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SHEET METAL PRODUCING PROCESS

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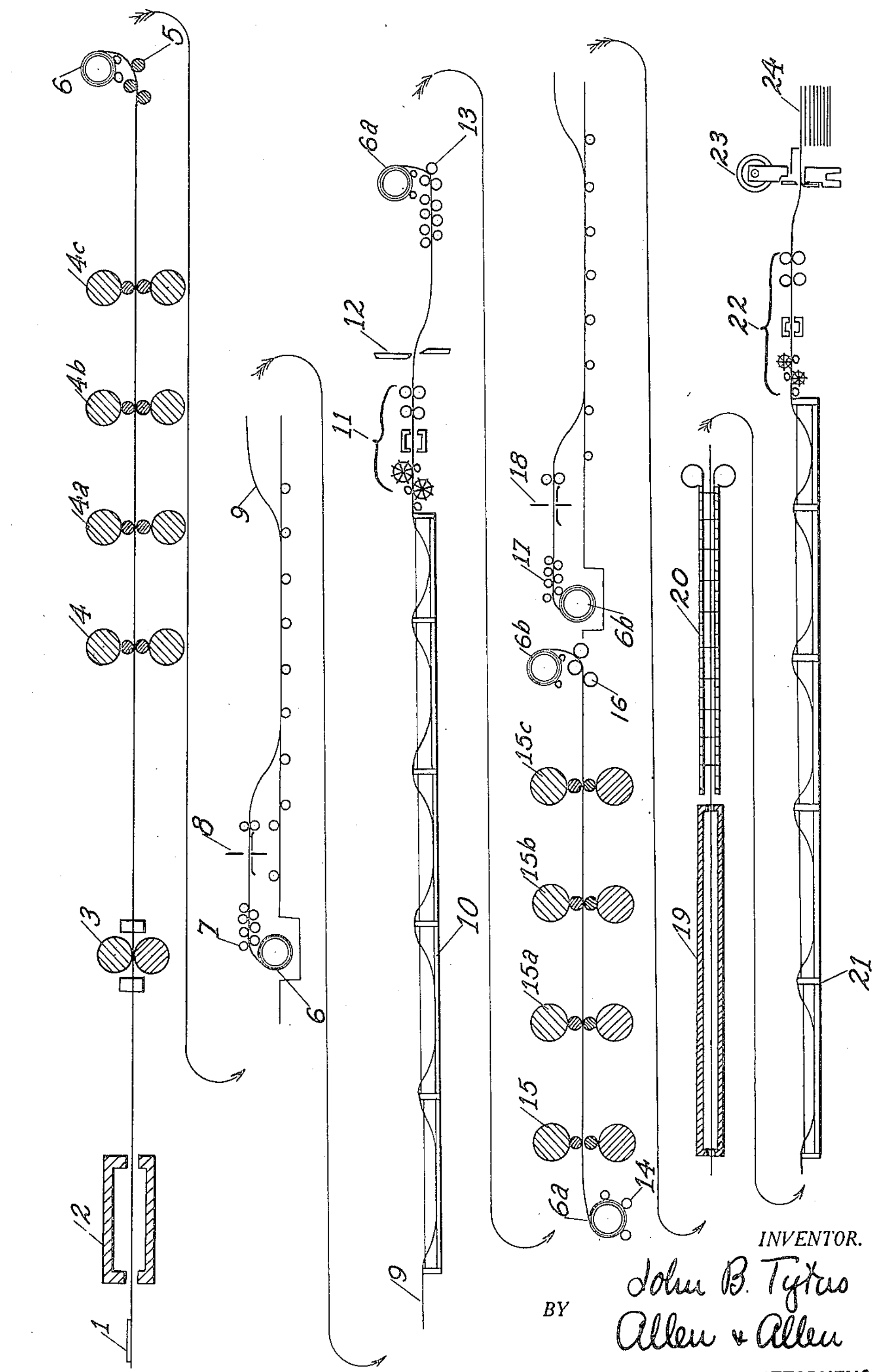


INVENTOR.
John B. Tytus

BY Allen & Allen

ATTORNEYS.

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JOHN B. TYTUS, OF MIDDLETOWN, OHIO, ASSIGNOR TO THE AMERICAN ROLLING MILL COMPANY, OF MIDDLETOWN, OHIO, A CORPORATION OF OHIO

## SHEET METAL PRODUCING PROCESS

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My invention is of importance in processes of producing sheet metal which involve a cold rolling operation which is of substantial character and is relied upon at least in part to bring the metal to gauge. One way of making sheet iron or steel comprises hot-rolling to gauge, pickling and finishing in any way desired. But for many uses a cold rolled product is to be preferred. To make it, it is usual to practice a preliminary hot-rolling, as of a sheet bar to a thick sheet, or a slab to a wide strip, pickle, and then cold roll to gauge with a substantial reduction. An annealing normally follows the cold rolling. The process may be carried out discontinuously or in the so called continuous manner.

