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J. E. BERGER

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METHOD OF HEAT TREATING FERROUS ALLOY SHEETS

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2 Sheets-Sheet 1

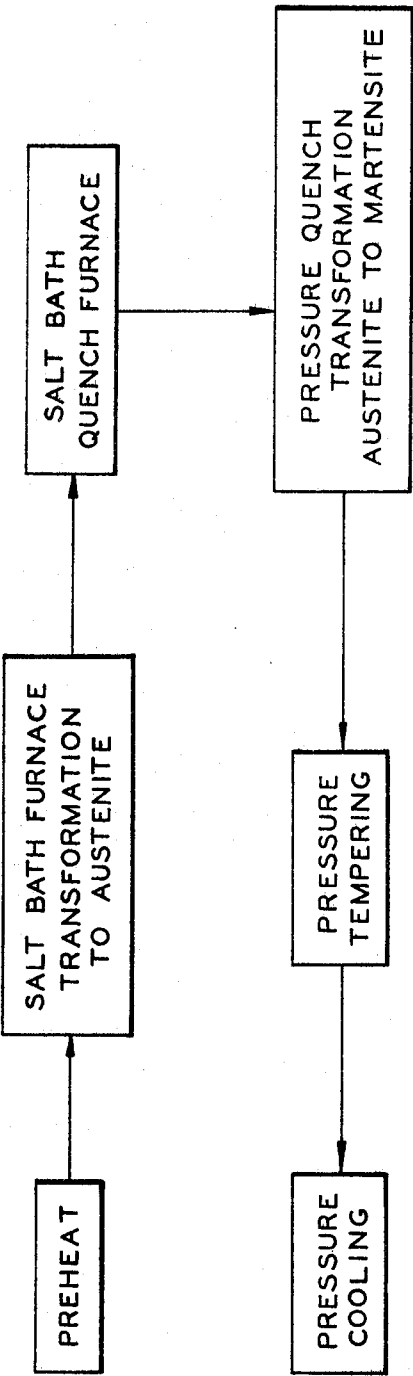


FIG. 1

INVENTOR
JAMES E. BERGER
BY
Burton & Parker
ATTORNEYS

May 5, 1970

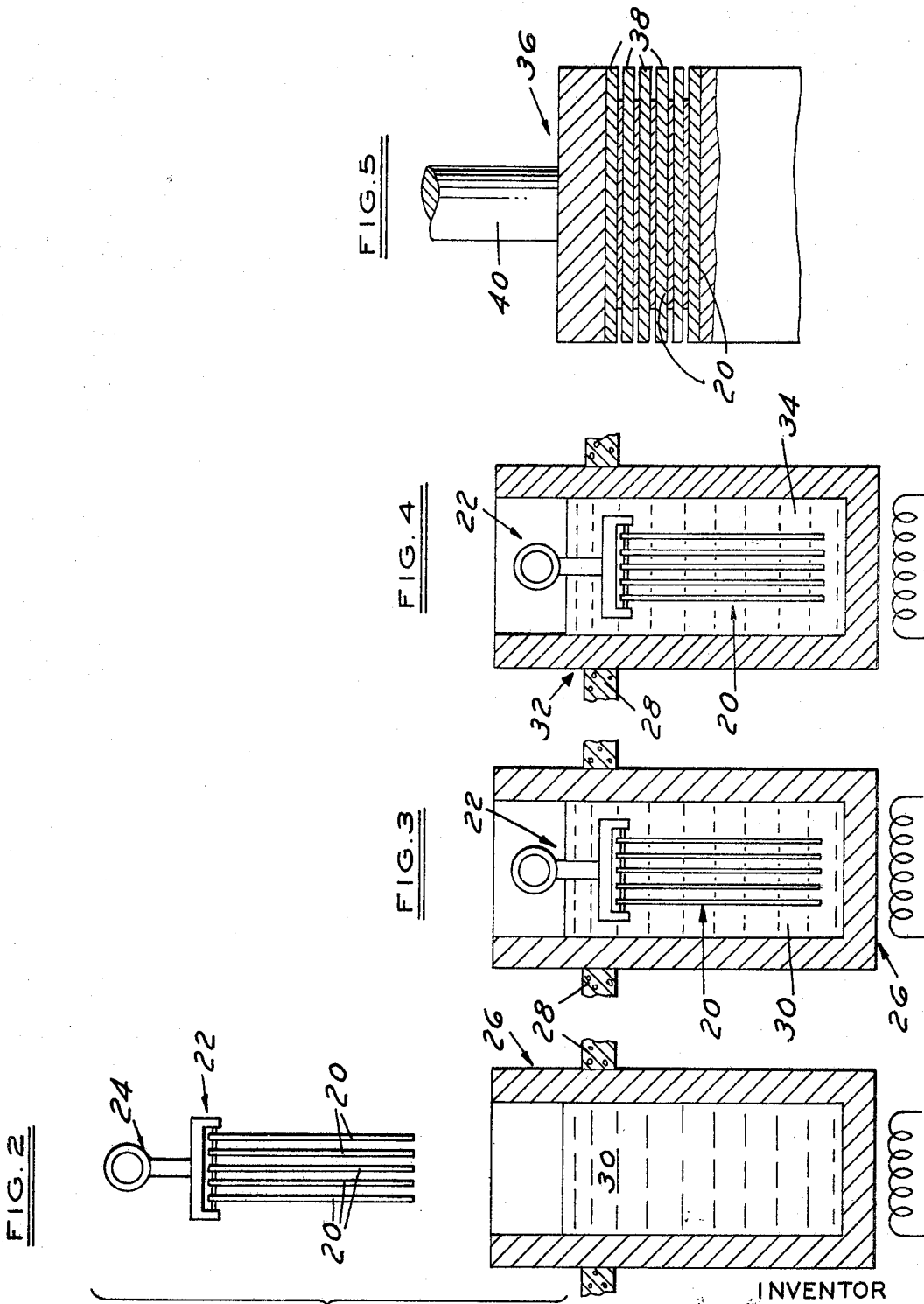
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2 Sheets-Sheet 2



