# United States Patent [19]

**Cantera et al.**

[11] **3,876,422**

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[54] **ELONGATED LEADED STEEL CASTING**


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[22] Filed: **Oct. 3, 1973**

[21] Appl. No.: **403,065**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 256,806, May 25, 1972.

[52] **U.S. Cl.** ..... **75/123 F;** 75/129; 148/36

[51] **Int. Cl.** ..... **C22c 37/00**

[58] **Field of Search** ..... 75/129, 123 F, 130, 130.5; 266/34 T; 29/187.5; 148/2, 36



[56] **References Cited**

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|---|---|---|---|
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| 3,671,224 | 6/1972 | North et al. | 75/123 F |
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FOREIGN PATENTS OR APPLICATIONS

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| 1,081,616 | 5/1960 | Germany | 75/129 |

OTHER PUBLICATIONS

Lyman, et al.; Metals Handbook (Vol. I) ASM, Cleveland, 1961, p. 308.



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[57] **ABSTRACT**

Uncropped, unworked, elongated, leaded steel castings, such as ingots, of commercial size (1,000 lbs. and heavier) or strand cast section. Lead content greater than 0.35 wt. percent and up to 0.70 wt. percent. Commercially acceptable surface. Lead present in inclusion form of microscopic size. No lead macroinclusions at bottom of uncropped ingot. No rare earths or lead oxide inclusions. Process for making is described.


**10 Claims, No Drawings**

# ELONGATED LEADED STEEL CASTING

## RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 256,806 filed May 25, 1972 and entitled "Method For Adding Lead To Steel In A Ladle."

## BACKGROUND OF THE INVENTION

The present invention relates generally to leaded steel ingots and more particularly to uncropped, unworked, leaded steel ingots having a relatively high lead content (greater than 0.35 wt. percent and up to 0.50 wt. percent or higher) with the lead being present solely as microscopic inclusions, the bottom of the ingot being essentially devoid of lead macroinclusions or macrosegregation as that term is generally understood in the art. (e.g. see North et al., U.S. Pat. No. 3,671.224, cols. 1 and 2).

Lead is added to steel to improve the machinability of the steel. Increasing the lead content generally increases the machinability, for lead contents below 0.8 wt. percent. Lead is present in solidified steel as inclusions. Lead inclusions of microscopic size are desirable, but lead macroinclusions are undesirable.

Conventional attempts to produce commercial-size, leaded steel ingots with the relatively high lead content noted above and without lead macroinclusions in the as-cast ingot have been largely unsuccessful. Even with lead contents below 0.30 wt. percent, lead macroinclusions segregated at the bottom of the as-cast ingot so that it was necessary to crop or cut off the bottom 4–10 percent of the ingot to eliminate the part of the ingot containing the undesirable lead macroinclusions. This reduced the yield from the ingot, which was undesirable.

There is prior art which teaches obtaining a relatively high lead content with an absence of lead macroinclusions in the as-cast ingot, but this art requires special addition ingredients, such as rare earths (Corradini U.S. Pat. No. 3,313,620) or special processing techniques which produce, upon cooling of the molten steel, lead oxide precipitates that do not settle by gravity in the molten steel (German Published Appln. No. 2,012,688).

There is some early prior art, dating back to the late 1930's, describing solidified steel containing large amounts of lead occurring solely as uniformly dispersed microinclusions; but this combination of features has not been obtainable under commercial conditions or in commercial-size ingots (e.g., 1,000 lbs. and heavier), and more recent prior art has acknowledged this failure (North et al. U.S. Pat. No. 3,671,224, listing early prior art at Col. 1, lines 40–42).

As previously noted, it is desirable to provide a commercial-size ingot with a high lead content and with essentially no lead macroinclusions at the bottom of the uncropped ingot, i.e., devoid of such lead macroinclusions as would render the bottom of the ingot commercially unacceptable and necessitate cropping the bottom of the ingot for that reason.

## SUMMARY OF THE INVENTION

The present invention is an uncropped ingot of commercial size and with a commercially acceptable surface devoid of surface defects usually associated with ingots sticking in the ingot mold, e.g., tears, cracks or mold pieces stuck on the ingot surface. This ingot has



a lead content greater than 0.35 wt. percent and up to 0.50 wt. percent or higher, with essentially no lead macroinclusions in the bottom of the as-cast ingot, with no rare earths and with essentially no lead oxide inclusions.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Commercial-size ingots in their as-cast, uncropped, unworked condition range in size from about 7 inches × 7 inches × 80 inches or about 1,000 lbs. up to ingots of 25,000 lbs. and over. Such ingots taper slightly and may be either what are known as bit end up ingots or big end down ingots. A typical commercial-size big end up ingot (open top or hot top) is 28 inches × 34 inches × 84 inches or about 18,000 lbs. A typical big end down ingot is 29 inches × 29 inches × 89 inches (16,000 lbs.) or 32 inches × 36 inches × 89 inches (25,000 lbs.). (The cross-sectional dimensions of ingots are usually measured at the top).

