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MOLDS AND STOOLS

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FIG. 1.

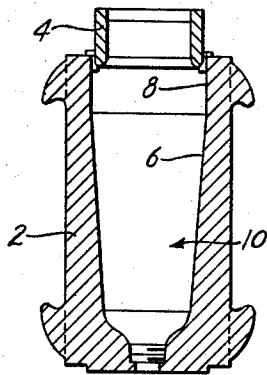
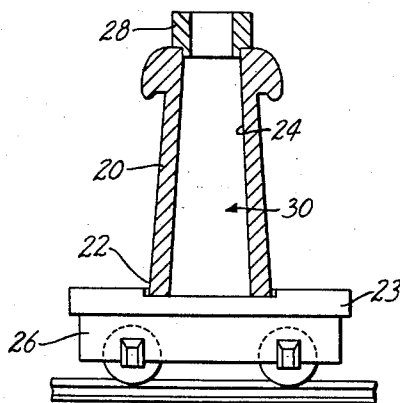


FIG. 2.



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MOLDS AND STOOLS

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This invention relates to molds and stools for making steel ingots, and more particularly to improved molds and stools which are highly resistant to cracking caused by thermal shock, scaling, corrosion and erosion, and which have a useful life considerably longer than that of conventional cast iron molds and stools. The invention also relates to improvements in methods of making molds and stools, and to cast iron compositions suitable for use in such methods.

Liquid steel is teemed into cast iron molds to prepare steel ingots. The molds are of two typical varieties: big end up and big end down. The big end down molds rest on stools, which are conventionally slabs of cast iron about 9 inches thick. Conventionally, the molds and stools comprise cast iron of either the direct, i.e., blast furnace, or cupola type.

The life expectancy of the conventional cast iron molds and stools is quite low. This is so because ordinary cast iron is quite susceptible to cracking caused by thermal shock, erosion and scaling under conditions of this particular use.

As a rule of thumb, with cast iron molds and stools made from direct or cupola cast iron, one ton of steel poured requires a mold weight of one ton. For each ton of steel poured, approximately 40 pounds of mold is consumed, and one ton of steel poured into big end down molds consumes approximately 10 additional pounds of stool. After handling the amount of steel indicated, the molds and stools are so damaged, principally because of cracking due to thermal shock, that they are no longer suitable for use and must be discarded to scrap. As may readily be appreciated, the cost of cast iron stools and molds is a significant item in the production of steel, and if their useful life could be prolonged without appreciably increasing material cost, significant savings could be realized.

It is an object of the present invention to provide molds and stools for making steel ingots which are significantly more resistant to cracking due to thermal shock, as well as to erosion, corrosion and scaling, than are the conventional cast iron molds and stools now in use.

It is a further object of the present invention to provide improvements in methods for making such molds and stools.

It is a further object of the present invention to provide cast iron compositions suitable for making the improved molds and stools.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

According to the present invention it has been discovered that incorporation of columbium into cast iron molds and stools, considerably increases resistance to cracking caused by thermal shock, corrosion, erosion and scaling.

Further in accordance with the present invention, there are provided new and useful cast iron molds and stools having improved resistance to cracking caused by thermal shock, scaling, erosion and corrosion and having incorporated therein between about 0.04 and 0.50, and preferably between about 0.08 and 0.15, weight percent columbium.

The molds and stools of the present invention, because of their great resistance to deterioration, have a useful life which is considerably greater than that of molds and

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stools made from ordinary direct or cupola cast iron. Moreover, the material cost of the new and improved molds and stools of the present invention is only slightly greater than material costs for conventional molds and stools.

The composition of the cast iron from which the molds and stools disclosed herein are prepared is as follows:

C	2.75 to 4.5, preferably 4 to 4.25.
Mn	0.30 to 1.50, preferably 0.80 to 1.20.
Si	0.80 to 2.50, preferably 1.2 to 2.0.
Sulfur and phosphorous	Normal.
Iron	The remainder.

The cast iron may be of the direct or cupola type, and columbium in the amounts indicated hereinabove may be added to the cast iron following the procedures described hereinbelow.

Typical embodiments of molds and stools described herein are shown in the drawings, wherein:

FIGURE 1 is a cross section of a big end up mold; and

FIGURE 2 is a cross section of a big end down mold resting on a stool.

