July 28, 1942. R. M. GIBSON 2,291,222

METALLURGICAL PROCESS

Filed July 24, 1941

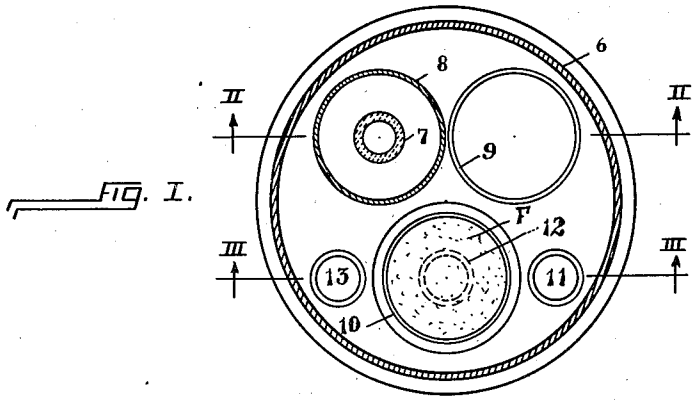


FIG. I.

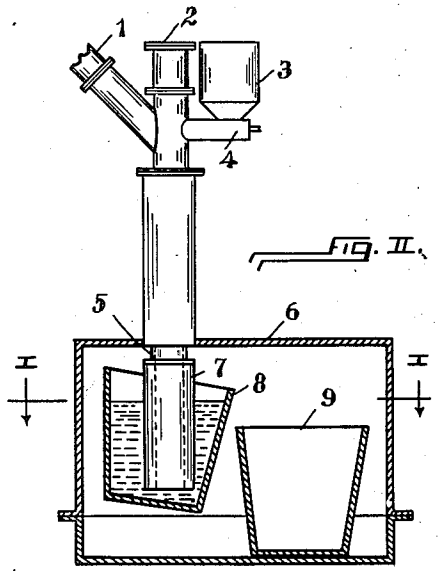


FIG. II.

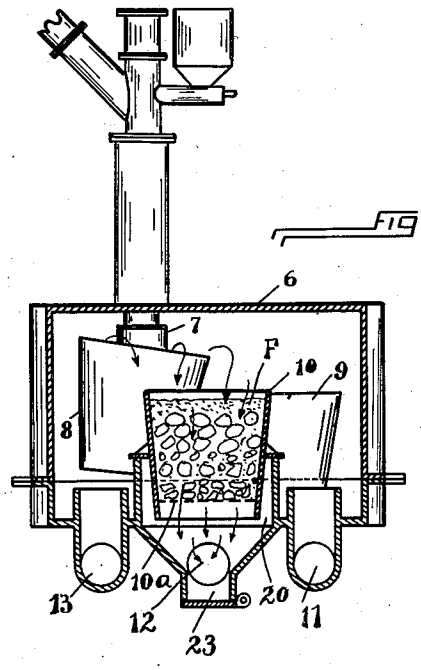


FIG. III.

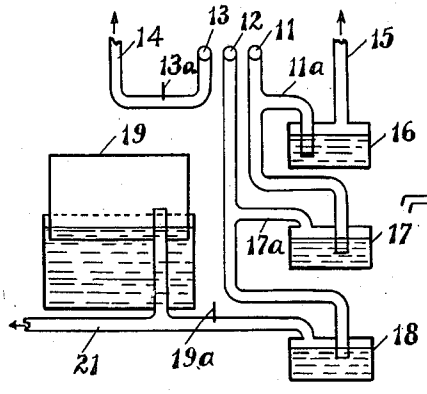


FIG. IV.

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2,291,222

UNITED STATES PATENT OFFICE

2,291,222

METALLURGICAL PROCESS

Robert M. Gibson, Pittsburgh, Pa.

Application July 24, 1941, Serial No. 403,783

3 Claims. (Cl. 75—60)

My invention relates to the reduction and refinement of metals, and consists in improvements in method.

The method of the invention may be practised to advantage in the reduction and refinement of various metals, but it is particularly designed for use in the production of steel, and more particularly to the production of steel in accordance with the Bessemer process.

In the production of steel by the Bessemer process a bath of molten iron (typically pig-iron) is blown through with air. By the in-blown air the silicon, the manganese, and the carbon present in the iron are burned out, with a generation of heat sufficient to maintain the metal in molten state. Afterward manganese and carbon in measured quantities and to the required degree are restored to the metal, and other and various desired components of the ultimate steel as well. The gaseous products that are driven or blown from the molten metal during the operation are composed principally of carbon monoxide (CO) and carbon dioxide (CO_2), together with fumes and particles of manganese and other ingredients of the mix. Hitherto, these products have been discharged into the open atmosphere, with substantial waste of valuable gases and metals.

In the practice of my invention, these hot gases rising from the converter are led through a filter bed or column formed of the materials that are used in the charge of a blast furnace. Specifically, the filter is formed of iron ore, limestone and coke, the iron ore consisting, conveniently, of flue dust obtained from blast furnace gas.

