Nov. 1, 1932. K. M. SIMPSON 1,885,380

METHOD OF PRODUCING FERROCHROME AND OTHER SIMILAR ALLOYS

Filed May 3, 1930 2 Sheets-Sheet 1

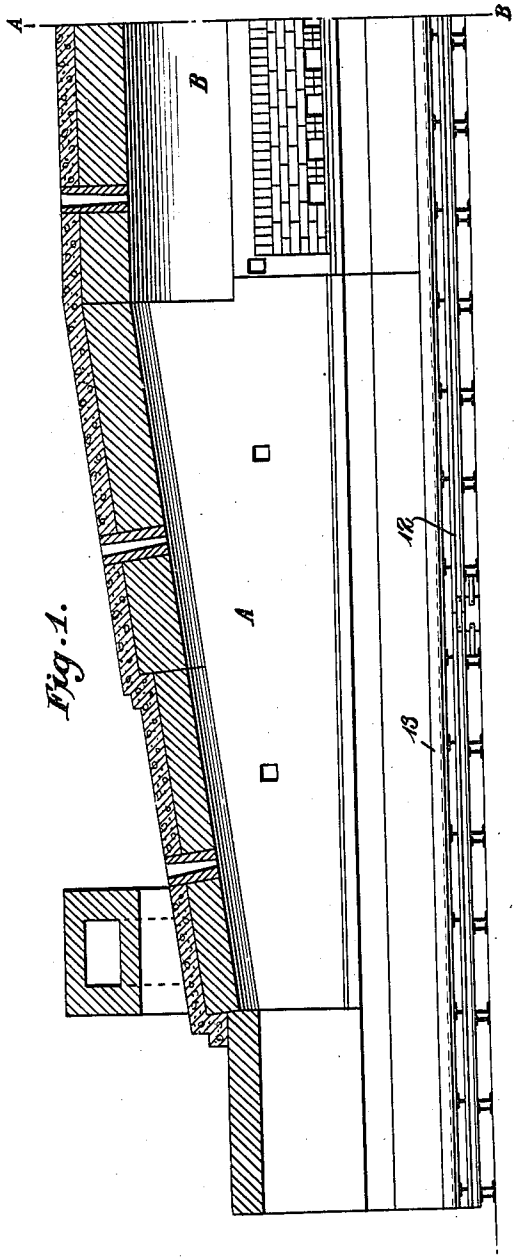


Fig. 1.