As shown in FIGURE 1, the big end up mold 2 is made of cast iron and provided with an insulated upper section or hot top 4 and an upwardly and outwardly sloping inner side wall 6 defining a cavity 10. Side wall 6 at the top of the cavity 10 is straight as shown at 8. The hot top is designed to ensure that the upper portion of the melt will be the last region to freeze. The tapered side wall 6 with the big end up and the hot top is designed to ensure progressive freezing from bottom to top so that the liquid steel can continue to feed into the center shrinkage zone as long as possible.

As shown in FIGURE 2, the big end down mold 20 rests at its big end 22 on a stool or slab of cast iron 23, and has an upwardly and inwardly tapered inner side wall 24 defining a mold cavity 30. The stool 23, which may conveniently have the shape of a rectangular slab about 9 inches thick, is supported on an ingot car 26. The big end down mold may also be provided with a hot top 28 to keep the top portion of the metal fluid until the last in a manner well understood in the art. As shown in the drawing, the hot steel impinges directly upon the stool 23 when it is teemed into the big end down mold.

In making cast iron, the heat is tapped from the furnace into a first or primary ladle. As the molten cast iron cools in the primary ladle, graphite in flake form is ejected from the melt and rises to the top of the ladle to form kish, which is the term used in the art to describe the graphite ejected from the melt. The kish layer may be 3 to 4 inches deep at the top of the primary ladle.

In order to rid the melt of the kish, the molten cast iron is ordinarily poured from the first or primary ladle to a second or supplemental ladle. The temperature of the cast iron when poured is about 2300° F., at which temperature kish forms continually. The columbium may be added to the first ladle, but is preferably added to the second ladle to prevent loss of this costly material with the kish.

It should be noted that although two ladles are ordinarily employed in handling the molten cast iron for convenience in ridding the melt of kish, a single ladle may also be used, and the kish removed by other techniques.

The temperature of the cast iron when tapped, or in the ladle, is below the temperature at which columbium and many of its alloys will melt. Accordingly, the columbium should be added to the melt in the form of a self reducing

exothermic mixture containing a columbium compound which can be readily reduced to provide liquid columbium for assimilation by the cast iron melt, or in the form of a suitable low melting alloy.

Suitable exothermic mixtures of the type described include columbium compounds, such as columbium oxide, columbium, halide, and the like, a reducing agent, such as aluminum, magnesium, sodium, silicon, and the like, and an accelerator. The presence of the accelerator is important, for in the absence thereof the evolution of heat would not be rapid enough to reduce substantially the temperature drop occurring when the mixture is added to the cast iron melt. The accelerator may comprise a wide variety of compounds, such as alkali and alkaline earth metal carbonates, nitrates, sulfates, halides and silicates, including mixtures of the foregoing.

An exothermic reaction mixture which may be used comprises columbium oxide, a mixture of aluminum and magnesium, as the reducing agent, and a mixture of cryolite and sodium nitrate as the accelerator.

Cryolite is sodium aluminum fluoride, and in its naturally occurring state contains substantial amounts of fluor-spar or siderite, together with minor amounts of silica. Typically, it contains about 70% cryolite, about 25% siderite or fluor-spar and a few percent of silica and other impurities. In most uses for cryolite, it must be purified; and beneficiated cryolite typically contains 90% or more of cryolite, with the remainder being principally fluor-spar and a minor amount of silica, and in general, special attention is usually paid to the removal of its siderite content, which is deleterious in aluminum metallurgy. However, for the purposes of the present invention, normal amounts of siderite and/or fluor-spar are not deleterious.

The following is a formulae for a self reducing mixture containing columbium oxide of the type described above:

	Parts by weight
Cryolite -----	10 to 20, preferably 15.
NaNO ₃ -----	2 to 15, preferably 5.
Cb ₂ O ₃ -----	20 to 75, preferably 65.
Mg+Al -----	10 to 20, preferably 15.

The magnesium and aluminum are properly balanced to give the proper reducing action. Of these two metals, the magnesium acts quickly and gives a high initial intensity of reaction with evolution of large quantities of heat. The aluminum is slower acting than the magnesium, but gives a follow through action necessary to complete reduction of the columbium oxide. The molar ratio of aluminum to magnesium in the admixture may vary from about 2:1 to 6:1, and is preferably between about 3.5:1 to 4.5:1. Particularly good results are obtained when the molar ratio of aluminum to magnesium is about 4:1.

