CONTINUOUS ANNEALING APPARATUS

Filed Aug. 6, 1925

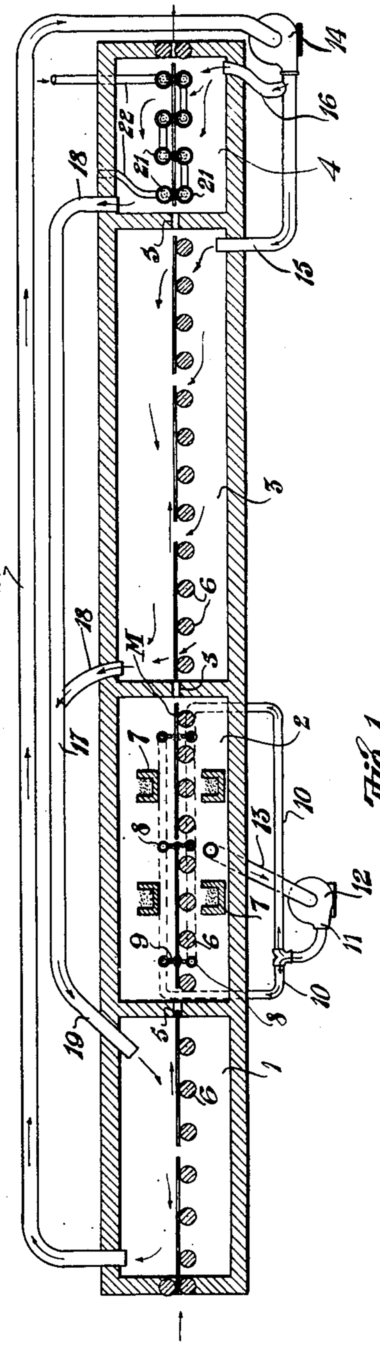

Fig. 1.

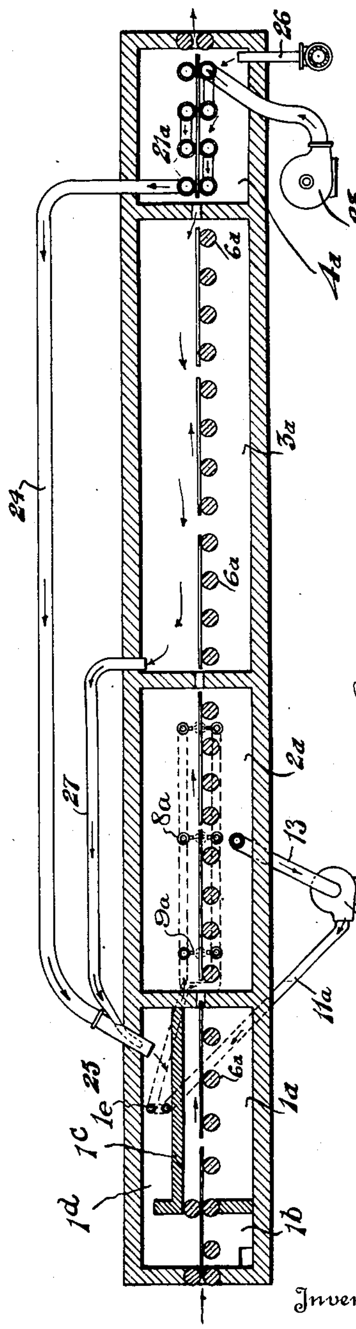

Fig. 2.

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Patented June 2, 1931 1,808,152

UNITED STATES PATENT OFFICE

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CONTINUOUS ANNEALING APPARATUS

Application filed August 6, 1925. Serial No. 48,541.

The invention relates to an apparatus for continuously annealing sheets and other rolled products, wherein the material is passed continuously through a furnace for heating to the desired temperature, cooling at a desired rate through certain critical temperatures and at a different rate through other critical temperatures, uniformly cooling the material throughout all surface portions. The method of continuously annealing sheets and other rolled products, which is described, but not claimed herein is made the subject matter of my copending application Serial No. 130,519, filed August 20, 1926, which is a division of this application.

In the production of deep drawing sheets for instance, it is a common practice to take the sheets as they come from the previous rolling, heat them above the upper critical temperature, allow them to cool in the air by passing them upon a cooling table while still at a considerable temperature, during which period additional oxidation takes place, and the edges of the sheets cool more rapidly than the center, producing different grain structures and therefore different physical properties between the edge portions and centers of the sheets.

