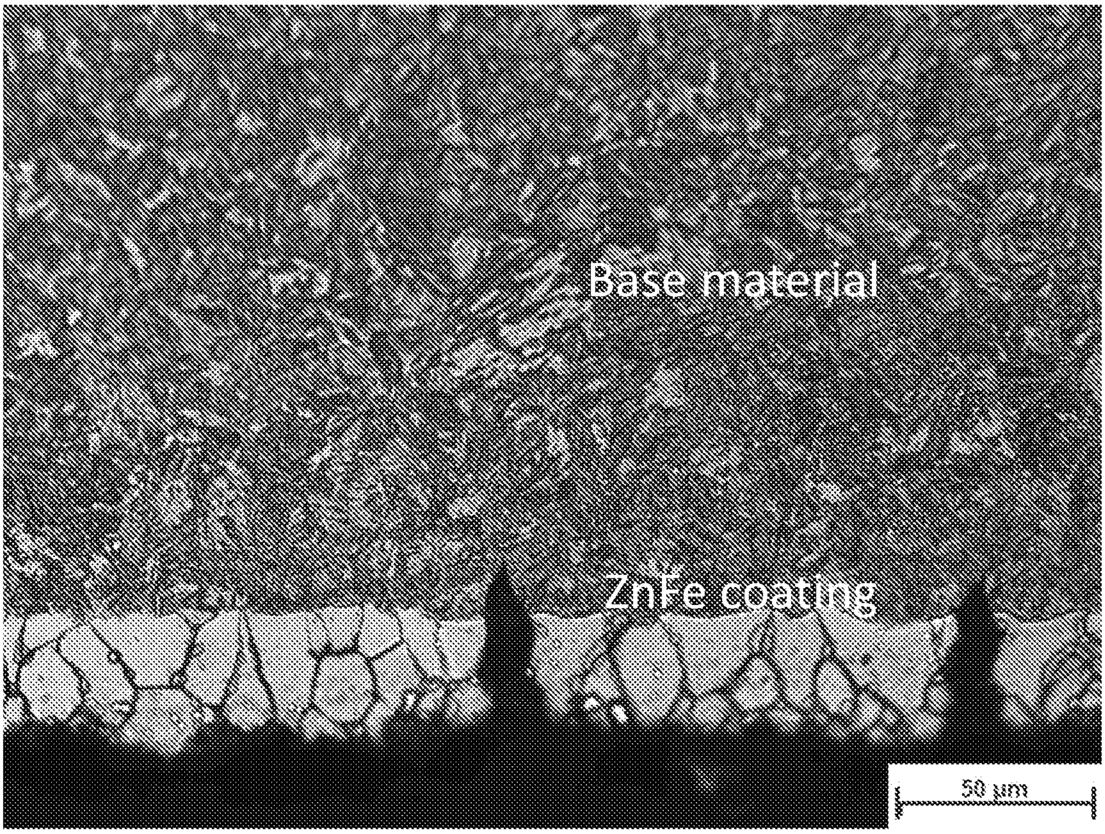
EG coating (Zn-based layer/coating)



Electrogalvanized part of the present patent application has no inter-metallic layer and no partial (or fully) inter-crystalline phases

FIG. 11

Voest Alpine Directform (ZnFe coating)



Voest Alpine Zinc coated material (undergoes hot stamping). After hot stamping, it shows partial inter-crystaline phases between the coating and the base material. It does not have an intermetallic layer.