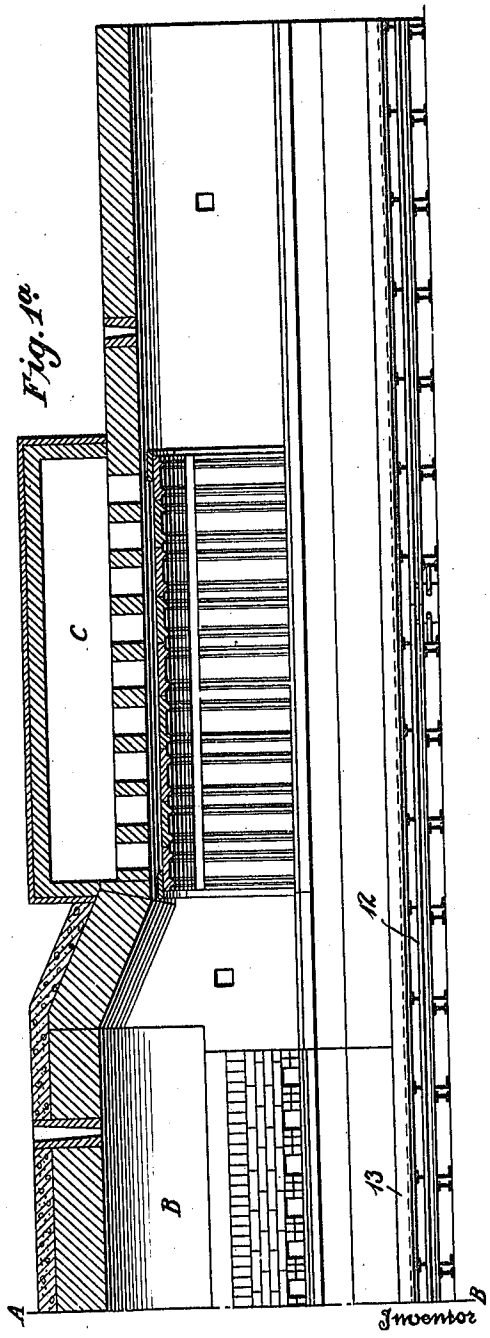


Fig. 1a.

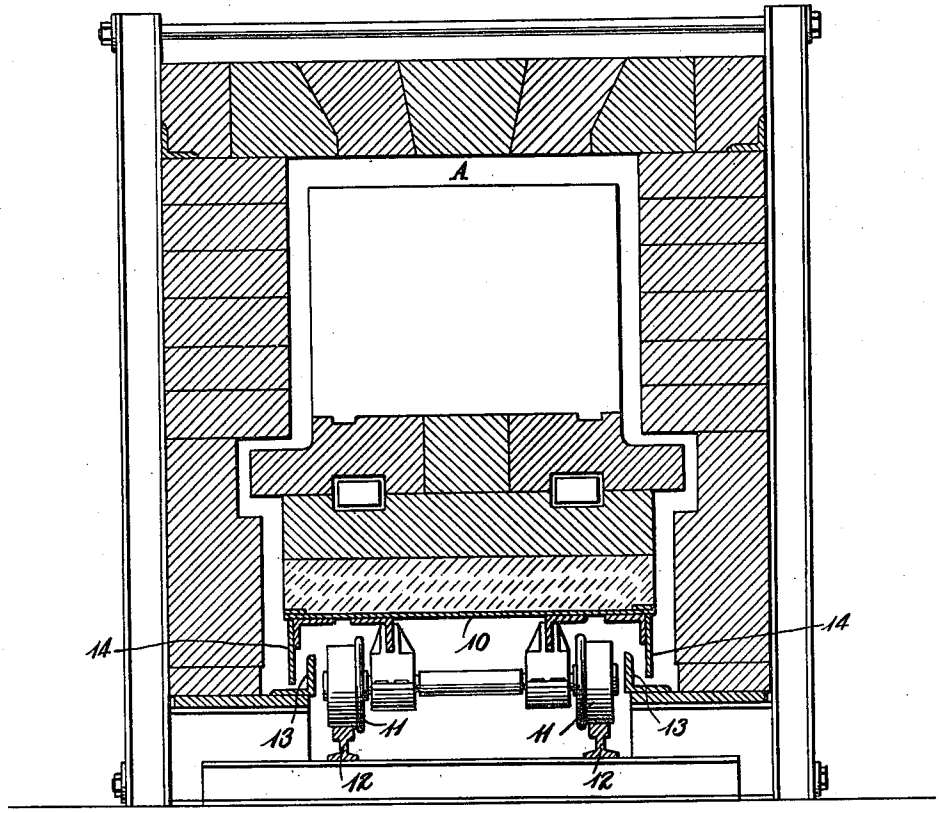
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Fig. 2.



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Patented Nov. 1, 1932 1,885,380

UNITED STATES PATENT OFFICE

KENNETH M. SIMPSON, OF NEW YORK, N. Y.

METHOD OF PRODUCING FERROCHROME AND OTHER SIMILAR ALLOYS

Application filed May 3, 1930. Serial No. 449,583.

My invention relates to an improved method for producing metals and alloys, and relates more specifically to the production of ferrochrome from chromite ore.