When the sheets are substantially cooled upon the cooling table they are placed in a pile adjacent to the end thereof where they still further cool on the edges more rapidly than at their centers. After the sheets are completely cooled they are subjected to a pickling operation for removing oxide and scale produced either by previous heating or while the sheet was exposed to the air in a heated condition.

It will thus be seen that in the present practice little if any control can be exercised in the rate of cooling of the sheets from the maximum temperature through the various critical ranges to the cold or normal temperature, and that there is bound to be a different rate of cooling between the edges and the center of the sheet, the sheet being also left in an oxidized condition requiring pickling to remove the oxidation and scale therefrom.

It is well known that sheets may be deoxidized in pack annealing, in which the material is placed in a pile on an annealing bottom, covered with a cast iron, gas tight cover or box, and natural or other reducing gas maintained within the cover or box during the heating and cooling of the sheets. The objection to this method, for deep drawing sheets, is that little control can be had of the rate of cooling, and the edges of the sheets heat faster than the centers thereof, and are liable to be overheated, producing a coarse grain structure on the edge portions of the sheet, and also in cooling, the edges cooling more rapidly than the central portions of the sheets, produce a different grain structure in the edges from that of the centers of the sheets.

Further, by this pack annealing, the length of time required, both at the maximum temperature and during the cooling, is so great that a coarse grain structure is produced in the sheets which adversely affects the deep drawing qualities thereof. It has been determined that for a steel of given analysis there is a certain maximum temperature which must be reached in order to produce the desired grain structure, and that sufficient time must be allowed, however short, for the rearrangement of the grains to take place. This is known to be above what is termed the upper critical point.

It is also known that steel in cooling normally passes through a number of critical ranges. As steel is cooled sufficiently slow for the following grain condition to take place, it will pass from the austenite, which is above the upper critical point through the martensite stage, then to the troostite, then through the sorbite, and lastly to the pearlite stage, which latter is the usual grain structure found in sheets that have been box annealed.

These sheets of pearlite structure have been found to be of coarse grain structure, very soft and ductile under preliminary strain, but they rapidly lose their ductility when strains are set up in drawing operations when formed into articles, or in subsequent rolling or cold working.

Sheets that are kept substantially in the sorbite stage, while not so soft, nevertheless have a greater drawing or deforming range without rupture, as compared with pearlite sheets.

To obtain sheets in the sorbite, on cooling from the austenite stage, it is necessary to have a controlled and gradual rate of cooling from austenite to sorbite, and on reaching the sorbite stage the sheets should be so rapidly cooled as to prevent change of grain to pearlite. The time necessary for these changes will vary with the thickness and mass of the sheet, and if the cooling be rapid as in case of water quenching, on thin sections, sufficient time will not elapse for the grain structure to pass through the intermediate stages to sorbite. In the case of cooling naturally in the air, as previously mentioned, in the present practice of open annealing, steel will pass perhaps too slowly or too rapidly through the intermediate stages to the sorbite, and then too slowly to atmospheric temperature, producing a coarse undesirable pearlitic grain structure.

The object of the present improvement is to provide for continuously annealing sheets or other rolled products by heating the same to the desired temperature and then controlling the rate of cooling, the material being cooled out of contact with the air at a predetermined rate through certain critical stages and then at another predetermined rate to a point below scaling temperature, the cooling being uniform throughout all surface portions of the material.

Another object of the invention is to provide for deoxidizing the material while in the heated condition, this deoxidizing process removing any scale which the sheets may contain when they are placed in the furnace, and eliminating the necessity of pickling the sheets after they are annealed.

By my method, which may be carried out by the approved apparatus illustrated herein, the rate of cooling is controlled so as to produce, if desired, substantially a complete sorbite grain structure, or if greater softness is required, a combination of sorbite and pearlite. It will be seen that by the use of this apparatus and method any desired grain structure may be attained throughout the entire area of the sheet, since provision is made for controlling the rate of cooling at any stage, and since provision is also made for cooling uniformly over all sections of the sheet, the grain structure of the entire sheet will be uniform.

It should also be noted, that by the deoxidizing arrangement shown, such scale as may be formed previous to the cooling stage may be deoxidized, and since provision is made for cooling below the oxidizing temperature before coming into contact with the air, the resulting product is free from scale or oxide, and the usual pickling operation is eliminated.

The improved apparatus, by which the method may be carried out, is illustrated in the accompanying drawings, in which;

Figure 1 is a longitudinal sectional view of an electrically operated furnace designed to carry out the improved method, and,

Fig. 2, a similar view of a gas heated furnace.

