

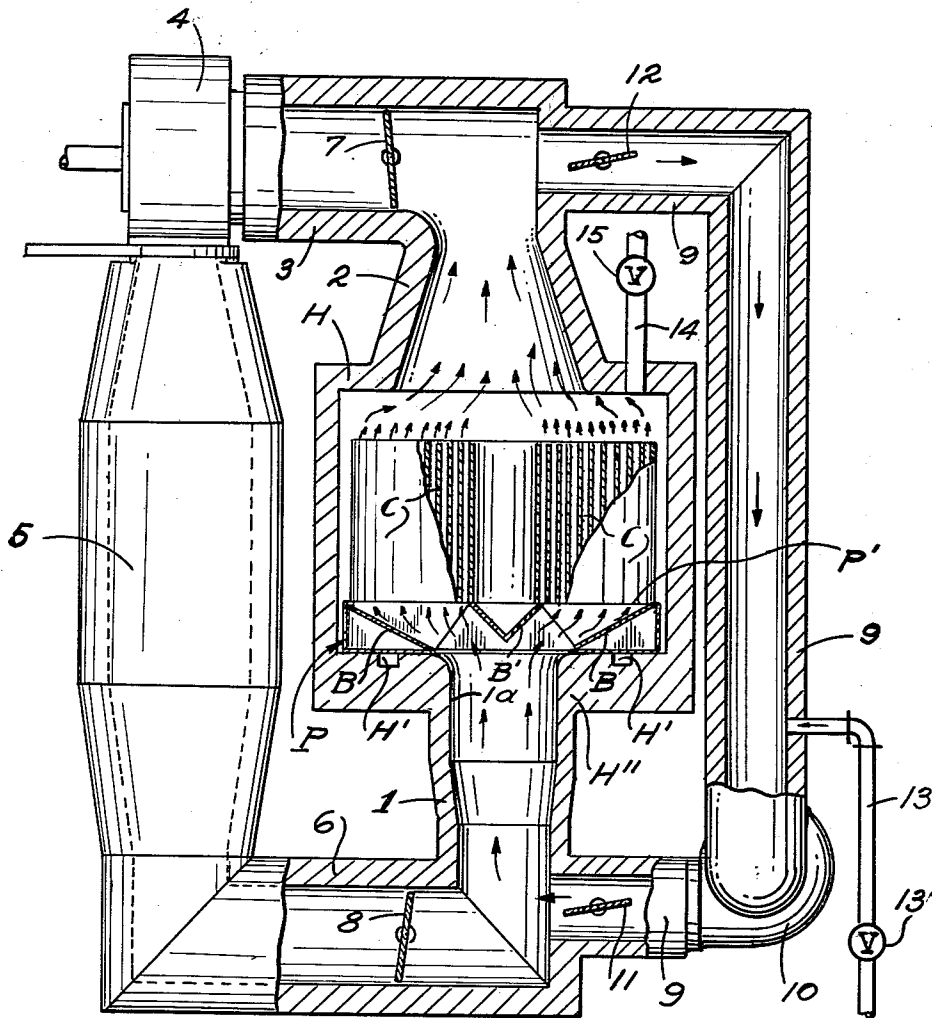
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APPARATUS FOR MODIFYING THE COMPOSITION OF STRIP METAL

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APPARATUS FOR MODIFYING THE COMPOSITION OF STRIP METAL

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This invention relates to improved methods of and apparatus for making metal strip and more particularly for producing the desired composition and physical or metallurgical characteristics in strip metal.

In the copending United States patent application of Lee Wilson and Edwin A. Corns, Serial No. 639,939, filed February 13, 1957, there is disclosed a method of and apparatus for heat treating elongated lengths of strip metal. Broadly speaking, the procedure of this copending application involves recoiling a tightly wound coil of strip metal into opened coil form with the laps thereof spaced apart, and then heating the strip by forcefully and repeatedly circulating a body of heated atmosphere vertically through the spaces between the laps of the opened coil, the axes of the tight wound and opened coils being maintained substantially vertical at all times during the procedure. By such an application of heat, the metallurgical characteristics of long lengths of strip metal, steel for example, may most efficiently and economically be modified.

In numerous instances it is desirable to modify the composition of a metal article. In the case of steel, various procedures have been developed for increasing or decreasing the percentage of various elements in the steel being processed.