According to present processes now in use for making ferrochrome and alloys of this general type, the reduction of the ore is carried out in an electric furnace. The furnace is charged with the ore to be reduced, and the temperature conditions under which the reduction is carried on are such that the metal and slag formed during the treatment become fluid, and remain fluid throughout the process. This is necessary in order to enable the metal and slag to be tapped off from the furnace when the reduction is complete.

The electric furnace processes for making ferrochrome, while effective for certain purposes, are quite expensive and do not give good heat economy. The operating temperatures necessary where the electric furnace is used, are invariably much higher than is necessary to effect the desired reduction, and to this extent are wasteful. Furthermore, reductions of this sort require the constant attention of expert manipulators, the control of the heating conditions being difficult. In addition, the high temperatures necessary in processes of this sort to maintain the charge under treatment sufficiently fluid to carry on the desired reduction and to enable the drawing off of the charge in the fluid state, cause undesirable side reactions to take place during the reduction of the ore to the metallic state, which affect the purity of the final product. For example, where chromite ore is smelted in an electric furnace, an appreciable amount of silicon is reduced from silica and is absorbed by the ferrochrome, constituting one of the principal impurities thereof. For this reason most of the ferrochromes now produced are contaminated with too high a content of silicon, due to the fact, as has been stated, that the operating temperature necessary in the production of the alloy is sufficiently high to cause reduction of silica. Similar undesirable side reactions take place where reducing agents other than ferrosilicon are used.

My invention relates to a process of forming alloys of the type of ferrochrome from ores yielding the desired product, using preferably ferrosilicon as the reducing agent although other exothermic reducing agents such as aluminum, and the like may be used, in which the above disadvantages attendant upon electric furnace processes are overcome, with the production of a high grade alloy having a low content of absorbed impurities. My process is adaptable generally to the production of metals from their ores although the description of my invention will be more or less specific to the production of ferrochrome.

In my process, in place of the electric furnace necessary under the present practice in the art, I use a tunnel kiln of the character to be hereinafter described in detail. The kiln is preferably oil heated although any other suitable means for heating the kiln may be used. The ore to be treated is run into the kiln on cars in comparatively small unit charges, the cars being formed with small shallow open hearths, into which the ore is placed, and proceeds progressively through the kiln. The kiln is provided with a central heating zone which is adapted to be maintained at a temperature sufficient to initiate the reduction of the ore. From the entrance end of the kiln the temperature rises progressively up to the maximum at the central portion, and in a similar manner falls off progressively from the central zone to the exit portion of the kiln. The charge of ore and reducing agent, therefore, in passing through the kiln is heated up gradually until it reaches a central heating zone, at which period the reduction of the ore begins, and is then carried on spontaneously due to the exothermic nature of the reduction, being substantially completed as the charge leaves the central zone. The metal and slag charge then cools off progressively as it approaches the opposite end of the kiln, at which point it may be conveniently and safely removed.

I carry out the reduction of the ore under such conditions that at no time does the temperature of the charge greatly exceed that required to permit proper separation of metal and slag. The temperature of treatment

within the central heating zone is adapted to be just sufficient to maintain the metal and slag fluid so as to allow separation of the same by causing settling of the reduced metal by gravity. As each individual charge leaves the heating zone it soon reaches a temperature lower than the fusing point of the metal and when the charge reaches the opposite end of the kiln it has completely solidified into two distinct layers of metal and slag, and has become practically cold. The slag layer which is about the consistency of brittle rock, can be very easily removed from the top of the metal pig, after which the metal is lifted from the hearth.

The temperature of treatment during the reduction of chromite ore in my process is lower than that at which reduction of silica occurs to any great extent. For this reason comparatively little silicon is formed and absorbed by the metal layer, resulting in the production of a ferrochrome relatively free from large amounts of impurities and particularly low in silicon content.

The type of kiln which I have found particularly adaptable to my process is exemplified in the accompanying drawings and description in which:

Figures 1 and 1*a* comprise a longitudinal elevation in section of my preferred form of kiln; and

Fig. 2 is a transverse elevation in section of the kiln.