Similar numerals of reference indicate corresponding parts throughout the drawings.

The improved method of annealing sheets and other rolled products, may be carried out in an electrically heated furnace as illustrated in Fig. 1, or in a gas heated furnace such as shown in Fig. 2.

Referring first to Fig. 1, the furnace may be divided into a series of communicating chambers, comprising the preheating chamber 1, the heating and deoxidizing chamber 2, the initial cooling chamber 3, and the quick cooling chamber 40, arranged in alinement, in the order named, the transverse walls of the several chambers being provided with restricted openings 5, through which the material may be passed as by the rolls 6.

The heating and deoxidizing chamber 2, may be provided, upon each side of the path of the material, with electric resistors 7, for the purpose of bringing the material, indicated generally at M, to the maximum temperature required for the annealing.

For the purpose of deoxidizing the material to remove any scale or oxidation which may be present when the material is passed into the furnace, means are provided for impinging a highly heated reducing gas upon each surface of the material, this means being illustrated as comprising a series of tubular heads 8, upon each side of the path of the material, said heads being provided with nipples or jets 9, for directing a blast of reducing gas upon all surfaces of the material.

These heads 8 are shown as connected to pipes 10 communicating with the outlet side 11 of a blower fan 12, the gas being returned from the deoxidizing chamber to the inlet side of the fan as by a pipe 13, whereby the gas is continuously circulated through the fan and impinged upon the material, removing scale and oxidation therefrom.

It will be seen that this reducing gas will be quickly heated, by means of the electric resistors, to a very high temperature, although if desired, outside means may be provided for heating the gas.

A fan 14 may be provided with pipes 15 and 16 communicating with the outlet side thereof and extended into the rear end portions of the cooling chambers 3 and 4 respectively, for the purpose of continuously circulating a nonoxidizing gas through said cooling chambers. This nonoxidizing gas is exhausted from the cooling chambers through a pipe or conduit 17 communicating with the forward end portions of said chambers as indicated at 18, passing the gas into the rear end portion of the preheating chamber as shown at 19. The forward end portion of the preheating chamber is connected to the inlet side of the fan 14 as by a return pipe 20. Thus a continuous circulation of nonoxidizing gas is passed through the chambers 3 and 4 for the purpose of cooling the material, and then through the preheating chamber 1 in order to preheat the material by recuperation of said gas, which is then returned in a closed circuit to the fan 14.

In order to very rapidly cool the material as it passes through the quick cooling chamber 4, upper and lower hollow rolls 21 are provided, the material being passed through said rolls and discharged from the furnace. These rolls are connected together in a continuous circuit and communicate with the inlet and discharge pipes 22, through which cold water, air or other cooling fluid may be passed for maintaining the surfaces of the rolls at the desired temperature, and as these surfaces of the rolls contact with the entire surface area of the material it will be seen that the material is uniformly and rapidly cooled throughout its entire surface area.

In the gas heated form of furnace, shown in Fig. 2, the preheating and final heating of the material may be accomplished in the chambers 1^b and 1^a, respectively while the deoxidizing alone is carried out in chamber 2^a, in which the deoxidizing apparatus may be substantially identical with that shown in Fig. 1; excepting only that the pipe 11^a communicating with the outlet side of the fan 12^a passes back and forth through the combustion chamber 1^d, as at 1^e before communicating with the head 8^a having the nipples 9^a, whereby the deoxidizing gas circulated is heated by the products of combustion in the combustion chamber.

A muffle wall 1^c, of carborundum or the like, separates the combustion chamber 1^d, from the heating chamber 1^a, the products of combustion passing over the incoming material in the preheating chamber 1^b, and then to the stack. The initial cooling chamber 3^a receives the material from the deoxidizing chamber, the rolls 6^a carrying the material entirely through the furnace as above described and passing it into the quick cooling chamber 4^a where it is rapidly cooled by passing between the hollow fluid cooled rolls 21^a.

Cold air is continuously forced through the hollow cooling rolls 21^a by means of a blower fan 23, said rolls being connected together in a circuit and exhausting through the pipe 24 to the gas burner 25 located in the rear end portion of the chamber 1^a.

A nonoxidizing gas, such as natural gas, is injected into the rear end portion of the quick cooling chamber 4^a as by the pipe 26, said gas passing in the direction of the arrows, through the chambers 4^a and 3^a and then through the pipe 27 to the gas burner where it is burned in combination with the heated air received from the pipe 24.

