March 26, 1974 F. BREUER 3,799,761

PRODUCTION OF FERROALLOYS BY MIXING IN THE EXCLUSION OF AIR

Filed Sept. 3, 1971

Fig.1

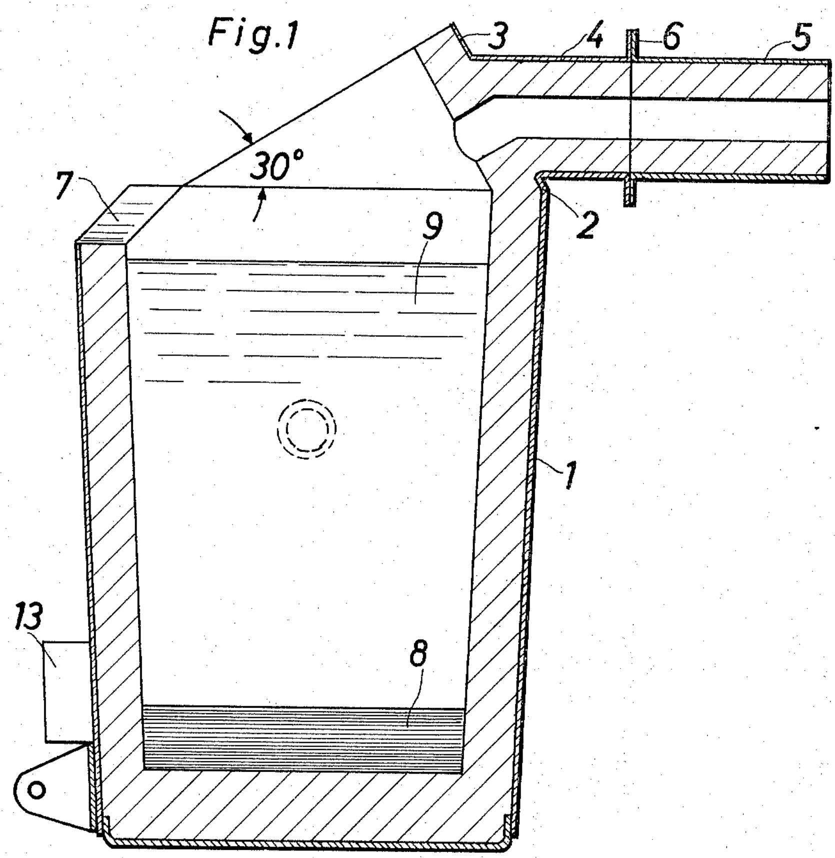
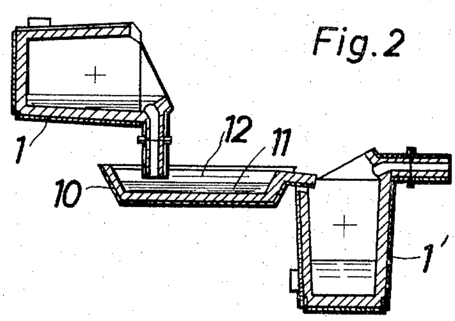


Fig.2



United States Patent Office

3,799,761
Patented Mar. 26, 1974

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PRODUCTION OF FERROALLOYS BY MIXING IN THE EXCLUSION OF AIR

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Filed Sept. 3, 1971, Ser. No. 177,694
Claims priority, application Germany, Sept. 5, 1970, P 20 44 143.4
Int. Cl. C21c 5/52
U.S. Cl. 75—13 9 Claims

ABSTRACT OF THE DISCLOSURE

Ferroalloys of the metals chromium, manganese, tantalum, niobium and/or vanadium with a nitrogen content of less than 0.015% may be obtained by reacting a molten mixture of raw stock and lime with metal-containing reducing agents while pouring the reaction mixture from one ladle to another in the absence of air, e.g. in the Perrin process, by the use of a ladle having a closed spout attached to the rim of the ladle of length at least equal to ¼ of the height of the said ladle whereby the liquid metal alloy is poured from the said ladle into liquid slag in a like ladle.

This invention relates to the production of ferroalloys of the metals chromium, manganese, tantalum, niobium and/or vanadium, from ores, slags and/or slag concentrates by the electro-metallothermal process, and particularly relates to a ladle for use in such a process.

Ferroalloys may be produced in conventional manner by reacting a molten mixture of raw stock and lime with silicon-containing reducing agents, the resultant ferroalloy melt being tapped into moulds in which the melt cools. Ferroalloys thus obtained contain varying contents of nitrogen, particularly when the liquid slag and the ferroalloy obtained by the reduction of the oxide with silicon-containing reducing agents such as ferrosilicon, silicochrome, silicomanganese, has been poured repeatedly from one ladle into another, as for instance in the Perrin process for the purpose of achieving an improved and more rapid reduction.

