Aug. 2, 1960 M. TENENBAUM ET AL 2,947,622

METHOD OF MAKING LEAD-CONTAINING STEELS

Filed June 23, 1958 2 Sheets-Sheet 1

Fig. 1.

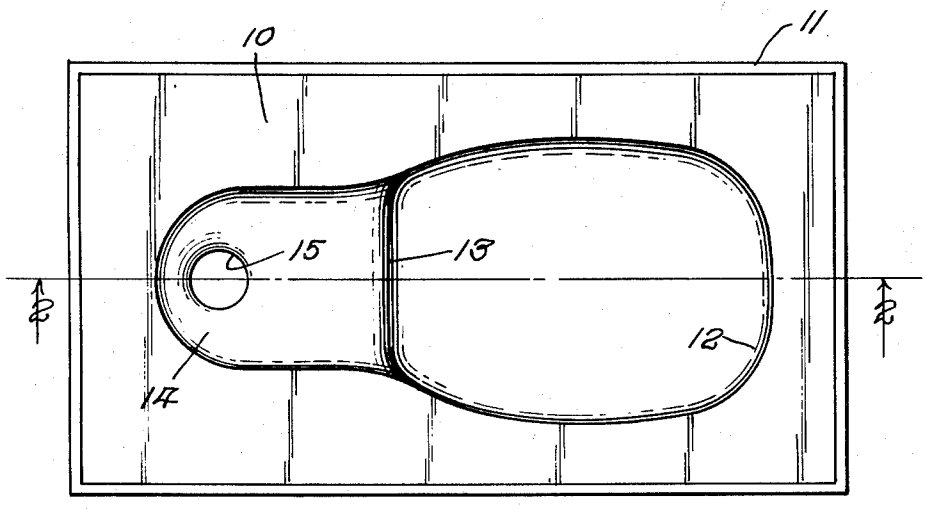
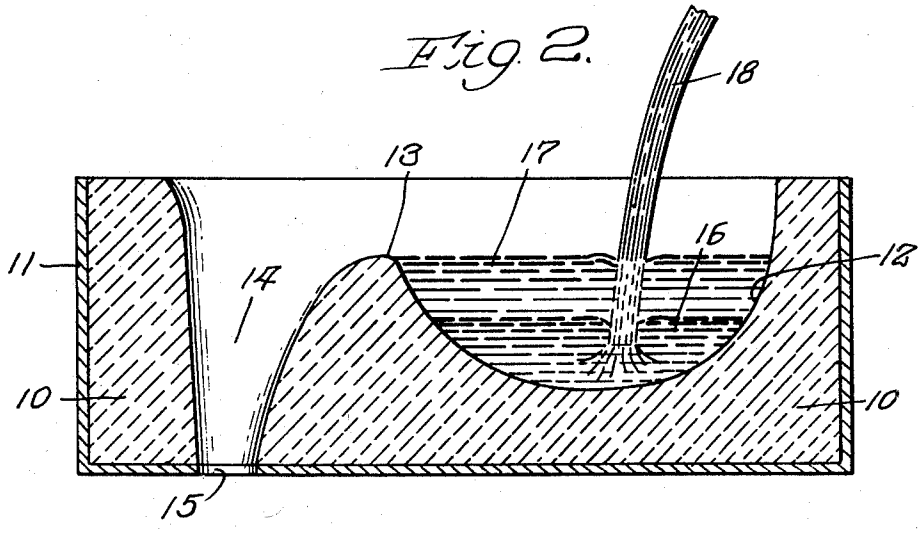


Fig. 2.



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Filed June 23, 1958 2 Sheets-Sheet 2

Fig. 3.

