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N. P. GOSS

2,165,368

SHEET METAL AND METHOD OF MANUFACTURE

Filed Feb. 20, 1936

Fig. 1.

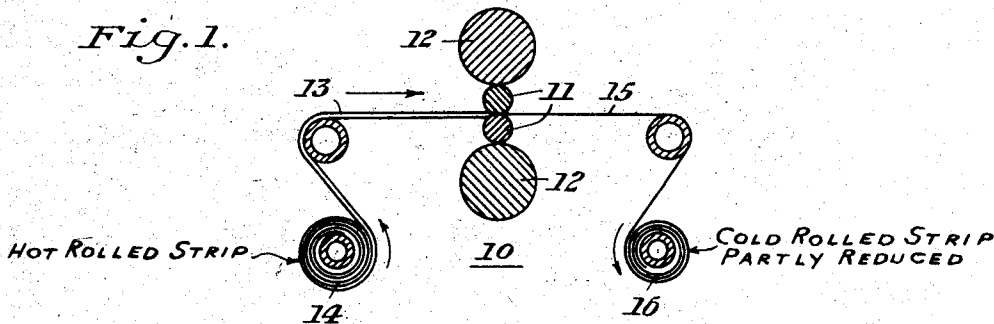


Fig. 2.

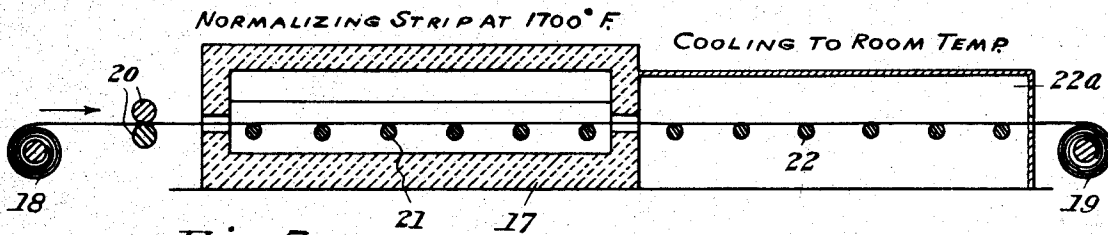


Fig. 3.

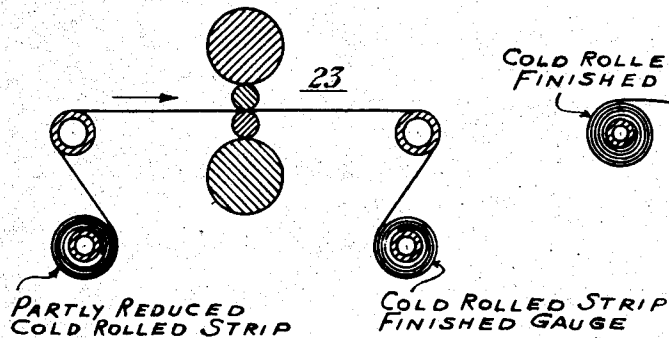


Fig. 4.

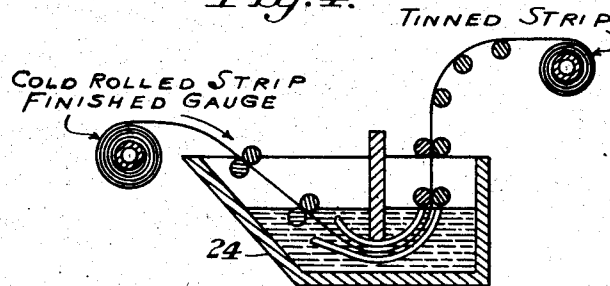
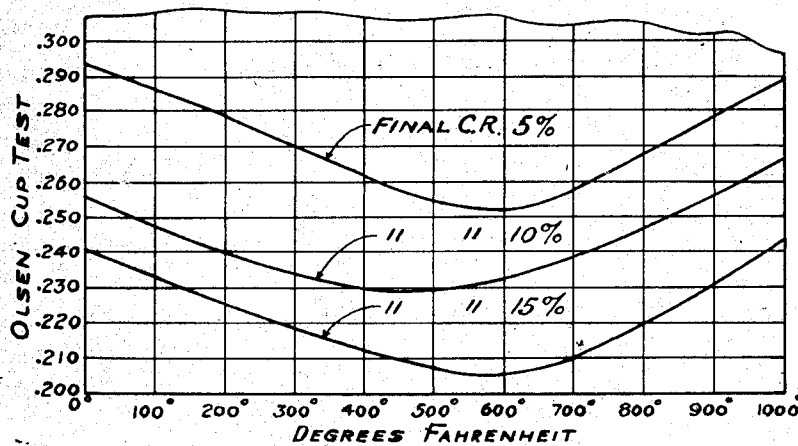