If desired, the Mg and Al in the above formulae may be replaced wholly or in part by silicon. The silicon may be in various forms, but preferably is added as ferrosilicon (FeSi) or calcium silicon (CaSi).

The self reducing admixture may be added to the cast iron melt as such, or if desired, a suitable binder, either organic or inorganic, may be added to the admixture and briquettes or pellets formed therefrom in a manner well understood in the art to facilitate the addition of the self reducing system to the melt.

In making briquettes or pellets from the above mixture, a suitable binder in an amount of between about 1 and 30 percent or more by weight of the mixture, is added to the admixture, and the resulting composition is molded or extruded, followed by curing as by sintering, to form dense briquettes or pellets in a manner well understood in the art.

Typical organic binders which may be used include long chain saturated or unsaturated hydrocarbons, polymeric organic compounds and so forth. Among such materials may be mentioned asphalt, tar, pitch, cellulosic derivatives, such as shellac, rubber, including natural rubber and synthetic rubbers such as butadiene, styrene copolymer, or

other suitable organic binder materials. As inorganic binders may be mentioned water glass, i.e., sodium silicate, clays, such as bentonite clay, and the like. Also if desired a mixture of organic and inorganic binders may be used.

As another example of a self reducing exothermic reaction mixture suitable for adding columbium to the cast iron melt may be mentioned a charge comprising columbium chloride, sodium chloride and metallic sodium.

The columbium compounds in the exothermic admixtures described herein may be in the form of pure compound, e.g., columbium oxide, columbium chloride, and so forth, or may be in the form of an ore containing a columbium compound.

If desired, the columbium may also be added as an alloy in admixture with a reducing agent and accelerator. Typical of such a composition is a mixture of ferrocolumbium, a reducing agent, such as a member selected from the group consisting of Si, FeSi, CaSi, AlMg, and mixtures of the foregoing, and an accelerator. As an accelerator may be mentioned any of those described hereinabove, although preferable for use is sodium nitrate.

The amount of ferrocolumbium in such alloy admixtures may vary between about 40 and 90 weight percent or higher, with the balance being reducing agent and accelerator suitably proportioned.

Typical examples of ferrocolumbium admixtures which may be used are as follows.

Example 1

Ingredient:	Weight percent
Ferrocolumbium -----	80
FeSi -----	10
NaNO ₃ -----	10

Example 2

Ingredient:	Weight percent
Ferrocolumbium -----	80
FeSi -----	7
AlMg -----	3
NaNO ₃ -----	10

Example 3

Ingredient:	Weight percent
Ferrocolumbium -----	80
NaNO ₃ -----	10
CaSi -----	10

The columbium in the form of a suitable self reducing exothermic admixture or otherwise as described hereinabove, is added to the tapped cast iron melt, and the columbium thereby released to and incorporated into the melt. As indicated above, the columbium may be added to either the first or the second ladle.

It is also possible, when the columbium is added in briquette form, to employ only one ladle, and to add the columbium containing briquette to the stream of metal as it leaves the furnace. In this embodiment, the stream will carry the briquettes into the ladle and will provide heat to start the reaction.

In making cast iron molds and stools from the resulting melt, the melt containing columbium in the amount specified above is poured from the ladle into sand molds suitably shaped to form the molds and stools disclosed herein and allowed to cool.

The invention in its broader aspects is not limited to the specific articles, compositions, steps and methods described, but departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed:

1. Molds and stools for making steel ingots having improved resistance to deterioration caused by thermal shock, scaling, erosion and corrosion, said molds and stools being fabricated from cast iron having incorporated therein about 0.04 to 0.50 weight percent columbium.
2. The cast iron molds and stools of claim 1 which

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consist essentially of, in percentage by weight, 2.75 to 4.5 percent carbon, 0.30 to 1.50 percent manganese, 0.80 to 2.50 percent silicon, 0.04 to 0.50 percent columbium, phosphorous and sulfur in normal amounts, and the remainder iron.

3. The cast iron molds and stools of claim 1 which consist essentially of, in percentage by weight, 4.0 to 4.25 percent carbon, 0.80 to 1.20 percent manganese, 1.20 to 2.0 percent silicon, 0.08 to 0.15 percent columbium, sulfur and phosphorous in normal amounts, and the remainder iron.