My invention comprises a new procedure in the manufacture of iron and steel sheets, and particularly a new sequence of process steps in a process involving heavy cold rolling. While its usefulness is not restricted thereto, it has the effect of facilitating the operation of continuous processes of producing sheet metal; but more primarily it is directed to the production of new sheets having properties hitherto unattainable.

In order that my invention may be understood, it is necessary to point out some of the problems involved in the continuous or discontinuous processing of sheet metal which are solved by my invention. As an example of a continuous process in present use (and discontinuous processes are likely to present the same difficulties, as will presently be outlined, in even an enhanced measure) sheet metal or iron may be made by hot rolling a slab to form a strip, pickling, cold rolling the strip to gauge, box annealing the cold-rolled strip in coils, and skin passing, if desired. As a substitute for box annealing, or as an extra step in the process, a continuous annealing may be used. The strip may be sheared into sheet length before the box annealing, and annealed in packs. Continuous annealing may comprise passing strip or stitched sheets through a furnace of horizontal type maintained at a suitable temperature for annealing, and of such length, taken together with the speed of travel of the material therethrough, as will allow the proper time interval for the heat treatment.

The first difficulty arises in the lack of uniformity of the hot-rolled strip. With a given batch of metal, if the temperature of the slabs being rolled were always uniform throughout the hot-rolling operation, the product would be to all intents and purposes uniform. But there will be variations in the temperature of individual pieces passing through the train of rolls, and the resultant strips formed from these pieces will exhibit more or less strains according to the temperature. The variations are likely to be greater in discontinuous than in continuous operations. They will inevitably occur unless the rolling be done with the stock always well above the A3 point at the end of the rolling operation. Thus hot rolled strip or sheet will not be entirely uniform in physical characteristics.

Such non-uniformity in physical characteristics as results from this cause will obviously persist through the subsequent cold-rolling operation. Nor, as will hereinafter be pointed out, can it be eliminated by any method hitherto suggested at any stage in the process which does not involve operating difficulties. It cannot, specifically, be eliminated by annealing treatments. These are heat treatments of time and temperature variables; they are carried out below the A3 point of the metal involved.

It is common practice in the manufacture of cold rolled products at times to give intermediate annealings. Upon recoiling such annealed stock it is strained beyond its elastic limit in many places, these strained areas being known as "cross breaks" or "coiler breaks". In difficult drawing operations these cross breaks again become evident as welts across the drawn pieces, even though the sheet process has proceeded with additional cold-rolling and box annealing. Obviously also the same difficulty resides in the annealing of the sheet subsequent to all cold-rolling to gauge. And it is not possible by annealing to remove all of the directional strains left in the product by the rolling operations.

Again, since annealing involves considerations of time, temperature, atmosphere and the like, and since continuous annealing operations are limited by the apparatus employed and the commercial considerations of speed of travel, further difficulties arise. Box annealing is thus far the most carefully controlled type of annealing and gives best results. It has already been pointed out why it is unsuitable for intervening annealings in a cold rolling process of continuous character. Hence such intervening heat treatments as have been necessary have usually been of the continuous type; and box annealing is preferably carried on with the strip cut apart in sheets and placed in the boxes in packs. But while in box annealing the general conditions of time, temperature and atmosphere may be most carefully controlled, there is a limit upon the temperatures practicable, and further, there is a lack of uniformity in the heat treatment in any given box, because it is not possible to heat all parts of coils or packs to the same temperature under identical conditions.

However, non-uniformity persists through all of these annealing treatments whether continuous or box. Broadly, it is not possible to produce metal of absolute uniformity so far as strains are concerned arising from previous working, excepting the metal be heated above the A3 point, or into the lower part of the gamma range. This cannot be done in ordinary box annealing. In other words, in commercial practice, it is not practicable to attempt to normalize in a box.

But it is practicable to normalize otherwise, and it is commercially advantageous to normalize continuously. By process, most briefly stated, comprises a substantial cold-rolling followed by a normalizing treatment. So far as I am aware, this is broadly new; and in this application I desire to secure patent protection upon its broader aspects.