Fig. 5.

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UNITED STATES PATENT OFFICE

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SHEET METAL AND METHOD OF
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7 Claims. (Cl. 148—4)

My invention relates to sheet metal and a method by which it is manufactured. Specifically, the invention relates to sheet steel in the lighter gauges such as tin plate, tin mill black plate, and terne plate, suitable for container stock.

It has not been possible heretofore to produce thin sheet steel suitable for container stock having the combined properties of stiffness and workability. Sheet steel now available that can be readily formed or stamped does not possess sufficient strength to resist deformation in ordinary handling, packing, and shipping, and furthermore lacks the resilience desirable for the manufacture of containers. Sheet steel now available which is thick enough to have the strength required to resist such deformation in handling cannot be readily stamped and formed into cans with satisfactory result. While considerable effort and money have been expended in an endeavor to produce material having the characteristics mentioned the desired results have not been achieved. My invention for the first time makes it possible to produce a material thinner than that now used for cans, possessing both the properties of stiffness and workability, and, therefore, highly suitable for can manufacture.

Light gauge sheet steel has been produced successfully and cheaply heretofore by cold rolling hot rolled steel strip in a continuous or reversing 4-high mill having anti-friction bearings. Material so produced has been characterized by a very high ductility after annealing in the usual manner, due to the large amount of cold reduction made. While this characteristic is desirable for many uses, it has disadvantages in other fields such as the manufacture of cans, unless it is combined with the proper amount of stiffness. Numerous efforts to impart such stiffness have failed heretofore to produce material suitable for container stock. Because the cold rolled product, when annealed and processed in the usual manner, has been found too soft to serve satisfactorily as stock for the manufacture of containers for certain commodities such as beer, can makers have continued to use sheet metal produced by the old hot packrolling method, or have used steel having a phosphorus content more than five times the usual value which increases the difficulty and cost of rolling.

The highly ductile product of the 4-high mill is satisfactory for can ends because the latter can be stamped more easily therefrom than from hot rolled sheets and will not tear in the stamping dies so readily. In order to provide the neces-

sary stiffness and strength, however, it is the practice of the can makers to use a heavier gauge material for the ends than for the can bodies, because of the extreme softness of the cold rolled strip, and the lack of the necessary stiffness.

The requirements for can body stock are quite rigid. A can body must be sufficiently stiff so that the can will not bulge readily nor become easily dented. It has previously been attempted to give the cold rolled product such stiffness by excessive cold rolling (i. e., about 5%) after box annealing, or by the use of steel having a high phosphorus content, but when this was done it was found that the seam in the body of the can would not solder properly because of the spring-back characteristic introduced. Any stiffness imparted was accompanied by an objectionable loss of ductility. Material so rolled, furthermore, lacks uniformity. Tests on a standard container made of present day tin plate show a variation in yield point from 22 to 30 kilograms per square millimeter (Schopper test) and a similar variation in ductility. This characteristic results in a leaky can unsuitable for packing requirements. The usual procedure, therefore, has included only a "skin pass" cold rolling ($\frac{1}{2}$ to 5% reduction) after box annealing.

