This invention is concerned with nonaging steel, the object being to combine the advantages of rimmed steel insofar as its fine surface qualities are concerned with those of steel to which sufficient aluminum has been added to make it nonaging and which is therefore killed steel.

Steel intended for deep-drawing or working involving extreme deformations conventionally is a plain carbon steel of very low-carbon content, it seldom containing more than .10% carbon. Such a steel can be produced as either a rimmed steel or as a steel that is killed by the use of aluminum. Also, it can be imparted nonaging characteristics by the proper use of aluminum, this requiring about 3 pounds of aluminum per ton of steel which is a greater amount than is necessary to produce a killed steel only.

When produced as a rimmed steel, it can be rolled into products having very good deep-drawing characteristics and possessing a very fine surface finish. However, it is necessary to temper these products by cold working them so as to avoid subsequent stretcher strains known as Ladders lines, it then being necessary to draw or form the products very shortly after this tempering to avoid trouble from the aging phenomenon to which rimmed steel is subject.

On the other hand, when produced as a nonaging steel by the use of an appropriate amount of aluminum, the steel can be rolled into products which can be kept for reasonable periods of time after being tempered by cold working, without trouble arising insofar as the evil of aging are concerned when the products are ultimately subjected to deep-drawing or other severe forming. However, this nonaging steel is a killed steel as has been explained, and a killed steel lacks the fine surface finish of a rimmed steel.

The fundamentals involved in the foregoing discussion of rimmed and nonaging low-carbon steels intended for use in connection with deep-drawing or forming operations, are so familiar to those skilled in the art as to obviate the need for detailed discussion.

The present invention is characterized in that low-carbon steel is poured into an ingot mold, this steel being oxidized to such an extent that it actively effervesces in the mold. In other words, it may be a plain carbon rimming steel. This steel is permitted to effervesce or rim in the mold until a skin solidifies that is of appreciable thickness, the thickness of the skin depending on the characteristics desired of the ultimate product. This skin has all the characteristics of the skin of an ordinary rimmed steel ingot, consisting of very clean low-carbon steel.

At this point, instead of permitting the core of the ingot to solidify in the manner which would be characteristic of such an ingot, an excess of killing agent is introduced into the steel so that the core will subsequently exhibit non-aging properties. The killing agent removes oxygen from the steel, and an incident of this treatment is that the core solidifies as a killed steel, with deep piping.

The nonaging core should by way of example, be treated with about 3 lbs. of aluminum per ton of steel. This is preferably introduced, if it is a bottom-pouring operation, by adding further steel through the runner, which steel is accompanied by a large excess of aluminum, the latter preferably added molten. Thus, if an ingot is first poured to contain 11½ tons, of which 1½ tons solidifies during the rimming period, there is left a core of 10 tons of molten steel. If 2 additional tons of steel are now added through the runner, making a total of 12 tons of liquid steel, then the last-added 2 tons should be accompanied by 36 lbs. of aluminum, so as to provide 3 lbs. of aluminum per ton for the 12 tons of liquid steel. In other words, an ingot is produced that consists primarily of nonaging steel that is free from blowholes and metallurgical segregations and which has all the characteristics of a nonaging and, hence, fully killed low-carbon steel ingot excepting that it has a skin of very clean low-carbon steel permitting this ingot to be rolled into products such as sheets having the fine surface finish characteristics of rimmed steel but which are not subject to the latter's objectionable aging phenomenon when tempered by cold working if a time period is permitted to lapse prior to its being subjected to the deep-drawing or other severe forming operations for which the products are intended.

Inkots have been produced in accordance with the present invention and processed into terne plate which was used for particularly difficult working under conditions where aging effects in the case of rimmed steel, terne plate had caused considerable trouble, the product having all the desirable characteristics of rimmed steel and being satisfactorily free from the latter's aging characteristics.

It is to be understood that an ingot of the character involved by the present invention rolls to an ultimate product consisting of a core or base of nonaging steel covered by a very thin integral layer of very clean low-carbon steel providing the
product with a fine finish and good deep-drawing characteristics. As is well known, a product rolled entirely from nonaging steel cannot be produced with the fine finish characteristic of rimmed steel. The aluminum added to the nonaging steel which is used to treat the core of the initially cast or effervescing steel, may be handled in any conventional manner. However, experience has shown that probably it is best done by adding the aluminum in molten form into the runner conventionally used in the bottom pouring of ingots, the amount of aluminum being proportioned as previously described to produce a nonaging steel.

Although low-carbon steels of various compositions may be used in carrying out the present invention, the steel specifically used in the previously described working of this invention had the following ladle analysis:

<table>
<thead>
<tr>
<th>Per cent</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>.07</td>
</tr>
<tr>
<td>Sulphur</td>
<td>.027</td>
</tr>
<tr>
<td>Manganese</td>
<td>.37</td>
</tr>
<tr>
<td>Silicon</td>
<td>.010</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>.009</td>
</tr>
<tr>
<td>Copper</td>
<td>.04</td>
</tr>
</tbody>
</table>

The above steel, of course, is normally a rimming of effervescing steel in view of its carbon and silicon contents and is cast as such in the case of the initial pouring. Then, at the time of treating the still liquid steel comprising the interior of the ingot, 3 lbs. of aluminum per ton of interior steel were added as described. This resulted in the steel being modified to the extent that it was fully killed and, in addition, contained metallic aluminum in an amount above that which would have been required merely to combine with enough oxygen to effect killing.

I claim:

1. Nonaging, fully killed, plain-carbon steel having a skin of clean, unkillled, plain-carbon steel providing the fine surface characteristics of rimmed steel.

2. A method of making steel, comprising bottom pouring a steel ingot of rimming, plain-carbon steel; allowing an ingot skin to form; and, prior to solidification of the ingot core, further bottom pouring plain-carbon steel, into the same ingot, containing sufficient aluminum to render the ingot core nonaging, fully killed, plain-carbon steel; and allowing the core to solidify.

JAMES E. LOSE.

CERTIFICATE OF CORRECTION.


JAMES E. LOSE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 33, after "evil" insert --effects--; page 2, first column, line 25, for "of effervescing" read --or effervescing--; and that the said letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of February, A. D. 1946.

Leslie Frazer
First Assistant Commissioner of Patents.
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JAMES C. AOSE.

CERTIFICATE OF CORRECTION.


October 30, 1945.

JAMES E. LOSE.

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