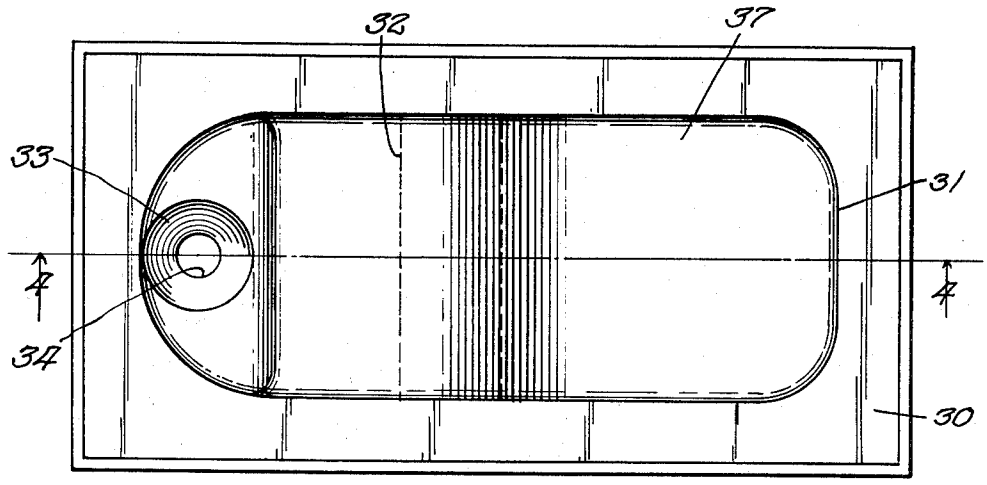
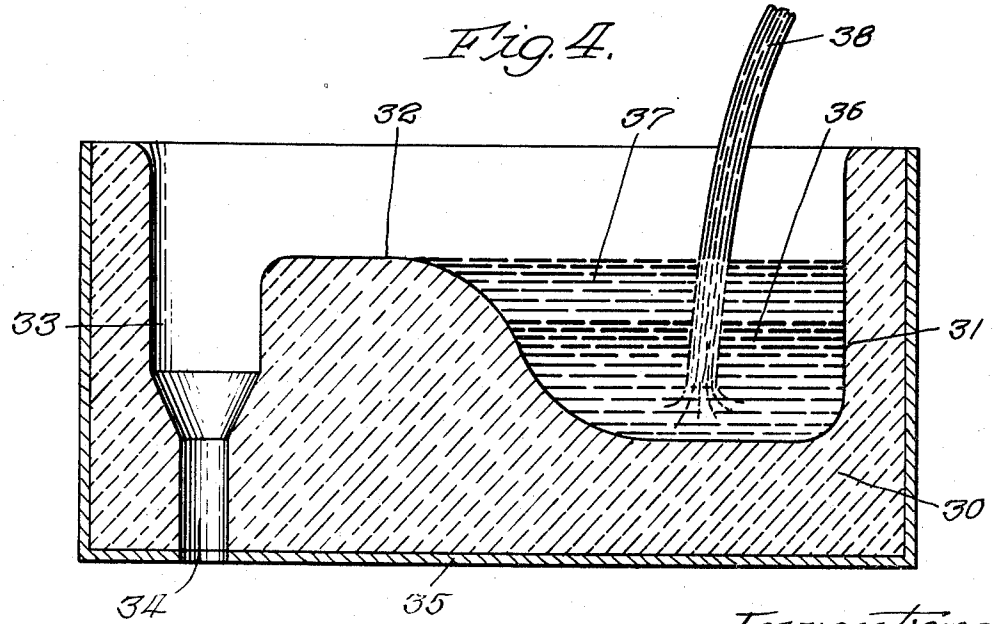


Fig. 4.



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METHOD OF MAKING LEAD-CONTAINING STEELS

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3 Claims. (Cl. 75—129)

This invention relates to steel. More particularly, this invention is concerned with a novel process of producing steel containing a small amount of lead to increase its machineability.

Steels containing small amounts, such as from about 0.03 to 0.5 percent, of lead are known to have superior machineability characteristics compared to unleaded steels. Lead containing steels are commercially available and are widely used where high speed machining of excellent quality is required.

The production of lead containing steels has been effected in a number of ways. One method tried was to introduce lead blocks to molten steel in a ladle or ingot mold. This method was not satisfactory because nearly all of the lead settled to the bottom with only a small insufficient proportion being dispersed throughout the steel. Even when the lead was added by pouring in small pieces of lead the result was not significantly different. A better method, and one that proved useful commercially, was to introduce the lead in the form of a continuous stream of small pellets directly into a stream of molten steel flowing into a mold, such as an ingot mold. Such a method, however, requires careful coordination of the flow of each stream, considerable manual labor and supervision and maintenance of the lead delivering equipment. These and other similar prior art methods of addition were all based on the assumption that lead is completely insoluble in molten steel and that, therefore, it was necessary to break up and disperse the lead particles in the molten steel just before freezing so that they would become entrapped in the steel. In practice, however, globules of lead were frequently found in ingots produced in this way.

A new, simple and efficient method of introducing lead into steel has now been discovered. According to the present invention this method, in one of the broad aspects thereof, comprises feeding a stream of molten steel to molten lead, separating the molten steel and molten lead into two layers by gravity settling, removing the upper layer comprising steel having a small amount of lead dispersed therein and solidifying the leaded steel so produced.

The method of this invention yields leaded steel remarkably free of lead globules and particles. This is due primarily to the gravity settling which permits lead particles to separate from the steel before the steel is solidified, as by introduction into an ingot mold. However, it is also apparently the result of a more uniform and thorough distribution of the lead in the steel, perhaps even as a true solution, than was achieved by prior art methods in which lead concentrations were often undesirably localized in certain areas, even though not present as globules.

The invention will now be described further in conjunction with the attached drawings in which:

Fig. 1 is a plan view of a vessel for holding and separating the molten lead and steel and conveying the leaded steel to a mold.

Fig. 2 is a sectional view of the vessel of Fig. 1 taken at the line 2—2;

Fig. 3 is a plan view of another type of vessel which may be used in the invention to hold the molten lead and effect separation of the molten steel therefrom; and

Fig. 4 is a sectional view of the vessel of Fig. 3 taken at the line 4—4.

The vessel shown in Figs. 1 and 2, generally called a tundish, is made of a suitable refractory material. The vessel **10** ordinarily has a reinforcing cover **11**. The vessel is shaped to provide a bowl area **12** which has lip **13** lower than the other sides of the bowl to permit excess molten material in the bowl to flow over the lip **13**, down the discharge conduit **14** and out the orifice **15**.