The zones within the furnace are represented generally by the letters A, B and C in Figs. 1 and 1*a* on the drawings. A represents the initial heating zone, B represents the central reduction zone which is maintained at the maximum kiln temperature, and C represents the zone in which the charge is gradually cooled as it leaves the zone of reduction until it reaches the exit end of the kiln.

The cars, indicated at 10, upon which the material to be treated is placed, are provided with wheels 11 which run along rails 12 on the kiln floor as indicated in Fig. 2. A sand seal is maintained between the cars and the kiln walls by means of flanges 13, which cooperate with flanges 14 on the cars to hold insulating sand. The sand seal retains the heat within the upper portion of the kiln, and enables the car wheels to operate under low temperature conditions, unaffected by the high temperature within the kiln.

To describe in detail a preferred form of my process:

Chromite ore is mixed with pulverized ferrosilicon, preferably in the ratio of 100 pounds of ore (50 to 52% Cr_2O_3) to 35.4 pounds of ferrosilicon (50% silicon). These proportions may, of course, be varied within limits. The mixed ore and reducing agent is then placed on the hearths built on the decks of the kiln cars or trucks 10. A string of cars loaded with the charge is then pushed one by one periodically, and preferably at the rate of one car an hour, into the tunnel kiln. As a new car is advanced into the kiln each preceding car in the whole string within the kiln advances one car length. The maximum temperature to which the cars are subjected in passing through the tunnel is 2640° F. The material being treated is exposed to this maximum temperature for a period of two hours although the cars remain in the kiln for a much longer period of time, the remainder of the time being consumed in allowing the cars to be gradually heated as they approach the hot central reduction zone, and to be gradually cooled after leaving the hot zone. When the car reaches the central zone, reduction of the ore by the silicon occurs, the chromium and the iron formed from the ore descending through the charge and lying at the bottom of the hearth in liquid metal form. The silica which is simultaneously formed during reduction, fuses with the impurities contained in the ore and forms a slag which collects on the top of the metal layer.

The cars after remaining within the reduction zone for a sufficient length of time are then gradually moved toward the exit of the kiln, the metal and slag soon reaching a solid state after leaving the hot zone, and gradually cooling off until completely cooled when they reach the other end of the kiln. The product obtained by this process contains from 35 to 60% chrome, from .3 to 3% silicon and from .04 to .5% carbon. Variation in the percentages of the various elements depends on the richness of the ore, the grade of ferrosilicon used, whether high or low in silicon, the amount of carbon contained in the ferrosilicon and upon other variables which may occur. Where reducing agents such as aluminum and the like or alloys containing the same are used as the reducing agents in place of ferrosilicon, equivalent amounts are used in lieu of those above given for ferrosilicon.

From the above description of the process, it will be evident that it offers numerous and desirable advances over the processes of the prior art. Tunnel kilns are particularly designed for accurate temperature control. The temperature in the hot zone of the tunnel kiln can be held to within very narrow limits and can be maintained practically constant. Obviously this results in a very desirable fuel economy. Furthermore, in my tunnel kiln process the metal and slag are required to be only sufficiently fluid to separate from each other by gravity over a period of time, actual removal of the slag from the metal taking place after the charge has been completely cooled. In the electric furnace process the slag and metal must be maintained fluid at all times, in order to flow from the furnace when the charge is removed. In this respect likewise my process results in a great saving of

fuel. The smelting operation is, moreover, carried on with small individual charges of ore and reducing agent. This allows the heat of treatment to penetrate very easily through the charge and likewise cuts down considerably on the time required to completely reduce the ore. Furthermore, the small unit masses being treated allow very easy handling of the metal and slag as it comes out of the kiln.

My process being in the nature of a semi-continuous operation, requires comparatively little expert attention, and entails low operating costs, being in these respects greatly superior to known prior processes in the art.