1

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**METHOD OF HEAT TREATING FERROUS
ALLOY SHEETS**

James E. Berger, Rockhill, S.C., assignor to Kent-Moore
Corporation, Warren, Mich., a corporation of Michigan

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11 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a method of heat treating sheets of steel and ferrous alloys, including the steps of: vertically suspending the sheets in a preheat atmosphere; immersing the suspended sheets in a salt bath furnace maintained at a temperature to cause complete transformation of the metal to austenite; quenching the metal by immersing the suspended sheets in a salt bath furnace maintained at a temperature just above the martensite temperature of the metal being treated; pressure quenching the sheets by transferring the sheets to a temperature and pressure controlled press, wherein transformation from austenite to martensite occurs at a controlled pressure; and tempering the sheets in the press by raising the temperature in the press and increasing the pressure. The pressure quenching is accomplished in the press by controlling the temperature of the press to above the temperature of martensite formation, applying pressure to the sheets, and lowering the temperature at a controlled rate to below the temperature of completed martensite structure of the metal being treated. The pressure is then momentarily released, and the sheets are cooled under pressure.

FIELD OF THE INVENTION

The heat treatment process of this invention is particularly, although not exclusively adapted to heat treating steel and ferrous alloy sheets, such as stainless steel plate, to produce scale free metal plates of the proper hardness, and maximum flatness. A primary object of the process of this invention is to eliminate the need for separate straightening, as required in previous heat treatment process. Another object is to eliminate the need of scale and oxidation removal, as required in previous methods.

The process of this invention is particularly useful for producing smooth, "flat" heat treated metal plates. Such plates are utilized in the production of high and low pressure laminated products such as plastic table and countertops, and the like, wherein it is imperative that the metal plates be relatively flawless, and as "flat" as commercially feasible.

DESCRIPTION OF THE PRIOR ART

The heat treatment processes shown by the prior art generally utilize a single "open hearth" type furnace, wherein the metal sheets are laid horizontally in a circulating air furnace. After transformation of the metal to austenite in the furnace is completed, the sheets are simply allowed to stand in the atmosphere until transformation to martensite is complete. Tempering is accomplished during scale removal process, wherein no pressure is applied.