On the other hand, if the material having a greater ductility is used for body stock, the completed cans are easily dented when handled, and subsequently the coating may crack, thereby spoiling the contents. Annealed and slightly work hardened cold-rolled strip steel also has a tendency to flute when formed into can bodies. Both these qualities are highly objectionable in cans used for packing food stuffs.

It has so far proved difficult to produce material by any known method that would have uniform physical properties and meet all requirements for can ends. If the material was sufficiently ductile the ends would easily deform in subsequent handling or bulge under internal pressure. If the material was stiff it would not form readily and would not only result in a large percentage of the ends being fractured in the stamping dies, but also usually the ends would assume an elliptical shape and would not properly fit the can bodies. The usual practice has been to compromise and use a heavier gauge material of a ductile quality in order to meet the requirements of strength and workability. All of these objectionable features have been due largely to the lack of uniform physical properties of the material used for this purpose. By

my invention, all these objectionable features are overcome, and a cold-rolled product of uniform physical properties is obtained.

I have invented a sheet metal and a method of manufacture whereby the foregoing objections to the products of the 4-high cold mill for can stock are entirely overcome. In addition, the new product is far superior to the sheets produced by the hot pack-rolling method or by cold rolling steel strip after annealing it, in an attempt to give it the desired stiffness.

According to my invention, I take hot rolled low carbon strip steel and subject it to cold rolling, preferably on a 4-high cold mill, until it is reduced to within from 5% to 25% of its desired final gauge. The strip is then heated above the A_3 point, so that a uniform small grain size is exhibited by the material. Heat treating in this manner produces a strip having uniform physical characteristics. In general, any type of heat treatment which will meet these requirements will be suitable for my process. It should be pointed out that the heat treatment is very important, in that proper initial physical properties are required, so that the final desired characteristics are obtained when the strip is further processed into the final product.

The heat treated material is then cold rolled to the final gauge. As above stated, this involves a reduction of from 5% to 25%. After cold rolling the strip is passed through a molten tin bath, either in strip form or after it has been sheared into sheet lengths. The strip ages when it is passed through the molten tin which is usually maintained at 550° F. to 600° F. The aging of the strip in the tin pot increases the stiffness, but reduces the ductility. The amount of ductility retained, however, is far in excess of the maximum required for can manufacture and other similar articles. The aging may also be accomplished by heating the material without passing it through a tin bath.

A complete understanding of the invention may be obtained from a consideration of the following detailed description thereof, referring to the accompanying drawings illustrating the sequence of steps involved in a preferred practice of the method.

In the drawing:

Figure 1 is a schematic view showing the initial cold rolling step;

Fig. 2 is a similar view showing the heat-treating operation;

Fig. 3 is a similar view showing the final cold rolling;

Fig. 4 is a similar view showing the tinning operation; and

Fig. 5 is a set of curves showing the characteristics of material subjected to different degrees of cold rolling after heat-treating and to aging at various temperatures.

In practicing my invention, I prefer to start with hot rolled low carbon (i. e. under .25% carbon) steel strip about .109" thick. This is a standard product in the steel industry. I subject the hot rolled strip to cold rolling and continue such rolling until the strip has been reduced to within from 5 to 25% of the desired finished gauge. The rolling may conveniently be carried out in a 4-high mill with relatively small work rolls backed up by larger rolls journaled in anti-friction bearings. Either a single stand reversing or a multi-stand continuous mill may be employed. I preferably take a heavy reduction in the material at each pass, reducing it to its in-

termediate thickness of about .008" (where the final gauge of tin plate desired is .007").

The cold rolling operation just described is illustrated diagrammatically in Figure 1 in which the mill 10 has working rolls 11 and backing rolls 12, the hot rolled strip 13 being fed between the former from a coil 14, the partly reduced strip 15 being received on a coiler 16.