The accurate control of the reduction temperature results in the production of a product which is highly superior to that produced by other known processes. In maintaining the temperature of treatment close to the fusion point of the metal formed, the amount of impurities, for example, silicon, where ferrosilicon is used as the reducing agent, which will be absorbed by the bath is kept down to a minimum, thus eliminating a substantial percentage of impurities which ordinarily occur in the formation of ferrochrome.

The obtaining of the alloy and slag layers in solid form at the end of the process enables an easy and complete separation of the slag from the metal without the concomitant heat losses which result in processes such as the electric furnace process where the charge must be maintained fluid at all times.

My process, although described particularly with respect to ferrochrome, might, as has been stated, advantageously be used in the manufacture of other metals and alloys, such adaptations being within the scope of my invention.

I claim as my invention:

1. A process of producing ferrochrome from ores yielding iron and chromium which comprises reducing the metal-bearing ore in the presence of suitable reducing agent at a temperature sufficiently elevated to maintain the ferrochrome in a fluid state but not appreciably in excess of such temperature so as to prevent any substantial reduction of the components of the slag.

2. A process for producing ferrochrome from ores containing iron and chromium which comprises reducing the ore in the presence of sufficient reducing agent at a temperature sufficiently elevated to maintain the ferrochrome in a fluid state but not substantially in excess of such temperature, then cooling and solidifying the charge prior to separation of the slag and the metal, and then physically separating the slag layer from the metal layer while in the solid state.

3. The process for producing ferrochrome from ore containing iron and chromium in which the ore is reduced in the presence of a suitable amount of silicon, and at a temperature sufficiently elevated to maintain the ferrochrome fluid but not appreciably in excess of that temperature.

4. The process as described in claim 3 in which the reduced charges are cooled and solidified prior to separation of the metal and slag, the slag and metal layers being subsequently separated while in the solid state.

5. A process of producing ferrochrome from a suitable ore such as chromite, in which the ore in the presence of sufficient reducing agent is continuously fed into a reducing zone, the temperature elevated sufficiently to maintain the ferrochrome fluid, but not substantially in excess thereof, then continuously cooling and solidifying the reduced material prior to any separation of metal and slag, and subsequently removing the slag from the metal while in the solid state.

6. A process for producing ferrochrome from suitable ores such as chromite, in which the ore is reduced in the presence of a sufficient amount of silicon, and at a temperature sufficiently elevated to maintain the ferrochrome fluid, then continuously passing the reduced material into a zone in which it is progressively cooled prior to any separation of slag and metal, and subsequently removing the slag layer from the metal while in the solid state.

7. A process for producing ferrochrome from suitable ores such as chromite, in which the ore together with a sufficient amount of ferrosilicon is continuously passed into an initial heating zone in which it is progressively heated to a desired temperature, then continuously passing the material under treatment into a maximum heating zone in which the temperature is sufficiently elevated to effect the desired reduction and to maintain the ferrochrome in a fluid state, the reduced material then being continuously passed from the reduction zone into a zone in which it is progressively cooled.

8. A process of producing ferrochrome from chromite ore in which the ore and a sufficient amount of ferrosilicon in small unit charges is fed continuously into an initial heating zone in which the material is progressively heated to a desired temperature, then continuously passing the unit charges of material under treatment into a maximum heating zone in which the temperature of treatment is sufficiently elevated to maintain the ferrochrome fluid and sufficiently low to prevent substantial reduction of the silica from the slag, then passing the unit charges of reduced material into a cooling zone in which the material is progressively cooled to a temperature at which it may be conveniently handled, then separating the metal and slag layers while in a solid state by physical means.

9. A process for producing ferrochrome from ores yielding iron and chromium which

comprises reducing the metal-bearing ore in the presence of an exothermic reducing agent at a temperature sufficiently elevated to maintain the ferrochrome fluid, but not appreciably in excess of that temperature.

In testimony whereof I affix my signature.

KENNETH M. SIMPSON.