When the melt is thus poured from one vessel into another, and also when it is tapped, a stream of liquid alloy makes contact with the ambient air. Owing to the relatively greater surface of the stream, metals that have an affinity for nitrogen, such as chromium, manganese, tantalum, niobium and vanadium, combine with the nitrogen in the atmosphere and the resultant ferroalloys have nitrogen contents between 0.03 and 0.05%.

Although such nitrogen-containing ferroalloys can be used for the production of many steels, the production of special steels having very low nitrogen contents requires that the nitrogen content of the ferroalloy should not exceed 0.015%. This applies for instance to the melting of ferritic steels. In these steels the sum of carbon and nitrogen should not be above 0.04%. Since the ferroalloys always have carbon contents of about 0.02%, the nitrogen contents should be below 0.015%. Hence alloys produced by the Perrin process cannot be used for melting such steels.

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Ferroalloys having nitrogen contents between 0.005 and 0.01% can be produced in a simple manner by allowing the ferroalloy obtained after the reduction of the oxides to cool under the protection of the covering slag which in bulk far exceeds that of the metal alloy. However, this procedure is uneconomical. Due to the protracted cooling times a large number of ladles is needed. The slag that is formed still contains a significant proportion, frequently up to 15%, of unreduced valuable oxides. In order to recover the metals from such slags these must be remelted, which increases the consumption of power.

These disadvantages can be mitigated by a further proposal comprising the employment of a two-part divided ladle for reacting the melt of raw stock and lime with the metal-containing, preferably silicon-containing reducing agents. After the completion of the reducing reaction from 80 to 90% of the slag is tapped from the removable upper part of the ladle which can hold this quantity, while the alloy in the bottom part of the ladle is allowed to cool under a layer of slag between 5 and 10 cms. thick. The detachable upper part of the ladle from which the slag has been tapped is placed on another prepared bottom part and in this fresh ladle a fresh reaction is performed. By using this arrangement it is possible to submit the major quantity of the slag to an after-reduction while it is still in the liquid state, since only about 10 to 20% of the slag is used as a covering layer for the liquid alloy while this cools. Alloys produced in such an apparatus contain less than 0.015% and generally only about 0.01% nitrogen.

While the described process permits alloys having the desired low nitrogen contents to be produced, nevertheless during reduction the valuable action of pouring the slag and the alloy from one vessel into another, which in the Perrin process serves for improving and accelerating the completion of the reaction of the oxide, must be completely dispensed with.

The present invention allows the advantages of frequent pouring of the reaction mixture from vessel to vessel to be retained, by the use of a ladle which has a pouring spout attached to the rim of the ladle, the length of said spout being equal to at least ¼ of the height of the ladle, depending upon the expected volume of slag.

From such a ladle the melt can be poured into another similar ladle in such a way that the entire metal melt remains under a layer of slag which entirely excludes contact with atmospheric air during the process of pouring. This is due to the fact that the liquid metal melt flows underneath a protecting layer of slag both in the reaction and in the second ladle, the pouring spout of the first ladle being immersed in the slag that has already been poured into the second ladle. The metal thus flows with the exclusion of air from ladle to ladle under the liquid slag.

By using such a particular arrangement according to the invention the pouring of slag and metal melt from ladle to ladle which in practice has proved to be so beneficial need not be dispensed with and nitrogen contents below 0.015% in the resultant ferroalloys are assured.

The ladle according to the invention may with advantage be fitted with a pouring spout at least 10 cms. below the rim of the ladle to ensure the presence of a supernatant layer of slag that is from 5 to 10 cms. thick when the liquid metal is poured out.

Alternatively there may be provided a hood carrying the pouring spout, which is attached to the rim of the ladle so that a collecting chamber is formed which has a capacity calculated to allow the liquid metal alloy to be poured out through the spout under a layer of slag that is 5 to 10 cms. thick. The hood is preferably attached to the ladle wall at an angle of about 30 degrees.

Preferably a combination of at least two ladles is used, the rim of the ladle which is diametrically opposite the pouring spout being formed with a recess corresponding to the ladle radius. The ladle that is to be emptied is inserted into this recess to enable the pouring to be accomplished without trouble and with the retention of a covering layer of slag of about 10 cms. thickness.

A preferred embodiment of a ladle according to the invention is illustratively shown in FIG. 1 of the accompanying drawing, which is a vertical section of a ladle according to the invention.

Referring to FIG. 1, attached to the rim **2** of the cylindrical body **1** of the ladle is a hood **3** disposed at an angle of 30° which carries a pouring spout **4** extending substantially at an angle of 90° to the vertical axis of the ladle **1**. Conveniently the pouring spout **4** may comprise two parts, portion **5** being connected by a flange **6** to portion **4**. This serves the purpose of permitting the end portion **5** which is subjected to greater wear, to be replaced.

Diametrically opposite the pouring spout **4** the ladle is conveniently formed with a circular recess **7** radially disposed to the body **1** of the ladle.

The capacity of the space covered by the hood **3** and of the outlet opening **4** is so calculated that the volume of metal indicated at **8** can be poured out under a cover of slag which is formed in the ladle in a volume indicated at **9**, so that the thickness of the layer of slag above the metal **8** as it flows out is between 5 and 10 cms.