By this proces I am able to make sheets of great uniformity as between individual pieces. My sheets are characterized by a fine and uniform grain, are practically free from non-uniformity of physical properties in the piece, and show no evidence of directional properties. They are practically free from any tendency to "cross breaks". They have the further advantage that they may be produced continuously and rapidly with the attendant commercial savings. My sheets are a new product, and it is to be pointed out that they differ from a hot rolled and normalized product as will be shown, and further that the process of this application may be carried further, as by an additional annealing step to the formation of still other products. In an application of even date herewith, and bearing Serial Number 333,263 I have described and claimed a process involving cold-rolling, normalizing, and annealing.

The objects of my invention set forth above, and others which will be set forth hereinafter or will be obvious from what follows, I accomplish by that certain process of which I shall now describe a preferred embodiment, reference being had to the drawing accompanying these specifications, and which shows in sequence the steps of my process. The drawing is diagrammatic; the instrumentalities which I employ in effecting my process are not per se new.

The preferred embodiment which I shall describe is a continuous process for the formation of sheets from wide strips, which in turn are rolled from slabs. Its analogy to other processes in which my invention will find equal usefulness will be readily understood by one skilled in the art.

A slab 1, which may be cold, is heated to a temperature for hot-rolling in a billet heating furnace 2, usually of the pusher type. The hot slab may then be passed through a universal mill 3 with edging passes, and then through a tandem of four four-high mills 4, 4*a* etc. It is now in the form of a hot-rolled strip which is coiled on a coiler 5 into the coil 6.

The coil 6, at the start of the next step, is placed in an uncoiler 7. As additional coils are processed the ends thereof may be connected together by a traveling spot welder 8 or otherwise, so that to all intents and purposes a continuous traveling strip of metal is formed for further processing. This strip, which I have indicated as 9, passes through a continuous pickling tank 10, which may be equipped with a scrubber and drying furnace indicated broadly at 11, and is then, after having been sheared apart into strips again by a shear 12, recoiled into a coil 6*a* by a coiler 13.

When ready for the next step the coil 6*a* is uncoiled in an uncoiler 14. The next step is a cold-rolling to gauge, and is to be distinguished from a mere skin passing, or rolling for leveling or the like. It is such a cold rolling as results in a substantial reduction of the metal, and is relied upon to produce substantially the required finished gauge. It may be accomplished by a tandem of four or more four-high cold rolls, indicated at 15, 15*a* etc. The operation is usually finished by a recoiling into coils on a recoiler 16.

Next, an uncoiler 17 straightens out the coil 6*b*, and again a traveling spot welder 18, a stitcher, or other suitable device connects the strips serially for continuous processing. The band of metal is conducted through a heat treating furnace 19 which will be preferably fitted with a cooling duct 20. A normalizing process is carried on in this furnace, and I desire it to be understood that by this term I mean such a heat treatment as will bring the metal above the A3 point, or into the lower part of the gamma range and then quickly cool it, as distinguished from a mere annealing. By doing this I recrystallize the entire sheet with a fine, uniform grain. In other words, at this point I bring about such a rearrangement of the structure of the metal that all strains of whatever character hitherto produced in it are wiped out as though they had never been. Such a rearrangement is a thing which occurs naturally when the normalizing temperature is reached. For the normalizing of steel or iron of any given carbon content, the necessary temperature may quickly be determined from the well known iron-carbon equilibrium diagram for the critical range.

My new sheet has thus been hot-rolled, cold rolled, and normalized. As one result of this the strains which have been put into it both as the effect of the hot and the cold rolling are completely relieved. I have already pointed out that my product is characterized by uniformity in bulk and in the piece, by lack of directional properties, and by lack of "cross breaks". It is also necessary to point out that it differs from and is superior to ordinary hot rolled and normalized steel in a number of respects. First it has a superior uniformity of grain size and structure. The reasons for this and the other points of difference in my product are matters of physical structure upon which I do not wish to be bound by theory. A long series of tests has demonstrated the differences. Possibly due to grain size inheritance, or some other reason, the grains in my product are more uniform in size and shape throughout the entire cross-section of the sheet than they are in the older hot-rolled and normalized sheet steel. When heavily cold-worked steel is heated to the upper part of the alpha range it recrystallizes with a fine grain, and the more the cold work, the finer the grain. Then when this fine grained iron is converted to gamma iron by a further increase of temperature, it is possible that the newly formed gamma grains are more uniform than when formed from much coarser alpha grains as would be the case in normalizing hot-worked steel. In turn then, the new alpha grains formed by cooling comparatively quickly through the Ar3 point would be small and more uniform.