The base composition of the steel (i.e., the steel composition without lead) includes virtually all base compositions to which lead has heretofore been added. The base composition for plain carbon steels may be in the following range:

| Element | Wt. % |
|---|---|
| carbon | 0.3–1.03 |
| manganese | .25–1.65 |
| sulfur | 0–.50 |
| phosphorous | 0–.20 |
| silicon | 0–.75 |
| nitrogen | .03 max. |
| tellurium | 0–.15 |
| iron | essentially the balance |

For alloy steels, the base composition may contain, in addition to the above-listed elements, one or more of the following alloying elements:

| Element | Wt. % |
|---|---|
| chromium | 0–1.60 |
| nickel | 0–3.75 |
| molybdenum | 0–.50 |
| vanadium | 0–.25 |
| boron | 0–.003 |
| titanium | 0–.50 |
| zirconium | 0–.25 |
| columbium | 0–.25 |
| aluminum | 0–.10 |
| calcium | 0–.02 |

Typical examples of such base compositions in the AISI 1200 series of steels are within the following ranges:

| Element | Wt. % |
|---|---|
| carbon | 0.13 max. |
| manganese | 0.60–1.00 |
| phosphorous | 0.07–0.12 |
| sulfur | 0.08–0.33 |
| iron | essentially the balance |

To such base compositions, lead is added, to provide a final lead content greater than 0.35 wt. percent and typically up to 0.50 wt. percent, although higher lead contents are contemplated, e.g., up to 0.60–0.70 wt.

percent. Preferably, the lead content is in the range of 0.45–0.50 wt. percent or 0.45–0.60 wt. percent.

The lead is present in the solidified steel as inclusions, and these inclusions are relatively uniformly distributed throughout the length of the as-cast ingot. Essentially all of the lead inclusions are microscopic, there being essentially no lead macroinclusions throughout the entire length of the as-cast ingot. There is essentially no peripheral segregation of lead-containing macroinclusions; and the bottom of the as-cast ingot is essentially devoid of lead macroinclusions, so that cropping of the ingot, to get rid of that portion of the ingot in which macroinclusions of lead have conventionally segregated, is not necessary.

The lead inclusions consist essentially of lead or a compound of lead other than lead oxide. The lead may be unassociated with other inclusions, or it may be associated with inclusions such as manganese sulfide or complexes of iron, manganese, oxygen and sulfur. An example of a lead compound is lead telluride (occurring when both tellurium and lead are added to the steel to improve machinability). Virtually none of the lead is present as lead oxide, no lead oxide having been found upon inspection of the microscopic inclusions containing lead. This condition occurs even in the absence of aluminum in amounts normally present when aluminum is added to kill the steel or refine the grain size (e.g., .015–0.65 wt. percent.

Prior to casting the ingot, the lead is added to the steel in the manner described below.

Molten steel of the desired composition, and at a temperature in the range 2900°–3100°C., tapped from a steel-making furnace into a ladle while retaining most of the slag in the furnace. The ladle is covered to isolate the ladle interior from the outside atmosphere. Only a very thin layer of slag covers the bath of molten steel in the ladle at this time.

The ladle bottom contains a pair of spaced-apart porous plugs through which inert argon gas is introduced into the bath. The rising argon gas bubbles stir the molten steel and, where the argon bubbles breach the surface of the bath, the slag layer is pushed aside uncovering a portion of the top of the molten steel bath. After introducing argon to the steel for 15–20 seconds, lead is introduced through a port in the ladle cover onto the top of the bath at the portion of the bath surface not covered by the slag, but at a location not directly over a porous plug. Argon stirring is continued during the lead-adding step which takes about 2–3 minutes, and stirring with argon gas also continues for 2–3 minutes after the lead-adding step.

Gases accumulating at the top of the ladle during the argon stirring and lead-adding steps (e.g., argon and lead fumes) are exhausted through an exhaust conduit communicating with an exhaust opening in the ladle cover. A conventional exhaust blower may be used to remove gases accumulating at the top of the bath inside the ladle. Removal of gases can be controlled to provide a pressure within the covered ladle greater than atmospheric. A gaseous atmosphere, less oxidizing than the atmosphere outside the ladle, is maintained over the bath inside the covered ladle, during the lead-adding step and thereafter.

Sufficient lead is added to give a final lead content greater then 0.35 wt. percent (preferably at least 0.45 wt. percent) up to 0.50 wt. percent or higher, consistent with obtaining the other objectives of the present invention. No rare earths are added to the steel; and the atmosphere within the ladle at the time the lead is added is less oxidizing than the atmosphere outside the ladle, a condition which does not favor the formation of lead oxide.

