Patented May 5, 1925. 1,536,663

UNITED STATES PATENT OFFICE.

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METHOD OF MANUFACTURING STEEL SHEETS.

No Drawing. Application filed October 13, 1924. Serial No. 743,497.

To all whom it may concern:

Be it known that I, OTTO HERRON CUNNINGHAM, a citizen of the United States and a resident of Brackenridge, in the county of Allegheny and the State of Pennsylvania, have made a new and useful Invention in Method of Manufacturing Steel Sheets, of which the following is a specification.

This invention relates to the manufacture of steel sheets and particularly to sheets capable of meeting the requirements of the automobile and metal furniture trade where difficult stamping operations are encountered and where a high surface finish is necessary.

An object of this invention is to provide a method whereby low carbon steel sheets having a highly finished surface and suitable for deep stamping operations can be uniformly produced at a relatively low cost.

Another object of this invention is to provide a method whereby low carbon steel sheets having a highly finished surface and free from Stead's brittleness can be produced at a relatively low cost.

A further object of this invention is to provide a method whereby steel sheets of uniform quality and free from Stead's brittleness and having a highly finished surface can be produced at a relatively low cost.

In the standard commercial methods of producing what are now known as high grade sheets for said trades, the ingots are first rolled into sheet bars which are cut up in lengths corresponding to the width of the sheets to be produced. The sheet bars are heated and roughed down in a two high mill to a definite length which length is determined by the final length of the sheet required. The roughed down sheets are then matched or paired, reheated and finished to length and gauge.

In this process, the number of sheets rolled in one pack and the number of times heated are determined by the final gauge and length of the sheet and the final length and gauge produced in the hot mill is approximately the final length and gauge of the finished sheet.

In order to obtain the surface finish necessary in these trades, the sheets, after being hot rolled, are pickled to remove the scale, then cold rolled to give the desired surface and then annealed to remove stiffness and strains.

It is extremely important that these sheets be properly annealed to adapt them to difficult stamping operations, but the annealing of these cold rolled and highly finished sheets is rendered difficult because of the phenomenon known as Stead's brittleness. This phenomenon occurs when hot rolled steel sheets having a low carbon content are cold roll finished and subsequently annealed at a low temperature. The fact that the sheets are pickled and cold rolled finished whereby a smooth polished surface is obtained necessitates low temperature annealing, since the smooth polished surface would stick or weld together if box annealed at normalizing temperature.

This phenomenon manifests itself in a growth of the ferrite crystals which causes the sheets to become extremely brittle.

It is well known that Stead's brittleness can be corrected by increasing the temperature of the anneal or increasing the reduction made during cold rolling. It is impossible to increase the anneal in the ordinary sheet process to a temperature sufficiently high to eliminate Stead's brittleness for the reason that at this temperature, which is in the neighborhood of 1650° F. the sheets will stick or weld together in the standard commercial box anneal process.

It has been shown by various researches that if low carbon steel is subjected to cold roll reduction in excess of 10 per cent, Stead's brittleness will not occur, even though the steel is annealed at a temperature below the normalizing temperature of 1650° F. This knowledge has, so far as I know, never been utilized in the manufacture of high grade sheets. The work done on the cold rolls has been confined merely to improving the surface and has not been sufficient to eliminate the strains that produce recrystallization during annealing.

In the regular commercial processes with which I am familiar, after the sheets have been hot rolled it is customary to anneal in some cases up to the normalizing temperature to pickle and then to cold roll in one, two or three passes with a total cold roll reduction that rarely exceeds 5 per cent. After the cold rolling, the sheets are reannealed at a low temperature made neces-

sary in order to prevent sticking of the smooth polished surfaces.

So far as I know, whenever hot rolled sheets have been cold rolled in order to improve or obtain the surface finish required in the automobile, metal furniture and other trades, when similar sheets are required, the cold rolling has invariably resulted in crystallization of the ferrite structure and consequently has produced brittle sheets.