The sheets must then be cleaned and hand straightened, or rolled "flat," which results in localized stress buildup, and the rolling leaves marks on the surface of the sheets. The sheets are not cleaned prior to roll straightening, which results in surface denting from rolled in scale deposits. The localized stresses in the sheets caused by

2

the rolling process to straighten often results in a wavy, hot flat finished sheet or plate.

SUMMARY OF THE INVENTION

The method of my invention includes the following steps:

(a) Vertically suspending the metal sheets to be heat treated in a salt bath furnace maintained at a temperature to cause complete transformation of the metal to austenite,

(b) Quenching the metal sheets by transferring and immersing the vertically suspended sheets in a salt bath quench furnace maintained at a temperature just above the martensite temperature of the metal being treated,

(c) Pressure quenching the metal sheets by transferring the sheets to a temperature and pressure controlled press, wherein transformation from austenite to martensite is accomplished under controlled pressure and temperature, and

(d) Tempering the sheets in the same press, by raising the temperature to the tempering temperature for the metal being treated, and increasing the pressure considerably above the pressure maintained during the pressure quenching cycle.

The metal sheets to be heat treated may be preheated, prior to the transformation to austenite, by vertically suspending the sheets over the "high-heat" salt bath furnace. This prevents warping or buckling of the sheets upon sudden change in temperature. Pressure quenching is accomplished by controlling the temperature of the press to above the martensite formation temperature for the metal being treated, and applying a pressure to the sheets which prevents buckling or stress buildup during transformation, and reducing the temperature at a controlled rate to below the martensite completion temperature of the metal being treated. The pressure is then momentarily released, and the sheets are cooled, under pressure, by circulating air through the press.

The process of my invention utilizes two specially designed salt bath furnaces, which permit complete immersion of the vertically suspended sheets. Vertically suspended sheets are less subject to warpage and stress than sheets which are horizontally supported under the temperature required in the furnaces. This is especially true of relatively large metal plates, which will warp under their own weight. The use of a salt bath furnace also precludes oxidation of the metal surfaces in the furnace, and a film of salt brine is retained on the metal surfaces, throughout the process of my invention, to prevent formation of scale or oxidation. It should be noted that scale and oxidation not only requires additional cleaning of the metal surfaces after heat treatment, but will also leave imperfections in the metal surfaces, which must be removed by hand straightening or rolling.

The temperature of the press during the pressure quenching cycle should be accurately controlled to assure uniform transformation of the metal structure from austenite to martensite. The temperature must also be accurately controlled during the tempering and cooling cycles to assure a uniform structure. The two-step pressure control in the process of my invention is also a considerable improvement over the "dead weight" press used previously, because it allows the use of a greater pressure during the tempering cycle. Pressure is applied during the quenching cycle to firmly hold the sheets in place during transformation, however the greater pressure used in the tempering cycle would not allow the requisite stress relief during quenching. The pressure may then be increased during the tempering cycle to insure maximum flatness. The pressure is momentarily released, prior to

the cooling cycle, to allow the plates to shift slightly and relieve stresses built up during the tempering cycle.

Briefly, the process of my invention provides several advantages. The plates are flatter than plates produced in the previous processes, and are relatively scale free. The hardness is more uniform because of the controlled pressures and temperatures, and because rolling is not required or utilized. Further, the sheet is less expensive to manufacture, and retains a maximum resistance to corrosion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram which may be utilized in the process of my invention;

FIG. 2 is a schematic representation of the preheat step of the process of my invention;

FIG. 3 is a schematic representation of the high-heat salt bath furnace utilized in the transformation step to martensite structure;

FIG. 4 is a schematic representation of the salt bath quenching step of the method of my invention; and

FIG. 5 is a schematic representation of the press utilized in the process of my invention.

DESCRIPTION OF THE DRAWINGS AND PROCESS OF MY INVENTION

FIG. 1 is a flow diagram of the process of my invention, and FIG. 2 to 5 illustrates schematically a means of carrying out the process. The "preheat" step shown in FIG. 2 may be accomplished by suspending the sheets or plates over the high-heat furnace. In this embodiment of the process of my invention, the sheets 20 are vertically suspended by a frame means 22. The sheets are suspended in spaced relation to permit exposure of all of the surfaces of the sheets, and the frame is provided with a support 24 to aid in material handling.

