April 12, 1932. E. S. LAWRENCE 1,853,439

METHOD OF HEAT TREATING STEEL

Filed April 22, 1929 2 Sheets-Sheet 1

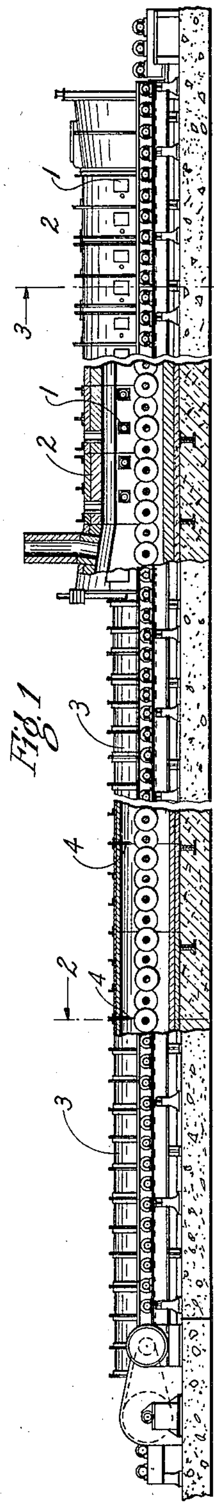


Fig. 1

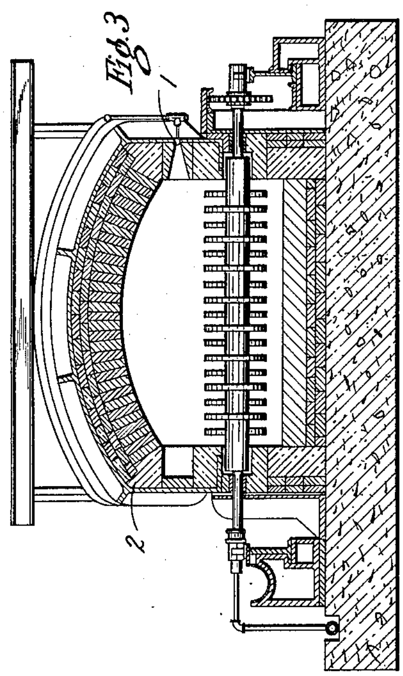


Fig. 3

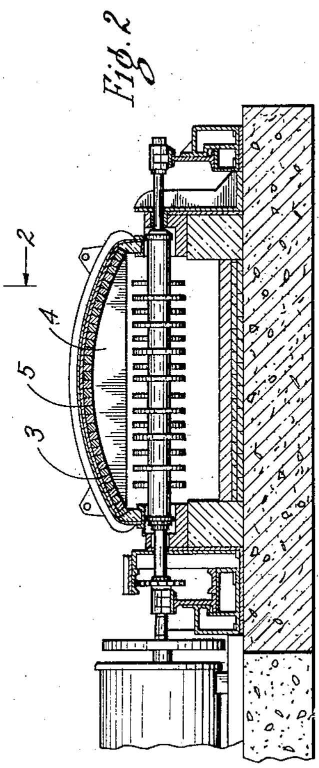


Fig. 2

INVENTOR
EDWARD S. LAWRENCE
BY Richey & Watts
ATTORNEY

April 12, 1932. E. S. LAWRENCE 1,853,439

METHOD OF HEAT TREATING STEEL

Filed April 22, 1929 2 Sheets-Sheet 2

Fig. 4

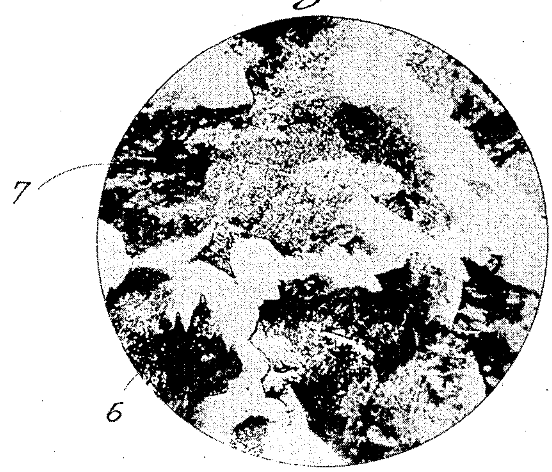
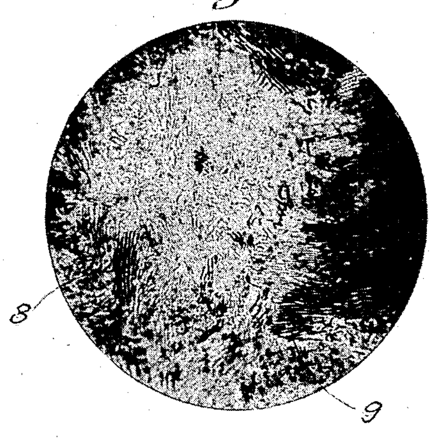


Fig. 5



INVENTOR
EDWARD S. LAWRENCE
BY Richey & Watts
ATTORNEY

Patented Apr. 12, 1932

1,853,439

UNITED STATES PATENT OFFICE

EDWARD S. LAWRENCE, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO THE DURALOY COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF DELAWARE

METHOD OF HEAT TREATING STEEL

Application filed April 22, 1929. Serial No. 356,965.