For example, steel is commonly carburized and decarburized, nitrided and de-nitrided, chromized and dechromized, etc. These changes in chemical composition may be effected by subjecting the steel to contact with a suitable reacting agent or material, which may be gaseous or solid in form, and heating same. Such processes are effective on parts such as castings, forgings, etc., to produce a relatively thin shell or "case" of the modified composition on the outside of the article being treated. The treatment of elongated lengths of strip metal in this manner, however, has been difficult, if not impossible, because, when strip is in its normal tight coiled condition, only the outer surfaces of the coil may contact the reacting material and no effective change in composition of the mass of strip making up the coil can be effected.

It is, therefore, an object of the present invention to provide an apparatus and procedure for making strip metal whereby long lengths of strip may be subjected, simultaneously over its entire surface area, to contact with a gas of such chemical composition that such contact, at proper temperature and for the proper time, will effect the desired change in the composition of the entire length of the strip for any desired penetration up to the full thickness thereof. The above and other objects of my invention will appear from the following description of one form of apparatus and several procedures which may be employed to carry out my process, reference being had to the accompanying drawing in which the drawing is a somewhat schematic vertical cross-sectional view of a combined heating and gas contacting apparatus for treating opened coils of strip metal to change the composition and/or metallurgical characteristics of the strip.

My process includes recoiling the usual tight wound coils of strip metal that come from the rolling mill or other processing step into opened form with the laps spaced apart. This may be done in any suitable manner,

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preferably as described in the above noted copending application Serial No. 639,939 to which cross reference is hereby made. The procedure of said application involves rewinding a tight wound coil with a spacer string or strand between the laps thereof. The diameter of the spacer strand is equal to the desired spacing between the laps of the opened coil and, after recoiling is completed, the spacer strand is withdrawn, leaving the coil with substantially unimpeded vertical passages between all of its laps. In some cases particularly when very thin strip is being treated, the lap spacer may be in the form of a corrugated strip or expanded coil spring and may be left in position between the laps of the coil during treatment. Thus, the term "opened coil" as used herein is intended to include both coils from which the spacer has been removed and those in which a pervious spacer is permitted to remain during my processing procedure.

Referring now to the drawing, in carrying out the treatment that is included in the present invention an opened coil C of suitable composition and gage is positioned in chamber or housing H through a suitable opening in one side thereof (not shown but which may conveniently be in the front or rear of the housing H seen in the drawing). The opened coil C is supported on a coil support and plenum chamber P, the upper face P' of which is in the form of an open grid on which the lower edges of the laps of the strip of coil C are supported. Plenum chamber P also includes suitable baffle walls B and B' whereby all of the atmosphere which is forced up through the inlet conduit 1 and inlet passage 1^a in housing H is caused to flow upwardly through the spaces between the laps of the coil C. Such atmosphere leaves the top of coil C as indicated by the arrows in the drawing and passes upwardly through the outlet conduit 2 from the chamber H.

To facilitate loading and unloading of an opened coil C into and out of chamber H, transverse slots H' may be provided in the base portion H'' of chamber H to accommodate the arms of a lift fork adapted to lift the coil support and plenum chamber P with a coil C supported thereon and move same into or out of chamber H.

An upper heating gas conduit 3 extends from the outlet conduit 2 to a circulating fan or blower 4, driven by suitable means (not shown). The output of blower 4 is directed into a heater 5 wherein the gas may be heated by any suitable means such as radiant combustion tubes, electric heating elements, etc. The output from the heater 5 flows through the lower heating gas conduit 6 which connects to the bottom end of inlet conduit 1. Dampers 7 and 8 are disposed in the heating gas conduits 3 and 6 respectively adjacent the inlet and outlet conduits 1 and 2. When these dampers are open, circulating of gas is effected by the blower 4 down through the heater 5, up through the opened coil C where heat is transferred to the coil, and back through the heater 5 again in continuous fashion. When the dampers 7 and 8 are closed, as seen in the drawing, circulation of gas through the heater 5 is prevented.

To permit the strip of coil C to be subjected to the action of a reactant gas (for example a gas containing ammonia if it is desired to increase the nitrogen content of the steel strip), a conduit 9 is provided which extends around the chamber H and is connected at its upper end to the outlet conduit 2 and at its lower end to the inlet conduit 1. A blower 10 is interposed in conduit 9 to move gas therethrough, and dampers 11 and 12 are provided to shut off the lower and upper ends of conduit 9 respectively from the inlet conduit 1 and outlet conduit 2 of the chamber H.