The high-heat furnace 26 is specially designed to permit complete immersion of the vertically supported sheets. The furnaces are recessed in the floor 28 to save work space, and a salt brine heating media 30 is preferred over a hot air furnace to preclude exposure of the sheets to the atmosphere during the high-heat and furnace quenching.

It will be understood by those skilled in the art that the temperature of the furnaces, and the duration of each step, will depend upon the composition of the ferrous alloy being treated. The details for a specific alloy can be determined from the steel manufacturers "TTT Charts"; which refers to "time, temperature, and transformation." The process of my invention has been very successful in heat treating plates of stainless steel alloys, such as 410 stainless steel, in rectangular sheet sizes ranging from 40 inches by 80 inches, to 72 inches by 13 feet. The furnaces now in operation can handle several sheets simultaneously. The salt brine is commercially available, and generally includes a mixture of barium chloride and sodium chloride. For stainless steel, the preheat time is approximately 5 minutes, and the sheets attain a temperature of 400 to 600 degrees over the high-heat furnace. The time and temperature of the preheat step, and the remaining steps are however dependent upon the metal being treated, and the data given herein in this regard is for illustrative purposes only.

The purpose of the preheat is to prevent warping or buckling of the metal sheets upon immersion in the high-heat furnace 26. The necessity of this step will therefore depend upon the metal being treated.

The sheets are next immersed in the high-heat furnace 26, as shown in FIG. 3, wherein the salt solution 30 is maintained at a temperature above the austenite temperature for the metal being treated. The sheets remain in the furnace until there is complete transformation to the austenite structure. For stainless steel, this requires approximately 5 to 15 minutes depending on the

total mass at a temperature of 1650 to 1825 degrees Fahrenheit.

As stated hereinabove, the utilization of salt brine furnaces precludes exposure of the metal surfaces to the atmosphere, which prevents formation of scale and corrosion. Further, a film of salt is purposely left on the metal surfaces throughout the process to limit the exposure of the sheets to the atmosphere.

This is especially important in producing commercially "flat" sheets, because corrosion and scale will cause pitting of the metal surfaces requiring special handling and flattening after the heat treatment process.

The sheets 20 are then immediately transferred to the quench furnace 32, shown in FIG. 4. The quench furnace is also a specially designed vertical salt bath furnace, however the temperature of the brine 34 is maintained just above the martensite formation temperature for the metal being treated. The purpose of this step is to stabilize the temperature of the sheets just above the martensite formation temperature, prior to pressure quenching. This requires approximately 8 to 20 minutes at about 700 degrees Fahrenheit for stainless steel.

After the temperature of the sheets has reached equilibrium in the quenching furnace, the sheets are transferred to a horizontal heated platen press 36, shown in FIG. 5. The temperature in the press is maintained slightly above the martensite formation temperature of the metal sheets 20. Spacer plates 38 may be positioned between the sheet to evenly distribute the load of the press. Pressure is then applied by the piston 40 to insure flatness during transformation from austenite to martensite. The optimum pressure to be applied during quenching will depend upon the number and size of the sheets. A commercial form of the press illustrated schematically in FIG. 5 will handle one to 20 sheets simultaneously. The pressure used for stainless steel plates is preferably between 150 to 300 tons.

The temperature in the press is then lowered at a controlled rate to cause transformation of the metal structure from austenite to martensite. This is achieved with stainless steel sheets by lowering the temperature to 100 degrees Fahrenheit below the martensite temperature of the metal at a rate not to exceed 75 degrees Fahrenheit per hour.

Tempering and stress relief is accomplished in the same press, as shown in FIG. 5, without the necessity of handling the sheets. After transformation of the metal structure to martensite is complete, the temperature and pressure of the press is raised to achieve the desired final hardness of the metal, as per the metal manufacturer's specifications. The pressure in the press may be increased at this point because transformation is complete. A pressure of 250 tons has been found satisfactory for stainless steel plate, and a hardness of 35 to 39 Rockwell "C" Scale is achieved by raising the temperature to 675 to 800 degrees Fahrenheit, and holding this temperature for one hour and 15 minutes.