After the hot rolled strip has been reduced to the intermediate gauge, I subject it to a continuous heat treatment above the A_3 point, as illustrated diagrammatically in Fig. 2. The heat treatment is preferably effected by passing the strip in strand form through a continuous furnace 17 from an unwinding reel 18 to a winding up reel 19 with the assistance of pinch rolls 20 and furnace conveyor rolls 25. The furnace may be heated by any convenient means and is preferably maintained at a temperature such that the speed of travel of the material therethrough may be coordinated with the length of the furnace so as to cause the material to be heated to a temperature above the A_3 point, e. g. about 1700° F. This causes complete recrystallization in a very short time, e. g., one-half minute. As the material emerges from the furnace it passes over a cooling table 22 and is thereby cooled to room temperature. A non-oxidizing atmosphere is maintained in the furnace and a chamber 22a enclosing the cooling table.

After heat treatment, the partly reduced cold rolled strip is finally cold rolled to finished gauge as illustrated diagrammatically in Fig. 3. This cold rolling is preferably carried out in a mill 23 similar to that shown at 10 or the final cold rolling may be conducted in the same mill as the initial cold rolling. By the final cold rolling, in either event, the material is reduced to a thickness of about .007". This amounts to a final cold reduction of 12½% from the intermediate gauge of .008".

After cold rolling to final gauge, the material is tinned in strip form or, after shearing, in the form of sheets, by passing it through a tin-pot 24 of ordinary construction. The resulting product is then ready for use in the manufacture of cans or other products for which its characteristics make it suitable.

The tinning of the cold rolled strip appears to exert an important effect on the qualities of the final product. The tinning bath is maintained at a temperature of about 600° F. and the strip passing through it is aged and acquires the desirable properties which will be described in detail hereinafter. The speed of the strip through the bath should be such that it is heated to the temperature of the latter. The aging may also be accomplished by heating the material to a temperature up to about 1100° F., without tinning, if desired.

The changes which occur in physical properties as a result of the several steps, will now be considered by tracing a typical procedure differing slightly from that already described.

After a hot rolled strip 0.109" thick was cold rolled to approximately 0.0105" and then heat treated at 1700° F., for a time sufficient to completely recrystallize the fragmented cold worked grains, tests were made on a Schopper bend tester. Tests were made on specimens cut parallel to the grain or rolling direction (which will be designated by the letter "P") and also on specimens cut in the transverse direction or cut across grain (designated by the letter "T"). Olsen cup tests were also made. After heat treatment

above the A₃ point, the Schopper tests made on the 0.0105" material gave the following for the yield point:

$$P=22 \text{ kg./sq. m. m.}$$

$$T=21.5 \text{ kg./sq. m. m.}$$

and for the Olsen cup test value, 0.33".

The yield points with and across the grain are nearly equal. This material is too ductile, however, for can stock.

- 10 After a reduction of 15% by cold rolling to final gauge (.009"), the yield points were:

$$P=32.85 \text{ kg./sq. m. m.}$$

$$T=39.06 \text{ kg./sq. m. m.}$$

- 15 The cold rolling, in addition to increasing P and T values given by the Schopper test by different amounts, reduced the ductility somewhat. This does not, however, imply that the workability has been reduced below the value necessary for can manufacture.

After the finally cold-rolled stock was aged or tempered at 600° F., (as by passing through a tin pot), the Schopper test gave as the yield points:

$$P=38.31 \text{ kg./sq. m. m.}$$

$$T=39.66 \text{ kg./sq. m. m.}$$

and the Olsen cup value was .210". The ratio of thickness to average yield point is .00023.

- 30 The P and T values for yield point were thus again made nearly equal. The P value of the aged strip nearly equals the T value of the cold rolled strip. This is a novel result in that the tempering or aging of the strip in the tin pot does not change the T value very much, but does raise the P value so that it nearly equals the T value.

- 35 This strip is well suited for the manufacture of cans, even though it has a high yield point and a somewhat reduced ductility. Can ends stamped therefrom are round and not elliptical, and do not tear in the die in spite of the high yield point. This is because the yield points with and across the grain are nearly equal.