After the lead has been added and after the lead-containing bath has been stirred with argon gas, as described above, introduction of argon gas is stopped, the cover is removed from the ladle, the top of the bath is covered with expanded vermiculite to suppress fuming, and the lead-containing molten steel is teemed into conventional ingot molds (either big end up or big end down) or into the tundish of a conventional continuous caster producing continuously cast strands of steel. After teeming, the slag is dumped from the ladle.

The temperature of the steel at the time of teeming is about 2850°F., and this is below the temperature at which there would be mold sticking problems, as described below.

The conventional mold for commercial-size steel ingots is made of cast iron. If the steel is teemed into the ingot mold at too high a temperature (e.g., 3,000°–3100°F.), the solidified ingot may weld or stick to the inside of the cast iron mold. When this occurs, it is difficult to remove the ingot and sometimes the mold even has to be broken open to remove the ingot. Because the cost of the mold is comparable to the value of the ingot, such a practice is commercially unacceptable. Moreover, ingots which stick in the ingot molds have surface defects, such as surface cracks, tears, etc., which render the ingot (and the steel rolled from such an ingot) commercially unacceptable without substantial special surface conditioning. An ingot in accordance with the present invention has, as-cast, a commercially acceptable surface, i.e., a surface devoid of such defects as would otherwise require said special surface conditioning.

The porous plugs are purged with an oxygen blow for about 5–10 seconds just before introducing the argon and for about 30–60 seconds after dumping the slag.

A further description of methods for adding lead to steel in a covered ladle is contained in parent application Ser. No. 256,806 filed May 25, 1972 and entitled "Method For Adding Lead To Molten Steel In a Ladle."

When the lead-containing steel is continuously cast into strands, a typical commercial-size strand would be 3inches × 3inches, on the small side. Larger sizes include strands 10inches × 23inches and over. Eventually these strands are cut into lengths up to 40 ft.

The present invention covers both continuously cast strands and ingots, both being included within the generic term "elongated casting," and is directed to the casting before it has undergone working. In both embodiments, the casting, whether it be a continuously cast strand or an ingot, is elongated and uncropped, with a lead content greater then 0.35 wt. percent and up to 0.70 wt. percent (preferably 0.45–0.60 wt. percent and a weight greater than about 1,000 lbs., the lead being present in inclusion form of microscopic size, there being essentially no lead macroinclusions in the bottom of the uncropped, elongated casting. Nor does the casting contain any rare earths or any significant amounts of lead oxide inclusions.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary

limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

**1.** An elongated, uncropped, as-cast unworked casting composed of leaded steel and comprising:

a weight greater than about 1000 pounds and a commercially acceptable surface;

a lead content greater than 0.35 wt. percent and up to 0.70 wt. percent;

lead inclusions, consisting essentially of microscopic inclusions comprising elemental lead, distributed throughout the length of said elongated casting;

said elongated casting being essentially devoid of macroscopic lead inclusions throughout its length including the bottom portion of said uncropped, elongated casting;

said casting being devoid of rare earths.

**2.** An elongated casting as recited in claim **1** and which is essentially devoid of lead oxide inclusions and of aluminum.

**3.** An elongated casting as recited in claim **1** wherein said casting is an ingot.

**4.** An elongated casting as recited in claim **1** wherein said casting is a continuously cast strand.

**5.** An elongated casting as recited in claim **1** wherein said lead content is in the range 0.45–0.50 wt. percent.

**6.** An elongated casting as recited in claim **1** wherein said lead content is in the range 0.45–0.60 wt. percent.

**7.** An elongated, uncropped, as-cast ingot composed of leaded steel and comprising:

a weight greater than about 1,000 pounds and a commercially acceptable surface;

a lead content greater than 0.35 wt. percent and up to 0.70 wt. percent;

lead inclusions, consisting essentially of microscopic inclusions comprising elemental lead, distributed throughout the length of said ingot;

said ingot being essentially devoid of macroscopic lead inclusions throughout its length including the bottom portion of said uncropped ingot;

said ingot being devoid of rare earths.

**8.** An uncropped ingot as recited in claim **7** and which is essentially devoid of lead oxide inclusions and of aluminum.

**9.** An uncropped ingot as recited in claim 7 wherein said lead content is in the range 0.45–0.50 wt. percent.

**10.** An uncropped ingot as recited in claim **7** wherein said lead content is in the range 0.45–0.60 wt. percent.

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UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 3,876,422

DATED : April 8, 1975

INVENTOR(S) : Gregorio Asua Cantera, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 46, after "1930's" insert --or early 1940's--.
Col. 2, line 13, delete "bit" and insert --big--.
Col. 3, line 4 , after "these" insert --lead--.
Col. 3, line 28, delete "0.65" and insert --.065--.
Col. 3, line 28, after "percent" insert --)--.
Col. 3, line 32, delete "C.," and insert --F., is--.

Signed and Sealed this

*nineteenth* Day of *August 1975*

[SEAL]

*Attest:*

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