The spout **4**, **5** has a length selected by reference to the expected volume of slag **9**. In practice the length of the spout **4**, **5** corresponds at least to one quarter of the height of the ladle to ensure that the end of the spout **4**, **5** dips into the slag in a receiving ladle when the metal begins to be poured out.

The ladle according to the invention is designed, in conventional manner, to incorporate a crossbar whereby with the aid of the lifting gear of a crane it may function as a tiltable ladle, and preferably a counter weight **13** may be provided near the ladle bottom.

In using the ladle according to the invention, liquid alloy will not make contact with atmospheric air when slag and metal are poured into another vessel, and nitrides do not therefore form.

When the final pouring operation has been completed the principal part of the slag, preferably about 80% of the total volume of slag, is poured off into a similar ladle. The residual slag remaining in the first ladle is poured into a cooling mould to a depth of about 10 cms. After immersion of the pouring spout in the liquid slag the liquid metal alloy is also poured in. It will then remain in this mould underneath the layer of slag until it has cooled to a temperature below 500° C. When cooling has taken place the slag and the metal alloy may be mechanically separated.

The separation of metal and slag in the liquid state can also be effected in a manner schematically indicated in FIG. 2, whereby an overflow mould **10** is provided between two similar ladles **1** and **1'** in such manner that the volume **11** of metal remains underneath a cover **12** of slag in the overflow mold while the overflowing volume of slag enters the second ladle **1'**.

If the slag that has overflowed into the second ladle should still contain a major proportion of unreduced valuable metal oxides, these can then be subsequently reduced with metal-containing reducing agents. When this after-reduction has been completed 80 to 90% of the now completely reduced slag is again poured off and discarded, whereas the liquid alloy and the remaining quantity of slag are added to a fresh melt of raw stock and lime or cooled under the completely reduced slag.

The ladles according to the invention can be used not only for the production of ferroalloys that are poor in nitrogen, but also whenever metal melts are required to be protected from the effects of atmospheric nitrogen or oxygen when being poured from one vessel into another. Naturally it is necessary that a sufficient volume of slag should be present during the melting and pouring process.

What is claimed is:

1. In a process for the production of ferroalloys of chromium, manganese, tantalum, niobium, vanadium or mixtures thereof having a nitrogen content below 0.015%, from raw stock comprising ores, slags, slag concentrates or mixtures thereof by the electro-metallothermal process comprising reacting a molten mixture of raw stock and lime with metal-containing reducing agents while pouring a reaction mixture of the molten mixture and the metal-containing reducing agents from a first ladle into a second ladle to produce a slag and a liquid metal alloy, the improvement comprising: using a ladle for the first and second ladle which has a closed pouring spout attached to the rim of the ladle of length at least equal to ¼ of the height of the ladle to pour a proportion of the total volume of slag from the first ladle into the second ladle, allowing the closed pouring spout to dip into the slag contained in the second ladle, the liquid metal alloy being then poured through the liquid slag to contact the liquid metal alloy with the liquid slag, whereby the liquid metal alloy is poured from the first ladle through liquid slag in the second ladle in the exclusion of air during the pouring process.

2. A process according to claim **1**, in which the closed pouring spout of the ladle is attached to the ladle at a point at least 10 cms. below the rim of the ladle to ensure the presence of a supernatant layer of slag that is 5 to 10 cms. thick during the pouring of the liquid metal.

3. A process according to claim **1**, in which the closed pouring spout is carried by a hood attached to the rim of the ladle to provide a collecting space for slag above the opening into the said closed pouring spout.

4. A process according to claim **1**, in which the said closed pouring spout is divided into parts detachably connected together by a flange joint.

5. A process according to claim **1**, in which the ladle rim contains a radial recess diametrically opposite the closed pouring spout whereby the closed pouring spout of the first ladle engages the recess during the pouring of metal from the first ladle to the second ladle.

6. A process according to claim **1**, in which the pouring process from the first to the second ladle is repeated several times.

7. A process according to claim **5**, in which after the last pour from the first ladle to the second ladle, as determined by the desired completion of the reaction, a major volume of the slag is poured off into a like ladle, and the residual volume of slag remaining in the first ladle is poured into a mold to a depth of about 10 cms., the pouring spout of the said first ladle immersed in the said slag and liquid metal alloy poured through the said slag into the said mold and therein cooled.

8. A process according to claim **7**, in which the cooling mould is an overflow mold interposed between adjacent like ladles.

9. A process according to claim **8**, in which after the last pour from the first ladle to the second ladle, a proportion of the total volume of slag is fully reduced in a like ladle with silicon-containing reducing agents to form a metal alloy, removing a proportion of the remaining slag therefrom, and adding the metal alloy formed to a fresh melt of raw stock and lime or cooled in an overflow mold under a cover of slag that is 5 to 10 cms. thick.

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U.S. Cl. X.R.

75—46, 61, 130.5