This invention relates to the art of continuously heat treating sheet steel, and more particularly to a method and apparatus for heat treating low to medium carbon steel sheets or strips to give the steel deep drawing properties.

Heretofore, the practice in producing drawing properties in low to medium carbon steel sheets or strips, that is, steel containing carbon up to .35% has generally followed one or the other of two fairly well defined heat treating processes. According to the first of such heat treating processes the hot rolled steel was first box annealed to relieve rolling strains. Then the boxes were removed from the furnace and the steel when cold was pickled to remove scale and was usually cold rolled for surface. Then the steel was repacked in boxes and again heated, but at a lower temperature, to refine the pearlitic structure and thereby to soften the steel. This process was necessarily expensive because of the many hours required for each heating step, the apparatus and extensive floor space required, and the labor necessary to load and unload the boxes and put them into and withdraw them from the furnaces. Moreover the physical properties and microstructure of the steel were not such as would permit of the difficult drawing operations now being demanded in present manufacturing operations. According to the second of such heat treating processes the hot rolled steel was passed through a normalizing furnace to relieve rolling strains and caused a recrystallization of the grains of the steel, for example, a continuous furnace of the type illustrated and described patents of A. T. Kathner Nos. 1,725,398 and Reissue No. 17,413, the patent of Marsh & Cochran No. 1,610,567, or the patent of F. J. Winder No. 1,738,130. The normalized steel was pickled and in some cases cold rolled. Then it was box annealed to refine the pearlitic structure and to make the steel suitable for difficult drawing operations.

The normalizing step gave the steel basic properties desirable for difficult drawing operations but these properties were brought out or developed to the necessary extent only by the subsequent box annealing step. This box annealing step had the same general effect on the normalized steel, as regards softening the steel and refining the pearlitic structure, as it had on box annealed steel treated by the first described process. By this second process the normalizing furnace made possible the elimination of the first box annealing step and constituted a decided advance over that process in such respects as: Length of time required for treatment of the steel; apparatus and space involved; labor costs in carrying out the method; and improvement in the microstructure obtained in the steel.

By my present invention I am enabled to completely eliminate both of the box annealing steps heretofore used and yet to obtain physical properties and microstructural characteristics which render the treated steel especially thin gauge sheets susceptible to difficult drawing operations and which have not been obtained heretofore, so far as I am aware, except by processes which included the second box annealing step.

My improved method may be briefly described as consisting of the steps of continuously heating and then cooling medium to low carbon steel in sheet or strip form. In the heating, the steel is heated to above the upper critical temperature range for such a length of time as is required to relieve substantially all strains set up in the steel by previous operations and to permit a recrystallization of the steel. After the grains have grown to the desired size, the growth of the recrystallized grains is arrested, following which the steel is cooled in such a manner that the recrystallized grains are converted into a structure in which the pearlite is changed from an emulsified or sorbitic state into a partially laminated condition. The step of heating the steel to remove strains and permit recrystallization may be carried out at various temperatures above the upper critical temperature range of the particular steel being treated, while the grain-growth-arresting or setting operation may be accomplished by passing the recrystallized structure into a cooler or cooling zone having a lower temperature than the temperature at which the recrystallization is carried out, this arresting or setting operation being controllable by maintaining a predetermined ratio between the difference in temperatures in the heating and cooling zones and the speed of travel of the recrystallized steel through the heating and cooling zones. The steel then cools gradually and uniformly throughout all parts thereof, the time and the rate of cooling being sufficiently prolonged to permit the emulsified or sorbitic pearlite to assume a partially laminated condition without causing any material furtherance of grain growth.

In the drawings forming a part of this specification

Fig. 1 is a side elevation, partly in section of a furnace embodying and suitable for practicing my invention;

Figs. 2 and 3 are respectively cross sectional views through the heating and cooling chambers of the furnace of Fig. 1;

Fig. 4 shows pearlite in an emulsified or sorbitic state at a magnification of about 750 diameters; and

Fig. 5 is a similar view showing the partially laminated pearlite.

In carrying out my method, I may employ a furnace of the general construction disclosed in the above mentioned Kathner Winder and Marsh & Cochran patents, but have chosen to refer herein to a furnace of the Kathner type. The herein described furnace is an elongated tunnel-like structure provided with heating means 1 near one end thereof to heat that portion 2 of the furnace which may be considered as a heating zone. The remainder of the furnace has a lower roof and may be considered as a cooling zone 3. I prefer to provide in the cooling zone 3 one or more baffles 4, extending downwardly from the roof 5 to a point adjacent to the top of the material passing through the furnace to deflect the waste gases downwardly and about the cooling steel. The cooling zone 3 is much longer than the heating zone 2 and is sufficiently long to permit the formation of the partially laminated structure just described before the steel emerges from the furnace.