The filter removes from the gases the particulate material and fumes that otherwise are discharged into the open atmosphere; the cleansed gases are collected and conserved for other uses; the sensible heat of the gases is transferred to the body of the filter, and the volume of the gases is reduced for storage; and the ore included in the body of the filter is partially reduced or sintered, and thus brought to superior condition for charging to a blast-furnace.

In an application for Letters Patent of the United States, Serial No. 396,568, filed by me June 4, 1941, I have illustrated and described apparatus for the production of steel by the Bessemer procedure, and in exemplary way I shall describe the practice of my present invention in an elaborated form of such apparatus.

In the accompanying drawing

Fig. I is a view in horizontal section of the apparatus;

Fig. II is a view of the apparatus, partly in vertical section and partly in side elevation. The plane of section of Fig. I is indicated by the lines I—I in Fig. II, and that of Fig. II by the lines II—II in Fig. I;

Fig. III is a vertical sectional view of the apparatus on the plane III—III of Fig. I; and

Fig. IV is a diagrammatic view in plan of a system of ducts and water-seals embodied in the apparatus.

Referring to the drawing, a converter 8 is arranged within the furnace walls 6. It may be understood that the converter 8 is mounted upon trunions as is usual, and that conventional means are provided for raising and lowering it to place upon its trunnions and for swinging it when it rests in place upon its trunnions.

Through the furnace wall from above and into the converter 8 extends an injection pipe 5. This pipe at its lower end is formed of or encased in refractory material 7, so as to maintain its integrity when in service it is at this its lower end immersed in a bath of molten metal within the converter.

At its upper end 2 the pipe 5 is hermetically tight, but provision is there made that the pipe shall constitute a tube through which the condition of the molten metal within the converter may be detected. Such provision may consist merely of a transparent closure at 2, with or without a ray filter; or, again, it may include a telescope of low power. It may be a detecting instrumentality whose sensitive element consists of a photo-electric cell, or, it may be, a radiation pyrometer.

Air under pressure has access to the pipe 5 through the lead 1, and the pressure of the introduced air is made sufficient not only to counterbalance the hydrostatic pressure of the molten metal in the converter and to keep the pipe open to its lower extremity, but to cause air emerging from the lower end of the pipe to bubble through the molten metal. It is in virtue of air injection that the receptacle (which otherwise would properly be called a ladle) becomes a converter.

The pipe 5 may additionally be provided toward its upper end with means for introducing such solid reagent material as dolomite or lime. Such means are diagrammatically indicated in a bin 3 and a screw-conveyor 4 leading from the delivery end of the bin through the wall of pipe 5. Appropriate known means are provided for maintaining this portion of the apparatus hermetically tight during the progress of operation.

In operation, the receptacle 8 carrying a

proper charge of molten metal still in unrefined state (pig-iron, for example) is brought to position upon its trunnions within furnace 6. It is conveniently tipped on its trunnions to position such as that shown, and a second receptacle 9 is placed beside it, to receive spill from the rim of receptacle 8. The furnace then is closed, the pipe 5 is caused to extend from above and its lower end 7 to be plunged beneath the surface of and to be immersed in the bath of molten metal within receptacle 8. Air is applied, excluding molten metal from the pipe, so that the pipe is free from end to end; and through pipe 5 air is admitted and caused to penetrate the molten metal. The air so admitted attacks primarily the silicon and secondarily the manganese and the carbon of the bath, and progressively burns these elements out. As this operation progresses a silicious slag forms, floating upon the bath of molten metal.

As this initial burning-out operation progresses the pipe 5 is caused to advance downwardly in the bath of molten metal. Such downward advance is serviceable, both to give progressive effect in the burning-out of the silicon (beginning near the surface and advancing more and more deeply) and also, by displacement, to effect a spilling of the slag as it accumulates, from the rim of receptacle 8 to the receptacle 9 that stands ready to receive it.

The furnace 6 not only conserves heat, but retains the fumes and gas and dust that are produced in converter operation. In accordance with the invention, I lead these by-products of converter operation through a filter, and effect the condensation of the fumes, and the separation of the condensate, along with the dust, from the gas. The cleansed gas, consisting of a mixture of CO and CO_2 passes off and is conserved for any use desired. For example, the gas may be used as fuel, or it may be used to provide a protecting atmosphere within a furnace used to heat metal articles.

The filter consists in a gas-pervious bed or column F formed of flue dust (iron ore), limestone, and coke. The filter-forming materials are sustained in a receptacle 10 having a reticulate bottom 10*a*; the ore, limestone and coke may be mixed and distributed throughout the body of the filter, but preferably I arrange the material in strata—a layer of coke at the bottom, a layer of limestone above the coke, and a layer of flue dust or ore on top. The receptacle is seated in the mouth of a well 20 formed in the bottom of the furnace, and a duct 12 leads from the well 20, through a water-seal 18 (Fig. IV), to a discharge pipe 21.