In carrying out this method, sheet bars of the proper length and gauge are produced according to standard practice. The sheet bars are then hot rolled according to standard practice to a length considerably less than the length of the sheet required or to be more definite, to a length which will require a reduction of at least 10 per cent of the total reduction (the reduction from the gauge of the sheet bar to the gauge of the finished sheet) to bring the sheet to the final length and gauge required.

The semi-finished sheets are then annealed or normalized at a temperature of from 1600° F. to 1700° F. The normalized sheets are then pickled to remove the scale and are then cold rolled to length.

The cold rolled sheets are then reannealed at a relatively low temperature in order to prevent sticking or welding. Low temperature annealing can be utilized since recrystallization will not occur due to the cold roll reduction of at least 10 per cent.

The cold rolled reduction of at least 10 per cent is preferably obtained in one pass, although I find that satisfactory results can be obtained if two or more passes are used.

I have found that instead of normalizing the semi-finished sheets, satisfactory results can be obtained, especially when rolling sheets of heavy gauge, if the sheets are brought to the semi-finished gauge (that is, the gauge where hot rolling ceases and cold rolling begins) in the hot mill at a normalizing temperature. That is, if the sheets are discharged from the hot mill at a normalizing temperature and thereafter pickled, cold rolled and reannealed as above described.

I find that sheets made in accordance with this method are uniform as to drawing and stamping qualities and due to the cold rolling have a highly finished surface such as required in the trades referred to.

Having thus described my invention, what I claim is:—

1. The method, which consists in hot rolling steel sheets to a size considerably less and a gauge considerably greater than the size and gauge of the finished sheets, in then annealing the sheets at a normalizing temperature, in then pickling the sheets to remove the scale, in then cold rolling the sheets to length and gauge and then in annealing the sheets at a temperature below the normalizing temperature.

2. The method, which consists in hot rolling steel sheets to a gauge which is at least 10 per cent greater than the gauge of the finished sheets, in then annealing the sheets at normalizing temperature, in then pickling the sheets to remove the scale, in then cold rolling the sheets to length and gauge and then in annealing the sheets whereby sheets of uniform quality having highly finished surfaces and free from Stead's brittleness are obtained.

3. The method, which consists in hot rolling sheets to a size considerably less than the size of the sheets required, in then annealing the sheets at normalizing temperature, in then pickling the normalized sheets to remove the scale, in then cold rolling the pickled sheets to length and gauge and then in box annealing the sheets.

4. The method, which consists in hot rolling sheets to a size considerably less than the size of the sheets required, in then annealing the sheets at normalizing temperature, in then pickling the normalized sheets to remove the scale, in then cold rolling the pickled sheets to length and gauge and then in box annealing the sheets at a temperature below normalizing temperature.

5. The method, which consists in hot rolling sheets to a gauge which is at least 10 per cent greater than the gauge of the finished sheets, in then annealing the sheets at a normalizing temperature, in then pickling the sheets to remove the scale, in then cold rolling the sheets to length and gauge and then in box annealing the sheets whereby sheets of uniform quality having highly polished surfaces and free from Stead's brittleness are obtained.

6. The method, which consists in hot rolling sheets and in discharging them from the hot mill at normalizing temperature and of a size considerably less and a gauge considerably greater than the size and gauge of the finished sheets, in then pickling the sheets to remove the scale, in then cold rolling the sheets to length and gauge and then in annealing the sheets at a temperature below normalizing temperature.

7. The method, which consists in hot rolling steel sheets and in discharging the sheets from the hot mill at normalizing temperature and of a gauge which is at least 10 per cent greater than the gauge of the finished sheets, in then pickling the sheets to remove the scale, in then cold rolling the sheets and then in annealing the sheets.

In testimony whereof, I have hereunto subscribed my name this 8th day of October, 1924.

OTTO HERRON CUNNINGHAM.