As illustrative of my invention, 18 gauge (U. S. S.) steel sheets or strips having a carbon content of .10% when treated according to my improved method will have practically all hot rolling strains relieved while the steel is in the heating zone of the furnace, and the recrystallized ferrite grains formed in the heating zone will be well defined and thoroughly equiaxed with a size which may range from about .00033″ to about .0015″ (under 100 diameters magnification) with practically no pearlite being visible. During the passage of such a steel from the heating zone into the cooling zone the steel is reduced sufficiently in temperature so that no material grain growth takes place. The slow, gradual and uniform cooling of such steel in the cooling zone 3 of the furnace results in a change in phase condition of the pearlite from a sorbitic or emulsified state, as illustrated in Figure 4, to a partially laminated state, as illustrated in Fig. 5. This cooling and change are important in imparting to the steel exceptionally good drawing qualities. In Fig. 4 the pearlite is in an emulsified condition and consists of particles 6 of ferrite and particles 7 of cementite. In Fig. 5 the cementite particles 7 have partially segregated and are shown at 8 in a stratified condition while the ferrite is shown at 9. Steel of the above mentioned carbon content and gauge when so treated is in part characterized by a hardness of from about 40 to 48 as measured on the B scale of a Rockwell hardness testing machine and in part by properties which adapt it to difficult drawing operations. Such a steel so treated has properties which are as good as or better than those of the same steel treated by processes which included the last box annealing step.

The foregoing example of steel composition is fairly typical of compositions of steel requiring difficult drawing properties but steels containing as much as .35% of carbon are often subjected to stamping operations and may be satisfactorily heat treated by my method and apparatus for such operations.

It will be understood that by my method clean steel is heated substantially uniformly throughout all its parts and hence possesses a substantially uniform recrystallized structure throughout. The operation of arresting the growth of the grains also takes place uniformly throughout the steel and the slow and prolonged cooling is likewise uniform throughout the steel so that the resultant product may be said to be uniform in all parts thereof.

As illustrative of the relative lengths of heating and cooling zones, I may employ a furnace having a heating zone of about 75 feet in length and a cooling zone of about 125 feet or more in length when 18 gauge steel sheets of .10% carbon content and 72 inches in width are to be treated singly or in packs in the amount of about 175 tons per day.

By my invention I am thus enabled to carry out in one continuous operation the heat treatment of low to medium carbon strip or sheet steel from the condition in which it comes from the hot rolling mill to a condition in which it possesses properties suitable for difficult drawing operations. I am able to so heat treat in about one hour a quantity of sheet or strip steel which by the previous processes would require about five days. My resultant product should be pickled and thereafter may be used immediately for various purposes including severe drawing operations.

While I have disclosed my invention in some detail I do not wish to be limited to the details set forth above. The scope of my invention is defined in what is claimed.

What is claimed is:

1. The improved method of heat treating low to medium carbon steel in strip or sheet form which comprises passing the steel through a continuous furnace having communicating heating and cooling zones; heating the steel in the heating zone to a temperature above the upper critical temperature range thereof in a manner to relieve substantially all rolling strains in the steel and to permit recrystallization of the grains of the steel; arresting the growth of the recrystallized grains when they have attained a desired size; and then cooling the steel substantially uniformly throughout all its portions in the cooling zone in a manner not only to prevent further substantial grain growth but also to produce a partially laminated structure of pearlite, and thus heat treated steel having a structure and physical properties substantially equivalent to the structure and physical properties of the same steel heat treated by a process which includes a final box annealing step.

2. The method of heat treating low to medium carbon sheet or strip steel which comprises passing the steel through communicating heating and cooling zones, heating the steel in the heating zone to above the upper critical temperature range of the steel, arresting the growth of the grains when they have attained a desired size, and then cooling the steel in a manner to produce a partially laminated pearlitic structure which is substantially uniform throughout all portions of the steel, the thus heat treated steel having a structure and physical properties substantially equivalent to the structure and physical properties of the same steel heat treated by a process which includes a final box annealing step.

3. The method of heat treating which comprises moving low to medium carbon sheet or strip steel progressively through an elongated zone of substantially non-oxidizing gases, and, while the steel is in said zone, heating the steel to above its upper critical temperature range, then cooling the steel quickly and sufficiently to arrest grain growth and then continuing the cooling at a slower rate until the pearlite of the steel has attained a partially laminated structure.

4. The continuous method of heat treating of low to medium carbon sheet or strip steel which comprises progressively heating and cooling the steel in the presence of substantiallly non-oxidizing gases, the steel being first heated to above its upper critical temperature range, then cooled quickly to arrest grain growth and then cooled more slowly until a partially laminated pearlitic structure is obtained.

In testimony whereof I hereunto affix my signature this 5th day of April, 1929.

EDWARD S. LAWRENCE.