4. A method of improving the resistance to deterioration of cast iron molds and stools for making steel ingots caused by corrosion, erosion, scaling and cracking, which comprises fabricating the molds and stools from cast iron which has incorporated therein between about 0.04 and 0.50 weight percent columbium.

5. The method of claim 4 wherein the cast iron consists essentially of, by weight, 2.75 to 4.5 percent carbon, 0.30 to 1.50 percent manganese, 0.80 to 2.50 percent silicon, phosphorous and sulfur in normal amounts, and the remainder iron.

6. The method of claim 4 wherein the cast iron consists essentially of, by weight, 4.0 to 4.25 percent carbon, 0.80 to 1.20 percent manganese, 1.20 to 2.0 percent silicon, sulfur and phosphorous in normal amounts, and the remainder iron.

7. A mold for making steel ingots having improved resistance to deterioration caused by corrosion, erosion, scaling and cracking, which comprises vertical side walls defining an opening at the upper end for reception of molten steel and a central cavity communicating with said opening, said side walls being made of cast iron having incorporated therein between about 0.04 and 0.50 weight percent columbium.

8. The mold of claim 7 wherein the side walls adjacent the cavity slope upwardly and outwardly towards said opening.

9. The mold of claim 7 wherein the side walls define a second opening at the lower end, the side walls adjacent the cavity extending upwardly and inwardly from the lower end to the upper end.

10. The mold of claim 9 including a stool supporting the mold at the lower end, the stool comprising a slab of cast iron having incorporated therein from between about 0.04 and 0.50 weight percent columbium.

11. The mold of claim 7 in which the cast iron side walls consist essentially of, in percentage by weight, 2.75 to 4.5 percent carbon, 0.30 to 1.50 percent manganese, 0.80 to 2.50 percent silicon, 0.04 to 0.50 percent columbium, phosphorous and sulfur in normal amounts, and the remainder iron.

12. The mold of claim 7 in which the cast iron side walls consist essentially of, in percentage by weight, 4.0 to 4.25 percent carbon, 0.80 to 1.20 percent manganese, 1.20 to 2.0 percent silicon, 0.08 to 0.15 percent columbium, sulfur and phosphorous in normal amounts, and the remainder iron.

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13. A stool for supporting a big end down mold comprising vertical cast iron side walls defining an upper and a lower opening and an elongated central cavity between the openings, the lower opening being larger than the upper opening, and the side walls adjacent the cavity extending upwardly and inwardly from the lower opening to the upper opening, said stool comprising a slab of cast iron having incorporated therein from between about 0.04 and 0.50 weight percent columbium.

14. In a method of making cast iron molds and stools which are resistant to deterioration caused by corrosion, erosion, scaling and cracking, the improvement which comprises preparing a melt of cast iron, adding to the melt an exothermic reaction mixture comprising a columbium compound capable of being reduced to columbium, a reducing agent for the columbium compound, and an accelerator to promote the reduction reaction, the amount of said mixture added to the melt being sufficient to provide between about 0.04 and 0.50 weight percent columbium, based upon cast iron, pouring the resulting melt into suitably shaped molds, and then solidifying the melt in the shape desired by cooling.

15. The improvement of claim 14 wherein the columbium compound is a member selected from the group consisting of columbium oxide, columbium halide, ferrocolumbium and mixtures of the foregoing, the reducing agent is a member selected from the group consisting of aluminum, calcium, iron, magnesium, sodium, silicon and mixtures of the foregoing and the accelerator is a member selected from the group consisting of alkali and alkaline earth metal carbonates nitrates, sulfates, halides, silicates, and mixtures of the foregoing.

16. The method of claim 14 wherein the exothermic reaction mixture comprises 10 to 20 parts by weight cryolite, 2 to 15 parts by weight sodium nitrate, 20 to 75 parts by weight columbium oxide, and 10 to 20 parts by weight of magnesium-aluminum.

17. The method of claim 14 wherein the exothermic reaction mixture comprises ferrocolumbium, sodium nitrate, and a member selected from the group consisting of iron-silicon and calcium-silicon.

18. The method of claim 17 wherein the exothermic reaction mixture includes aluminum-magnesium.

19. The method of claim 14 wherein the exothermic reaction mixture comprises columbium chloride, sodium chloride and metallic sodium.

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