From the above description, it will be observed that when the dampers 7 and 8 are closed and dampers 11

and 12 are open (as seen in the drawing), and the blower 10 is operating, atmosphere will be continually circulated upwardly through the spaces between the laps of the opened coil C, through outlet conduit 2, down through conduit 9, through blower 10, and then back into the inlet conduit 1 and again up through the plenum chamber P into and through the spaces between the laps of the coil. In order to supply reactant gas of the desired composition to the system for circulation by blower 10 through the path just described, a reactant gas inlet 13 is provided. An outlet pipe 14, having a control valve 15 therein, extends from the upper portion of housing H to atmosphere or other suitable place of discharge whereby the composition of the reactant gas may be controlled by permitting a certain portion of the reactant gas being circulated to bleed out of the system while additional fresh and undepleted gas enters the system through pipe 13. Suitable control valve means, as indicated at 13', are provided in pipe 13.

In the operation of the above described apparatus to carry out the modification procedure of my improved method an opened coil of suitable gage and composition, depending on the final product desired, is inserted into chamber H and supported on the top grid of plenum P. The charging door (not shown) of the chamber is then, of course, closed and, with baffles 11 and 12 closed and baffles 7 and 8 open, circulation of the atmosphere is effected by the blower 4. This flow is up through the laps of the coil C, down through the heater 5 where heat is added to the gas, and again up through the coil C until the coil reaches the desired temperature. This heating operation is very rapidly and efficiently carried out because the entire surface area of both sides of the entire length of the strip making up coil C is simultaneously and at all times exposed to the rapidly moving stream of heated gas. The heating gas may be of any desired composition, for example inert or nonoxidizing in the case of the treatment of steel strip.

After the desired heat is attained in the coil C, the blower 4 is stopped, dampers 7 and 8 are closed by suitable outside control and dampers 11 and 12 are similarly opened. Now when the blower 10 is started and a reactant gas, for instance ammonia in gaseous form, is supplied to the system through pipe 13, the heated steel strip is subjected to contact over its entire surface with the reactant gas (the composition of which depends on the type and quantity supplied through pipe 13) for such time as is necessary to produce the desired change in composition of the strip. In some instances the desired result may be achieved after one heating of the opened coil whereas in other cases it may be necessary to heat the strip several times by stopping the circulation of the reactant gas (by shutting down the blower 10 and closing the dampers 11 and 12) and reheating the coil by again circulating heating gas therethrough and through the heater 5.

In any event, by subjecting the strip to the proper gaseous medium for the proper length of time at the proper temperature, the entire strip, either on its outer surfaces only or through its complete thickness, may be modified in its composition. Because of the full area contact of both the heating gas and the reactant gas with the entire surface of the strip, the complete operation may be carried out most economically and in a relatively short time.

Although the procedure described above contemplates one or more cycles of alternate circulation of heating gas and reactant gas through the opened coil, it will be understood that in some cases the conduit 9 and blower 10 may be shut off or omitted and reactant gas circulated through the opened coil and through the heater 5. In such a situation a reactant supply pipe, corresponding to pipe 13, may be connected into the conduit system to permit the reacting agent to be added in proper quantity. Bleed pipe 14 and valve 15 could, of course,

be used to permit and control exhaust and replenishment of the circulating atmosphere.

My improved method is particularly adapted for making steel strip in long lengths of substantially uniform and homogeneous composition throughout. For example, when it is desired to produce mild steel of relatively low carbon content, i.e., below about .008% carbon, in strip form the following procedure obtains excellent results. First, iron is partially refined, as in a Bessemer converter or an open hearth furnace, to produce a mild steel having approximately .012% carbon. This steel is then cast in ingots which are rolled by any suitable procedure to produce strip of a gage or thickness between about .04" and about .10". This strip is formed into tight wound coils which are then converted into opened coils with their laps spaced apart as by the procedures referred to previously in this specification. Next, the entire length of the strip making up an opened coil is subjected, preferably at a temperature from about 1250° F. to 1400° F., to intimate contact with a rapidly moving flow of a suitable decarburizing gas (such as water vapor mixed with hydrogen and nitrogen, or other gaseous agents which have an affinity for and will combine with and remove carbon from the steel without undesirable oxidation) simultaneously over both sides of its entire length. This contact with decarburizing gas is continued at a temperature and for a length of time such that the carbon content of the strip will be reduced to the desired and preferably substantially uniform value throughout the thickness of the strip. By this procedure homogeneous steel strip may be produced having a carbon content from substantially zero up to about .008% at a cost greatly below, and with a much better control of the final product than previous procedures for making such low carbon steel strip which required that the carbon content of the steel be brought down to the desired final low value in an open hearth furnace or the like before rolling into strip form.