Secondly, in regular hot mill practice it is not unusual to encounter irregularities in thickness due to the uneven flow of the metal in the hot mill caused by an improper amount of center in the stock or improper shape of the rolls. This condition will show up as welts or ridges across deeply drawn forms, and will cause rejections. My improved sheet does not have this defect, which is known as "mill choke".

Thirdly, when the surface of the old type of hot rolled and normalized steel shows irregularities, due to rough rolls or other causes, and the material is normalized in this condition, the portions which are high, upon being subsequently cold rolled receive more cold work than the lower portions. Thus they become harder, and they remain so even through a subsequent box annealing. When such metal is drawn, the harder spots stand up in relief and give rise to the defect known as "open surface" or "orange peel" in the drawn article. My new sheet is free from this defect. In it a normalizing has been practiced subsequent to all hot- and cold-work to gauge.

So far as I am aware, continuous furnaces have not hitherto been used for heat treating operations above the A3 point, i. e. for normalizing cold reduced material when the cold reduction has been of the order of 20% or higher. Ordinary annealing is a function of time and temperature as well as other conditions, and as has already been pointed out the control of all of these conditions is difficult in continuous operation. No such difficulty, however, attends continuous normalizing, and it is only necessary to raise the furnace temperature to such a point as to cause the sheet with certainty to reach the A3 point, to accomplish this end. The time of the treatment is unimportant providing the temperature is attained, the change occurring at that temperature; and indeed it is a thing which may be controlled by visual examination, if desired. The sheet or strip is normalized when the dark spots disappear. Normalizing implies a comparatively quick cooling, and the continuous furnace and its equipment are well adapted for this.

After the normalizing, the strip is conducted through a pickler 21. Scrubbers and drying furnace, indicated at 22, may again be used, and the strip is sheared by a shear 23 into sheets 24. They may be left in this condition, or finished as may be desired, possibly by skin passing through cold rolls. For some uses the pickling step last described may be omitted; again, my process as described may serve as the foundation for subsequent treatment by annealing or otherwise. Such a process is described and claimed in my copending case hereinabove referred to.

The instrumentalities in my process, which I have indicated diagrammatically in the drawing are all well known and require no description. Nor is my process restricted to instrumentalities of a particular type or the operation thereof as described. Thus, as an example, instead of carrying my process through with strip, I may use sheets which will preferably be connected together by stitching for the continuous parts thereof. Or again, each step of my process may, if desired, and at some sacrifice of economy, be carried on discontinuously. Various modifications may be practiced without departing from the spirit of my invention, or varying that sequence of process steps with which my invention is concerned. Having thus described my process, what I claim as new and desire to secure by Letters Patent is:

1. The process of producing sheet metal which comprises cold-rolling the metal to gauge, and afterwards heating the metal at least to the A3 point, and quickly cooling it.

2. That process of producing sheet metal which comprises forming metal into sheet gauge by hot and cold rolling and afterwards subjecting said metal to a normalizing treatment, whereby strains due to working are completely removed.

3. That process of producing sheet metal which comprises cold-rolling the metal to gauge and afterwards normalizing it.

4. That process of continuously producing sheet metal which comprises cold rolling to gauge, normalizing and pickling in the order named.

5. That process of producing sheet metal which comprises the steps of cold rolling to gauge, continuously normalizing, continuously pickling, shearing and skin-passing in the order named.

6. That process of producing sheet metal which comprises hot rolling slabs to form strips, interconnecting said strips and pickling them, shearing into strips, cold-rolling said strips to gauge, interconnecting said strips and continuously normalizing and pickling them.

7. That process of producing sheet metal which comprises hot rolling slabs to form strips, interconnecting said strips and pickling them, shearing into strips, cold-rolling said strips to gauge, interconnecting said strips and continuously normalizing and pickling them, shearing them into sheets and skin-passing said sheets.

8. That process of producing sheet metal which comprises hot-rolling, pickling, cold-rolling to gauge, normalizing, and pickling in the order named.

9. That process of producing sheet metal which comprises hot-rolling, pickling, cold-rolling to gauge, normalizing, pickling, shearing to sheets and skin passing, in the order named.

10. That process of producing iron or steel sheets of a carbon content less than .25 which comprises cold-rolling metal of said character to gauge, and afterwards heating said metal at least to 1650 degrees F. followed by a rapid cooling.

11. That process of producing iron or steel sheets of a carbon content less than .25 which comprises hot rolling metal of said character, pickling, cold-rolling said metal to gauge, heating said metal at least to 1650 degrees F. and quickly cooling it, pickling, shearing said metal to the desired length, and skin passing.

JOHN B. TYTUS.