**FIG. 12
(PRIOR ART)**

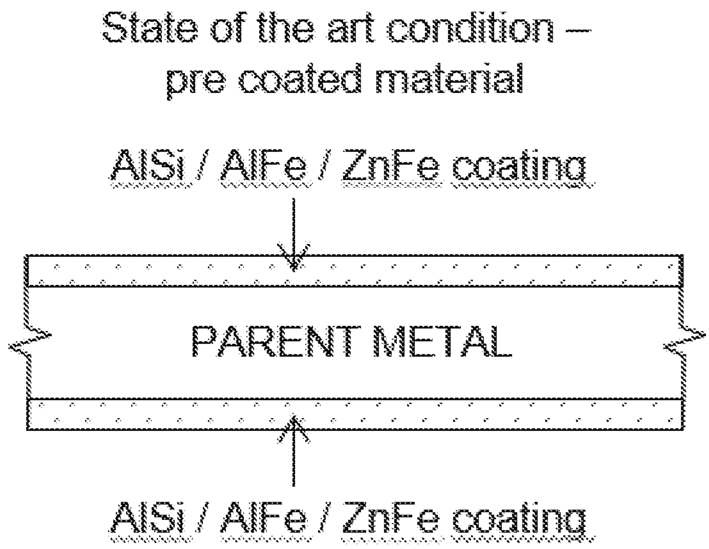


FIG. 13
(PRIOR ART)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/051692

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***C23F 17/00*** (2006.01) , ***B21D 53/88*** (2006.01) , ***B23P 25/00*** (2006.01) , ***C21D 1/00*** (2006.01) , ***C23G 1/02*** (2006.01) , ***C25D 3/22*** (2006.01)

CPC: **C23F 17/00** (2020.01) , B21D 53/88 (2020.01) , B23P 25/00 (2020.01) , B23P 2700/50 (2020.01) , C21D 1/00 (2020.01) , C23G 1/02 (2020.01) (more CPCs on the last page)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: ***C23F 17/00*** (2006.01) , ***B21D 53/88*** (2006.01) , ***B23P 25/00*** (2006.01) , ***C21D 1/00*** (2006.01) , ***C23G 1/02*** (2006.01) , ***C25D 3/22*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, QUESTEL-ORBIT (keywords: austen, steel, galvan, zinc, Zn)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/0167453 A1 (SANDERS et al.) 19 June 2014 (19-06-2014) *whole document*	1-24
Y	EP 2 102 389 A1 (HOLDER et al.) 23 September 2009 (23-09-2009) *whole document*	1-24
A	EP 2 496 371 B1 (SOMMER et al.) 12 March 2014 (12-03-2014) *whole document*	
A	CA 3 177 824 A1 (SKSZEK) 25 November 2021 (25-11-2021) *whole document*	

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 19 June 2024 (19-06-2024)	Date of mailing of the international search report 25 June 2024 (25-06-2024)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Malcolm Downey (819) 639-8453

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2022/004820 A1 (KOMINE et al.) 06 January 2022 (06-01-2022) *whole document*	

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US2014167453A1	19 June 2014 (19-06-2014)	CN103866094A	18 June 2014 (18-06-2014)
		DE102012024626A1	18 June 2014 (18-06-2014)
EP2102389A1	23 September 2009 (23-09-2009)	EP2102389B1	27 April 2016 (27-04-2016)
		DE102006060255A1	19 June 2008 (19-06-2008)
		DE102006060255B4	27 September 2012 (27-09-2012)
		WO2008071298A1	19 June 2008 (19-06-2008)
EP2496371B1	12 March 2014 (12-03-2014)	EP2496371A1	12 September 2012 (12-09-2012)
		CN102665955A	12 September 2012 (12-09-2012)
		CN102665955B	06 May 2015 (06-05-2015)
		DE102009052210A1	28 July 2011 (28-07-2011)
		DE102009052210B4	16 August 2012 (16-08-2012)
		US2012304448A1	06 December 2012 (06-12-2012)
		WO2011054575A1	12 May 2011 (12-05-2011)
CA3177824A1	25 November 2021 (25-11-2021)	CN115667568A	31 January 2023 (31-01-2023)
		EP4153791A1	29 March 2023 (29-03-2023)
		EP4153791A4	10 April 2024 (10-04-2024)
		US2023183828A1	15 June 2023 (15-06-2023)
		WO2021236619A1	25 November 2021 (25-11-2021)
WO2022004820A1	06 January 2022 (06-01-2022)	CN115715332A	24 February 2023 (24-02-2023)
		CN115715332B	12 April 2024 (12-04-2024)
		EP4141132A1	01 March 2023 (01-03-2023)
		EP4141132A4	11 October 2023 (11-10-2023)
		JP2022034016A	02 March 2022 (02-03-2022)
		JPWO2022004820A1	06 January 2022 (06-01-2022)
		JP7031801B1	08 March 2022 (08-03-2022)
		KR20230013273A	26 January 2023 (26-01-2023)
		MX2022016016A	02 February 2023 (02-02-2023)
		US2023243014A1	03 August 2023 (03-08-2023)

IPC:

CPC:
C25D 3/22 (2020.01)