In my process the intimate contact of the gas with the entire surface area of both sides of the full length of the strip making up the opened coil accomplishes such an efficient heat transfer between the gas and the metal that the temperature difference between the steel and the atmosphere gases is so small as to be undiscernible with the ordinary furnace thermocouple. This is of importance in my gas modification procedure because, in order to effect decarburizing, or other modifications of the composition of the steel, the temperature of the gas and of the steel should be very close to permit the desired action to take place and the desired control to be maintained. Furthermore, by repeatedly causing a relatively large body of heated reactant atmosphere to be circulated over the surface of the strip at high velocity and in intimate contact therewith, the establishment of equilibrium conditions between the carbon in the gas and the carbon in the steel, such as might occur in the absence of the rapid changing of the gas at each point on the surface of the strip and which would slow down or stop the decarburizing reaction, is prevented and decarburizing takes place at a maximum rate. With my system many gas charges per minute are effected across the entire surface of the coil, the temperature of the gas and steel is substantially the same, and optimum and uniform conditions for carrying out the desired modification may be maintained over the entire area of the strip for the time necessary to secure the desired result.

Although I have described one type of apparatus, and several procedures which may be employed in carrying out my improved process, it will be understood that variations and modifications may be made therein without departing from the spirit of my invention. It will also be understood that, in addition to modification of the chemical composition of the strip metal which is effected by my process, the metallurgical characteristics of the metal may also be modified concurrently by the action of heat

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supplied to the strip by the moving gas. Thus, for example, a coil of strip steel may be annealed and decarburized in a single operation and without taking any more time than would be required merely to anneal the strip.

In view of the above comments, I do not wish to be limited to the exact forms of my method and apparatus herein described but claim as my invention all embodiments thereof coming within the scope of the appended claims.

I claim:

1. Apparatus for modifying the chemical composition of opened coils of strip metal having the laps thereof spaced apart including, a treatment chamber having spaced gas inlet and outlet openings, an inlet conduit extending from said inlet opening and an outlet conduit extending from said outlet opening, means for supporting an opened coil in said treatment chamber and directing gaseous atmosphere vertically through the spaces between the laps thereof, gas atmosphere heating means, gas conducting conduits extending from said outlet conduit to said heating means and from said heating means to said inlet conduit, blower means disposed to circulate gaseous atmosphere through said chamber and the laps of an opened coil supported therein and through said heating means, means for closing one of said gas conducting conduits whereby circulation through said gas atmosphere heating means is prevented, a reactant gas circulating conduit extending from said chamber outlet conduit outside of said chamber and back to said chamber inlet conduit, blower means for effecting circulation of gas through said reactant gas conduit and said chamber and the laps of an opened coil supported therein, means for supplying a gaseous reactant material to the gas circulated through said reactant gas conduit, and means for shutting off said reactant gas conduit from said treatment chamber whereby circulation therethrough is prevented.

2. Apparatus for modifying the chemical composition of opened coils of strip metal having the laps thereof spaced apart including, a treatment chamber having spaced gas inlet and outlet openings, an inlet conduit extending from said inlet opening and an outlet conduit ex-

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tending from said outlet opening, means for supporting an opened coil in said treatment chamber and directing gaseous atmosphere vertically through the spaces between the laps thereof, means for charging an open coil into and removing same from said treatment chamber, gas atmosphere heating means, gas conducting conduits extending from said outlet conduit to said heating means and from said heating means to said inlet conduit, blower means disposed to circulate gaseous atmosphere through said chamber and the laps of an opened coil supported therein and through said heating means, means for closing one of said gas conducting conduits whereby circulation through said gas atmosphere heating means is prevented, a reactant gas circulating conduit extending from said chamber outlet conduit outside of said chamber and back to said chamber inlet conduit, blower means for effecting circulation of gas through said reactant gas conduit and said chamber and the laps of an opened coil supported therein, means for supplying a gaseous reactant material to the gas circulated through said reactant gas conduit, means for shutting off said reactant gas conduit from said treatment chamber whereby circulation therethrough is prevented, a reaction gas bleeder conduit adapted to permit the escape of reactant gas, and valve means for controlling the flow through said bleeder conduit.

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