The pressure is then momentarily released to allow the plates to shift slightly and relieve stresses in the structure. The sheets are then cooled at a controlled rate, under pressure, to a temperature of 250 degrees Fahrenheit or less, prior to removal. Proper cooling generally requires 8½ to 12 hours. The improved press utilized in the process of my invention incorporates an air circulation system, which permits control of the cooling rate to that required by the metal being treated.

Finally, the sheets are washed to remove the excess brine remaining on the surfaces, which has protected the metal surfaces previously from scale and corrosion. The resultant metal sheets are flatter and relatively scale free. The density is more uniform because of the controlled pressures, and because roll straightening is not required or utilized. The sheets are therefore less subject to corrosion, and the sheets are less expensive to manufacture because

the requirement of local stretching and smithing has been eliminated.

What is claimed is:

1. A steel sheet heat treating process, including the steps of:

- (a) vertically suspending the steel sheet in a salt bath furnace maintained at a temperature to cause complete transformation of the steel to austenite,
- (b) quenching the steel sheet by immediately transferring and immersing the vertically suspended sheet in a salt bath quench furnace maintained just above the martensite formation temperature of the steel being treated,
- (c) pressure quenching the steel sheet by immediately transferring the sheet to a temperature and pressure controlled press wherein transformation from austenite to martensite is accomplished at a controlled pressure and temperature, and
- (d) tempering the sheet in said press by raising the temperature in the press to the tempering temperature for the steel being treated and increasing the pressure considerably above the pressure maintained during pressure quenching.

2. The steel sheet heat treating process defined in claim 1, characterized in that the pressure quenching of the steel from austenite to martensite is accomplished by;

- (a) controlling the temperature in the press to above the martensite formation temperature for the steel
- (b) applying a pressure to the sheet to prevent buckling or stress buildup during transformation, and
- (c) lowering the temperature at a controlled rate to below the martensite completion temperature of the steel being treated.

3. The steel sheet heat treating process defined in claim 1, characterized in that the sheet is vertically suspended over the salt bath furnace to preheat the sheet prior to austenitising.

4. The heat treating process defined in claim 1, characterized in that the pressure is momentarily released after tempering and the sheet is thereafter cooled under pressure in the press.

5. The heat treating process defined in claim 4, characterized in that the platens of the press circulate a cooling fluid which provides a controlled cooling rate for the steel being treated.

6. A heat treating process, including the steps of:

- (a) vertically suspending steel sheets in a furnace maintained at a temperature above the austenite temperature for the steel being treated causing complete transformation of the steel to austenite,
- (b) quenching the steel sheets by vertically suspending the sheets in a furnace maintained at a temperature just above the martensite formation temperature for the steel,
- (c) pressure quenching the sheets in a temperature

and pressure controlled press wherein transformation from austenite to martensite is accomplished under controlled pressure,

- (d) tempering the steel sheets in said press by raising the temperature to a tempering temperature for the steel being treated while maintaining the press pressure,
- (e) momentarily releasing the pressure of the press, and
- (f) reapplying the pressure while cooling the sheets in said press.

7. The heat treating process defined in claim 6, characterized in that the austenitising and quenching furnaces are of the salt bath type and the sheets are immersed in the salt bath to prevent oxidation of the steel surfaces.

8. The heat treating process defined in claim 7, characterized in that salt remaining on the steel surfaces of the sheets from the salt bath furnaces is permitted to remain on the surfaces until after cooling to provide substantially oxidation free steel sheets.

9. The heat treating process defined in claim 6, characterized in that the sheets are cooled in the process by circulating air through the platens while maintaining the pressure.

10. The heat treating process defined in claim 6, characterized in that the pressure is substantially increased during the tempering cycle.

11. The heat treating process defined in claim 6, characterized in that the pressure quenching of the steel from austenite to martensite is accomplished by;

- (a) controlling the temperature in the press to above the martensite formation temperature as the sheets are being loaded in the press,
- (b) applying a pressure to the sheets to prevent buckling or stress buildup during transformation, and
- (c) lowering the temperature at a controlled rate to below the martensite completion temperature of the steel being treated.

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CHARLES N. LOVELL, Primary Examiner

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