- 40 From the foregoing, it is apparent that the stiffness depends only upon the magnitude of the yield point. The higher the yield point, the stiffer the strip, and the lower the ductility. In spite of the decrease in the ductility and increased stiffness, the strip can be readily worked and formed into cans. In fact, the strip has ample "workability" for can manufacture even though it does not have the high ductility and low strength and yield point usually considered necessary by the tin plate industry.

- 50 Another important result is that the aging treatment in the tin pot or at any temperature up to 1000° F. (for strip reduced 15%) does not cause the return of fluting. For certain types of low carbon open hearth steels, fluting does not return when heat treated at 1200° F.

- 60 The value of the yield point permissible for any given stamping or forming operation can be obtained by selecting the amount of cold rolling after heat treatment (5% to 25% area reduction) and the P and T values made nearly equal by controlling the aging or tempering treatment, giving a material having nearly uniform physical properties with and across the grain.

- 70 Fig. 5 shows the changes which take place in the physical properties (Olsen cup tests) where materials subjected to different amounts of final cold rolling were tempered and aged at various temperatures. As shown by the curves, minimum ductility and maximum stiffness can be obtained by tempering at about 500° F. to 600° F.

Because of the high yield point of this material, cans made therefrom can stand more severe handling without danger of denting or crushing and are more resistant to bulging under internal pressure than cans made of previously known material of the same gauge. I have tested a number of cans made from this material and found that if the walls of these cans are pressed firmly with the fingers so as to cause flexure, they will resume normal shape on release of the pressure, without leaving any permanent set. This is a new characteristic not found in present-day cans, and is a much desired and long sought feature. The yield point of tin plate used heretofore for can ends exhibits yield points from 14 to 30 kilograms per square millimeter, the average being about 24 kilograms (Schopper test). The yield point of material made according to my invention may be as high as 45 kilograms per square millimeter and averages 38 kilograms.

According to present requirements for can body stock, the Olsen cup test should not be less than 0.25" and not more than .310". In the material made by my method the Olsen cup value is at times as low as 0.21" but it has ample workability for can manufacture, will not flute after aging, and the body of the can does not exhibit sufficient spring-back to cause the lock seam of the can to open up or become leaky after the seam has been soldered. This assures a tight joint free of pin-hole leaks. Previous attempts to stiffen can body stock by drastically cold rolling commercial sheets after box annealing met with the result that the can seams could not be soldered properly due to spring-back. At the present time tin plate after box annealing is reduced by cold rolling from 5% to .3% in thickness.

Black sheets which have been used heretofore for making a tin plate show the following yield points under the Schopper test:

$$P=20.7 \text{ kg./sq. mm.}$$

$$T=24.9 \text{ kg./sq. mm.}$$

(Specimen .0105" thick)

This material is too ductile for can stock. When the P and T values differ by more than 15% difficulty is encountered in stamping can ends. Its ratio of thickness to average yield point is .00046.

When cold rolled, box annealed tin plate is substituted for the hot rolled product, it is necessary to use a slightly heavier gauge for can ends, in order to leave them stiff enough after forming or stamping. It will be apparent therefore, that my new product is characterized by several distinct advantages over the present-day tin plate. It is cheap to make, and results in a saving of 20% to 40% in the thickness of the can stock, and yet the cans are stronger and can be handled more severely without danger of crushing the wall. This and other advantages may be summarized as follows:

1. Cans may now be made of tin plate much thinner than used heretofore without sacrificing strength. The cost of the can is thus reduced since less steel is required.
2. Such cans are stiffer than those previously available although the strip used is lighter in gauge.
3. The completed cans are not easily dented and can stand more severe handling than cans previously made.
4. The material does not flute during the manufacture of the body of the can.

5. The uniformity of the characteristics of the material in all directions eliminates any tendency to tear in the stamping die, and assures round can ends instead of elliptical ones.

5 6. The yield point of the new product is much higher than that of present day commercial tin plate, and is substantially equal in all directions.