The hot gases and fumes, rising from the bath of metal under the superatmospheric pressure of the in-blown air, percolate downward through the filter bed F. The body of the filter, being cooler than the gaseous and vaporous products yielded by the converter, condenses the fumes streaming into it, and the resulting condensate, together with the dust and particles carried in the stream, are retained in the filter body. From the bottom of the filter clean gas ($CO+CO_2$) emerges, and finds escape through the duct 12 and water-seal 18 to the discharge line 21. The discharge line 21 may communicate with a storage tank 19, or with a heating furnace, or some other piece of ancillary equipment. Thus it is that the gases are cleansed, and the manganese and other ingredients, which usually are burned out of the metal in the converter and lost, are recovered in the filter.

When the filter bed F has become saturated or clogged, the material is removed from the receptacle and charged into a blast furnace. The body of the filter includes not only the initially provided normal components of a blast furnace charge, but includes as valuable additions the manganese and other ingredients that have been reclaimed as by-products of the Bessemer process. And it is further important to note that the flue dust included with the limestone and coke in the filter body is, under the influence of the hot gases meandering through the filter body, sintered and partially reduced, whereby it is more quickly responsive to the metal-reducing reactions within the blast furnace. (It will be understood that it is customary in normal blast furnace operation to sinter flue dust and finely divided ore, in order that it may be used in the charge of a furnace.) In the bottom of the well 20 a trap 23 is provided for the retention of such molten metal and slag as may drain from the filter body under the metal-reducing influence of the hot gases.

Two auxiliary ducts 11 and 13 communicate with the converter-enclosing chamber of the furnace. The auxiliary duct 11 extends from the furnace chamber to a water-seal 17 (Fig. IV) whose outlet 17*a* leads to the main outgo duct 12, and a branch 11*a* connects the auxiliary duct 11, through a water-seal 16, to a stack 15. If the body of the filter should, during converter operation, become sintered or clogged to such degree that the gases and fumes can not flow through it, the duct 11 provides an escape. The gases flow through duct 11 and water-seal 17 and branch 17*a* to the main delivery duct 12, whence they pass through water seal 18 to the discharge line 21. And if for any reason it is desired to interrupt the delivery of gas to the discharge line 21 or storage tank 19, the valve 19*a* is closed, with the consequence and effect that the gases escaping from the furnace to auxiliary duct 11 are bypassed through the water-seal 16 to the stack 15. It will be perceived that the inlets to the several water-seals 16, 17, 18 are submerged in the water at successively decreased depths, so that the hydrostatic heads against which the gases must flow to enter one or another of the seals are correspondingly graduated. The hydrostatic head is greater for the seal 17 than for the seal 18, and in turn is greater for the seal 16 than the seal 17. Thus, the different courses of gaseous flow are automatically determined and maintained under the several conditions of operation described. It may also be noted that the water-seals serve not only to insure proper flow of the gases, but additionally serve as gas washers.

The auxiliary outlet duct 13 of the furnace leads through a valve 13*a* to a stack 14, and by means of such outlet the gases and fumes produced at the start of converter operation are by-passed to the stack. It will be understood that when the Bessemer procedure is initiated upon a fresh bath of metal in the converter 8, the silicon in the metal burns first, and the gaseous products are in the main nitrogen and carbon dioxide. During this stage of the operation the valve 13*a* is held open, and the products, useless for present purposes, are discharged into the stack. When the silicon has been burned out, the gases and fumes contain the desired products. The valve 13*a* is then closed and procedure above described is followed.

The outlet 13 is also opened to vent the gases within the furnace to the outer atmosphere before the furnace is opened for the introduction and removal of the converter 8 and slag container 9, or for renewal of the filter body F.

I claim as my invention:

1. In the production of steel by the Bessemer process, the method herein described of conserving useful materials that consists in percolating through a body of normal blast-furnace charge ingredients the hot and gaseous stream that flows from a Bessemer converter when under blast, and while cleansing the gases of the stream, enriching such body for charging to a blast-furnace with material filtered from the stream, and collecting the cleansed gases in segregated and industrially useful condition.

2. In the production of steel by the Bessemer process, the method herein described of conserving useful materials that consists in percolating through a body of finely divided iron ore the hot and gaseous stream that flows from a Bessemer converter when under blast, and, while cleansing the gases of the stream and while effecting coalescence of the finely divided ore, enriching the body of ore for charging to a blast-furnace with materials filtered from said stream, and collecting the cleansed gases in segregated and industrially useful condition.

3. In the production of steel by the Bessemer process, the method herein described of conserving useful materials, that consists in percolating through a body of blast-furnace charge material the hot and gaseous stream that flows from a Bessemer converter when under blast, and, while cleansing the gases of the stream, enriching the body of blast-furnace charge material, and valving the cleansed gases alternately to waste and to storage.

ROBERT M. GIBSON.