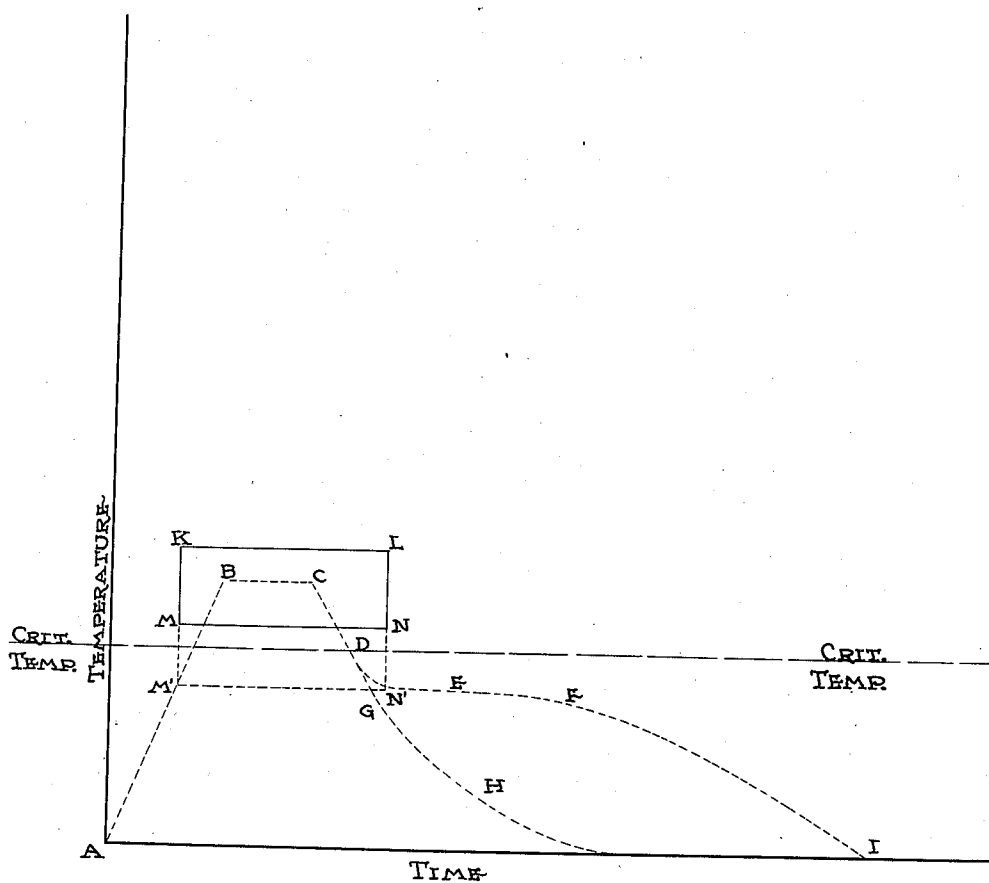


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PROCESS OF HEAT TREATING STEEL

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PROCESS OF HEAT-TREATING STEEL

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This invention relates to the heat treatment of steel strips, sheets, strands, rods, and wires and has for its object the provision of a process for producing on the surface of the steel at the very beginning of the heat treatment a thin, uniform, fine-grained, tenacious, adherent, impervious protective coating which shall shield the steel from oxidation during the remaining steps of the process, and shall also to a considerable degree protect the same from subsequent scaling and weather-oxidation, but without impeding subsequent operations on the metal such as drawing, pickling, painting, etc. Heat treating of some kind is very old, the earlier methods generally entailing the heating and cooling of piled or stacked sheets, and the more recent methods entailing the passing of the sheets through heating and cooling zones in a continuous moving web or rod. The old method exhibited the defects that owing to the large mass to be heated and cooled the times required were long, often 24 hours per cycle, resulting in abnormal grain growth and non-uniformity of treatment as between the interior and exterior of the pile or pack. The next step was the development of the continuous furnace which discharged the steel into the open air at the full furnace temperature, which saved time and grain-growth but entailed two new main difficulties, first, that the action of the air on the hot steel produced excessive scaling, and second, the rapid cooling rate produced excessive hardness. The old process, however, exhibited one advantage which the newer process lacked, namely that it was possible to produce unscaled sheets which the new process could not accomplish. Various attempts were made, such for example as those set forth in the Marsh and Cochran Patent No. 1,610,567, to produce bright annealed sheets but the difficulty of maintaining a true non-oxidizing atmosphere is very great since ferrous metal at all temperatures above a red heat will become oxidized in contact with gases ordinarily recognized as "reducing", such as those produced by the combustion of hydrocarbon fuel with a deficiency of oxygen. Furthermore the rapidity with which the metal passes through the furnace requires that the furnace

be very long if the metal is to be cooled to a point where it can be discharged into the air in a bright annealed condition, since its discharge at any temperature above about 450° F. entails the formation of loosely adherent oxides of the higher chemical valency such as Fe_2O_3 , or Fe_3O_4 .

The object of my invention is not to produce a bright annealed sheet, but rather to produce, in the early stages of the operation, a sub-oxide coating of a nature which will not itself injure the sheet for any subsequent practical use but will itself, when treated as hereinafter described, protect the sheet from the formation of the loosely adherent higher oxides even though the sheet be discharged from the furnace at a rather high temperature.