In the practice of this invention molten lead **16** is placed in the bowl **12** but to a level appreciably below the lip **13**. A stream of molten steel **18** is then caused to flow into the bowl and into the molten lead where the steel stream is dispersed. The molten steel, being the lighter of the two metals, rises to form an upper lead-containing steel layer **17** over the molten lead. As the molten steel stream **18** continues to flow, the lead containing steel layer **17** continues to rise until it spills over lip **13**, flows through conduit **14** and out discharge orifice **15**. The leaded steel may then be directed to an ingot mold.

A modified tundish adapted for production of larger quantities of leaded steel and increased lead settling is shown in Figs. 3 and 4. The vessel **30** of refractory material is reinforced with a steel cover **35**. It has bowl area **31** which functions as a lead reservoir and steel-lead mixing and settling area. The bowl **31** has a dam **32** on one side lower than the other three sides. The molten steel which flows over the dam **32**, goes through conduit **33** and flows out nozzle **34**.

In practicing the invention using a vessel as shown in Figs. 3 and 4 a molten pool of lead **36** is provided in the bowl **31** but of insufficient volume to fill it completely; a maximum of one-half to two-thirds is generally satisfactory. A stream of steel **38** is then directed into the pool of molten lead with sufficient force or velocity to be dispersed thoroughly in the lead. By this action and through the steel rising to the surface of the lead, small amounts of lead become uniformly and thoroughly dispersed in the steel. The continuous addition of steel by stream **38** causes the lead-bearing molten steel layer **37** to build up until it flows over the dam **32** and into conduit **33** from which it may be directed into a mold. If desired a stopper may be provided in the conduit to regulate, or stop completely, the flow of lead-containing molten steel through the conduit.

Obviously, as leaded steel is produced using vessels such as those illustrated by the drawings, the amount of lead in the reservoir will be reduced. The rate of lead consumption can be readily determined, however, and the necessary quantities added periodically to maintain a suitable lead supply.

The quantity of lead dispersed in a steel using this process can be varied by changing the velocity of the steel stream, the depth of molten lead in the reservoir and the total volume of lead present. It is generally, however, unnecessary to produce leaded steels containing minimum or maximum amounts of lead. The desired amount of lead, i.e., 0.20 to 0.35%, will normally be dispersed in the steel by following the invention employing considerably varied conditions and equipment.

The following examples are presented to illustrate the invention.

Example 1

To a tundish as in Figs. 1 and 2, 16" long, 8½" wide and 6" deep there was added 30 lbs. of molten lead at a temperature of 1500° F. to the bowl area. About 300 lbs. of molten steel was poured in a stream into the molten

lead continuously. The layer of leaded steel spilled over the lip and was discharged into an ingot mold. The lead analysis of the ingot was as follows:

Percent ingot height:	*Lead analysis, percent*
5	0.30
30	0.37; 0.37
60	0.27; 0.28
90	0.25

Example 2

One thousand pounds of lead in the molten state was placed in the bowl of a vessel or tundish as shown in Figs. 3 and 4. The tundish was 88" long, 42" wide and 42" high. The molten lead was at 2500° F. A total amount of about 14,900 lbs. of molten steel was added in a stream to the molten lead in about two minutes. The molten steel layer on top of the molten lead continued to build up until it overflowed the dam and passed through the conduit from which it was directed into an ingot mold. The ingot analyzed as follows:

Percent Ingot Height	Lead Analysis, percent	
	Piece 1	Piece 2
4	0.28	0.28
	0.24	0.23
		0.27
23	0.30	0.28
	0.28	0.25
	0.27	0.24
44	0.31	0.30
	0.42	0.45
	0.30	0.28
69	0.28	0.40
	0.27	0.30
	0.27	0.29

Various changes and modifications of the invention can be made and, to the extent that such variations incorporate the spirit of this invention, they are intended to be included within the scope of the appended claims.

What is claimed is:

1. The method of dispersing small amounts of lead in steel to increase the machineability of the steel which comprises feeding a stream of molten steel to a pool of molten lead, separating the molten steel and molten lead into two layers by gravity settling, removing the upper layer comprising steel having a small amount of lead dispersed therein, and solidifying the leaded steel so produced.

2. The method of dispersing small amounts of lead in steel to increase the machineability of the steel which comprises separately melting steel and lead, adding the molten steel to a pool of the molten lead in a stream with sufficient velocity so that it is distributed in the lead, separating the molten steel and molten lead into two layers by gravity settling, removing the upper layer comprising steel having a small amount of lead dispersed therein, and solidifying the leaded steel so produced.

3. The method of producing lead containing steel which comprises partially filling a vessel with molten lead, feeding a stream of molten steel into the pool of molten lead with sufficient velocity so that the steel stream is dispersed in the molten lead, separating the molten steel and molten lead in the vessel by gravity into two layers, continuing the introduction of the molten steel stream into the molten lead during separation of said layers so that the upper layer of molten steel containing a small amount of lead dispersed therein overflows the vessel, and directing the lead-containing molten steel which so overflows into a mold.

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