7. The increased stiffness of the material compared to that of previously known material of the same gauge facilitates the tinning operation. 10 The stiffness of the latter material is so low that it is practically impossible to handle through the tinning bath.

8. The material is free from excessive spring back. This prevents opening up of the locked 15 seam.

A further advantage of the product is that the bending moment of a can body blank of .005" material is only 20% of that of a similar blank of 20 .010" material. This relation can be demonstrated mathematically by well-known formulas. The material of my invention, furthermore, is characterized by great strength resulting from the stiffness imparted thereto by the heavy final 25 cold rolling. The desired workability is provided by the final aging or heat treatment. The material also has a high degree of resilience because of its high elastic limit. It is for these reasons that thinner material may be used for the same 30 applications requiring heavier gauges of previously known material.

As a specific example of the qualities of the material of my invention, .007-.008" tin plate produced by my method is stiffer than .010" material as made previously. The new material be- 35 haves quite differently from the thicker tin plate now in use and this quality is characteristic of thin material.

While I have illustrated and described herein 40 but a preferred practice and form of my invention, it will be understood that the method may be applied to products requiring similar characteristics without departing from the spirit of the invention as defined by the appended claims 45 or sacrificing the desirable characteristics of the resulting product.

Where the term "tin plate" is used in the claims, I intend to include tin mill, black plate and terne plate as well as what is technically 50 known as tin plate.

I claim:

1. In a method of making sheet metal suitable for the manufacture of containers, the steps including reducing low-carbon steel strip by cold- 55 rolling to a thickness less than 40% of the original thickness and about 15% greater than the desired final gauge without intermediate annealing, heating the strip above the A₃ point for a time sufficient to cause recrystallization, cooling the 60 strip in strand form, reducing the thickness of

the strip about 15% by cold rolling, and heating the strip to a temperature between 300° and 1100° F. to age it and develop Schopper values for yield point above 30 kilograms per square millimeter with and across the grain.

2. A method of making thin sheet-like metal, comprising reducing low-carbon steel strip by cold rolling to a thickness less than 40% of the original thickness without intermediate annealing, heating the strip to a temperature above the A₃ point for a time sufficient to cause recrystallization, 10 cooling the strip in strand form, further cold rolling the strip, controlling the reduction effected by the last cold rolling between 5% and 25% to cause the resulting material to exhibit approx- 15 imately equal yield points in the direction of rolling and exceeding 30 kilograms per square millimeter in the Schopper tester at right angles thereto, applying a coating of protective material and heating the strip to a temperature between 20 300° and 1100° F.

3. In a method of making sheet metal suitable for container manufacture, the steps including reducing hot-rolled low-carbon steel strip by cold rolling without intermediate annealing to a thick- 25 ness less than 40% of the original thickness and from 5 to 25% greater than the desired final gauge, heating the cold-rolled strip to a temperature above the A₃ point, cooling the strip rapidly in strand form, further cold rolling the strip sub- 30 stantially to final gauge, aging it by heating to a temperature below 1000° F. and so proportioning the amount of reduction effected in the second cold rolling to the final gauge as to obtain a pre- 35 determined relation between the yield point and thickness of the metal and minimize spring back in a can seam formed from said metal.

4. As a new product, low carbon sheet steel produced according to claim 1.

5. As a new product, low carbon sheet steel 40 produced according to claim 2.

6. As a new product, low carbon sheet steel produced according to claim 3.

7. As a new product, low carbon sheet steel of tin plate thickness, suitable for the manufacture 45 of containers, said steel produced by cold rolling low carbon steel strip without intermediate annealing to a thickness less than 40% of the original thickness and from 5% to 25% greater than the desired final gauge, heating the cold-rolled 50 strip to a temperature sufficient to cause recrystallization and produce a uniformly small grain size, cooling the strip, further cold rolling the strip from 5% to 25% of its thickness substantially to 55 final gauge, and then heating the strip to a temperature between 300° F. and 1100° F. to age it and develop Schopper values for yield point above 30 kilograms per square millimeter with and across the grain.

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