In the performance of my said invention I employ any kind of continuous furnace, such for example as that set forth in my Patent No. 1,623,469, April 5, 1927, or in my copending application Serial No. 219,886, filed September 16, 1927, and the important procedures are two in number, viz: that the heating of the steel is effected in an atmosphere which is limitedly oxidizing to ferrous metal at the temperature employed for the first step of the process, namely, the heating above the critical range; and, second, the cooling below the critical range is effected in this same limitedly oxidizing atmosphere, after which the sheet can be discharged into a fully oxidizing atmosphere as quickly as one pleases.

This limitedly oxidizing atmosphere is produced, preferably, by burning hydrocarbon fuel in a deficiency of oxygen so as to produce a mixture of H_2O , CO , and a small amount of CO_2 , together of course with N , and sometimes with some free hydrogen or some free carbon or some free hydrogen and carbon though not always. The presence of the incompletely oxidized fuel guards against the presence of free oxygen. The heat can also be secured, if desired, by electrical means, but precautions are often necessary to avoid dangerous explosions if electrical heat be employed alone since the limitedly oxidizing atmosphere is generally explosive unless produced by incomplete combustion methods so that even if electricity be employed as the

main source of the heat required (and it has some marked advantages in respect of distribution and control) it is best to employ at least fuel combustion to produce the necessary atmosphere which must, to effect the purpose of my invention, be of a nature to oxidize the ferrous metal but only to the limited degree mentioned, which is secured when the oxygen required for the purpose is derived by the decomposition of oxygen-containing compounds in the furnace atmosphere, such as CO_2 .

This only occurs at the elevated temperature range and the oxide coating produced is non-progressive, self-protective, tough and so firmly adherent that bending of the sheet does not dislodge it. Furthermore it is stable against further oxidation if only the temperature of the sheet be slightly reduced before its discharge from the particular atmosphere. I have not ascertained the exact temperature at which such film becomes insusceptible to atmospheric oxidation, but it is possible to discharge the sheets thus coated from the furnace at a red heat, e. g. about 1400 F., or any lower temperature without any scaling. The surface of the sheet looks and acts much as does that of a heat-resisting chromium alloy, that is, it exhibits a silky, glossy sheen, often shown iridescent colors when hot but nearly black when cold and without any roughness.

In the drawing accompanying and forming a part of the application I have shown a diagram of the time and temperature relations, showing also the incidence of my invention upon the usual process.

When the steel enters the furnace it is heated quickly from seasonal temperature at A to a temperature at B which is above the critical temperature at which carbon is redissolved and grain-structure altered. It is kept at this temperature for a short time expressed in minutes or seconds depending upon the composition and thickness of the sheet C after which the temperature is dropped rather quickly to D where it falls below the critical temperature. Thereafter the procedure follows either of two courses depending upon circumstances: if, as is preferable, the sheets are still held inside the furnace (or other chamber of restricted heat dissipating nature) the cooling curve follows the path E. F. I.; if discharged immediately into the open air it follows the path G. H. I.

My invention relates only to that part of the diagram comprised within the area K L M N or K L M' N', since it is only within this range that the lower oxide (which I regard as FeO although without committing myself to that composition) is formed. I do not limit myself to any fixed temperature for its formation since the composition of the steel probably affects the same; neither do I limit myself to any fixed critical temperature since the composition of the steel certainly affects

the same. Neither do I assert any relationship between the critical temperature and the area of chemical action I have described since both of the same vary with differences of composition and may or may not coincide. Accordingly I do not limit myself in any wise excepting as specifically recited in the following claims which I desire may be construed, each independently of limitations contained in other claims.

Having thus described my invention what I claim is:

1. The improvement in the method of heat treating steel which consists in heating the same quickly to a temperature above its critical temperature in a limitedly oxidizing atmosphere containing H_2O , CO , CO_2 and N but substantially devoid of free oxygen, and cooling such steel in such atmosphere to a temperature which is both below the critical temperature and below any temperature at which such oxide of iron will react with free atmospheric oxygen to form scale.

2. The improvement in the method of continuous heat treatment of steel sheets, strips, strands, rods, and wires which contains the steps of conveying the same continuously through an atmosphere which is maintained at a temperature above the critical temperature of the steel and containing a mixture of carbon monoxide and carbon dioxide substantially devoid of free oxygen, and reducing the temperature of the steel to a degree below that at which the oxide so formed is reactive to atmospheric oxygen prior to removing the same from said first atmosphere.

3. The improvement in the method of continuous heat-treatment of steel sheets which contains the steps of conveying the same continuously through an atmosphere which is maintained at a temperature above the critical temperature of the steel and which contains a mixture of carbon monoxide and carbon dioxide, and thereafter reducing the temperature of the steel below about 1400° F. while still surrounded by an atmosphere of the composition described and before delivering it into the open air, whereby the decomposition of the carbon dioxide by the metal in the presence of the carbon monoxide produces on the surface of the steel a tough and adherent protective coating which prevents further oxidation of the metal upon its delivery into the open air substantially as described.

In testimony whereof I hereunto affix my signature.

FRANK A. FAHRENWALD.