The operation of each of these forms of the furnace comprises a preheating, heating to a maximum temperature, and a deoxidizing of the material as it is passed continuously through the furnace, and then an initial cooling through certain critical ranges at a controlled rate of speed, and a final cooling through other critical ranges at a different rate of speed.

In carrying out the improved method of annealing, assuming that deep drawing sheets are to be annealed, they are first heated to a point above the upper critical temperature of the particular material, and may be deoxidized while hot, the cooling being controlled at a rate which permits the grain structure of the material to pass from the austenite through the martensite and troostite stages and into the sorbite stage, when a very rapid cooling of the material from that temperature retains the fine grain sorbite condition in the finished sheet, the final cooling being preferably accomplished to a point below the scaling temperature before the material is passed out of the furnace and into contact with the atmosphere.

The different temperatures at which the different stages of the process are carried out will of course depend upon the ingredients of which the material is formed and the particular use for which the material is intended.

Assuming that 20 gauge steel sheets, having a carbon content of .10, are desired to be annealed for deep drawing, the sheets will be first heated to substantially 1650° F., which carries them above the upper critical temperature and produces an austenite grain structure. The sheets will then be uniformly cooled from 1650° F. to 1350° F. in substantially 15 seconds, the grain structure passing from the austenite, through the martensite and troostite stages, and reaching the sorbite stage at about 1350° F., the cooling from 1350° F. to 350° F. being carried out very rapidly, in not over 5 seconds time, arresting the grain structure in the sorbite stage and producing a finished sheet having the maximum drawing qualities.

In some instances, as in case of cold worked strips, it may be desired to heat only to approximately the lower critical temperature, for relieving distortion of grain set up by cold rolling, after which steel is continuously cooled at a predetermined rate to below a scaling temperature.

For the purpose of deoxidizing the sheets, as they pass through the furnace, a wet carbonaceous coating, such as charcoal and water, may be applied to the surfaces of each sheet before it enters the furnace. As the sheets are brought to a red heat and then cooled below an oxidizing temperature, while in a reducing atmosphere, all scale or oxidation is removed by this process.

I claim:

1. A furnace for annealing sheets and the like including a heating chamber in which fuel is burned for heating, a cooling chamber, hollow rolls in the cooling chamber connected in series through which air for combustion in the heating chamber is heated, a pipe leading from said rolls to the heating chamber and means for passing material through the heating chamber and between said rolls.

2. A furnace including a combustion chamber heated with fuel, a deoxidizing chamber, means within the deoxidizing chamber for impinging heated reducing gas upon material, means for heating said deoxidizing gas by products of combustion in the combustion chamber, a cooling chamber, means for conveying material successively through the combustion, deoxidizing and cooling chambers, and means for forcing reducing gas through the cooling chamber.

3. A fuel fired annealing furnace including a combustion chamber, a preheating chamber communicating with the combustion chamber, a heating chamber communicating with the preheating chamber, a muffle separating the combustion chamber from the heating chamber, means for circulating the products of combustion around material in the preheating chamber, a deoxidizing chamber communicating with the heating chamber, means for impinging heated reducing gas upon material in the deoxidizing chamber, a cooling chamber communicating with the deoxidizing chamber, means for cooling the material under treatment, and means for conveying the material successively through the preheating, heating, deoxidizing, and cooling chambers.

4. A furnace for annealing sheets and the like including a gas tight chamber, means for impinging heated reducing gas against material in said chamber, a preliminary cooling chamber, and a final cooling chamber, there being transverse walls provided with aligned restricted openings between said chambers, rolls located in said chambers for passing successive sheets through the chambers and restricted openings, a conduit supplying reducing gas to the final cooling chamber, and an outlet conduit for leading the reducing gas from the preliminary cooling chamber, whereby the reducing gas is circulated from the final to the preliminary cooling chamber through the restricted opening in the wall between the chambers.

5. A furnace for annealing sheets and the like including a gas tight chamber, means for impinging heated reducing gas against material in said chamber, a preliminary cooling chamber, and a final cooling chamber, there being transverse walls provided with aligned restricted openings between said chambers, rolls located in said chambers for passing successive sheets through the chambers and restricted openings, a conduit connecting the final cooling chamber and the heating chamber, a conduit connecting the preliminary cooling chamber and the heating chamber, and cooling means in one of said cooling chambers.

In testimony that I claim the above, I have hereunto subscribed my name.

THADDEUS F. BAILY.