Jan. 2, 1962 R. RUMMEL 3,015,554

METHOD AND DEVICE FOR CARRYING OUT METALLURGICAL PROCESSES, PARTICULARLY AIR REFINING PROCESSES

Filed April 15, 1958 2 Sheets-Sheet 1

Fig. 1

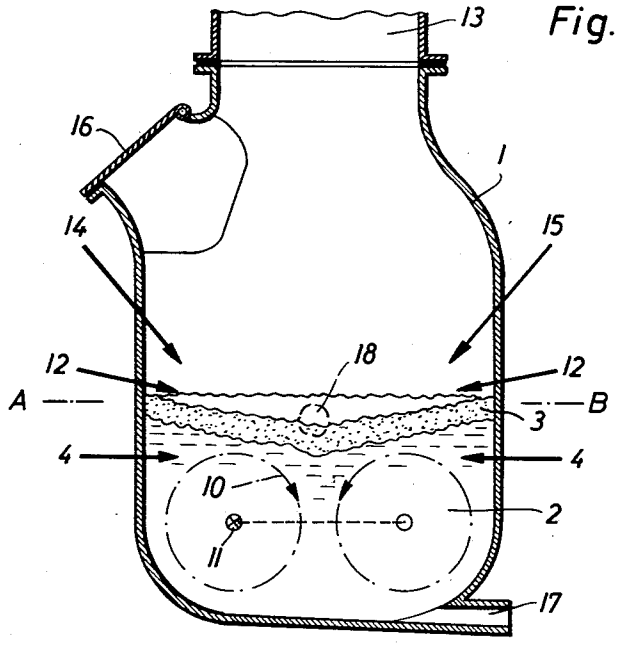
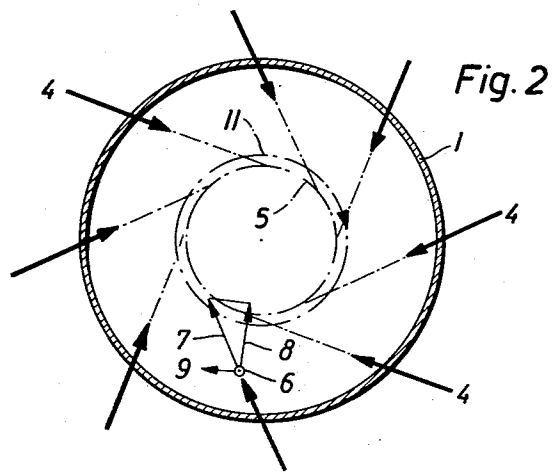


Fig. 2



INVENTOR

ROMAN RUMMEL

BY

Burgess, Dinklage & Sprung

ATTORNEYS

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Fig. 3

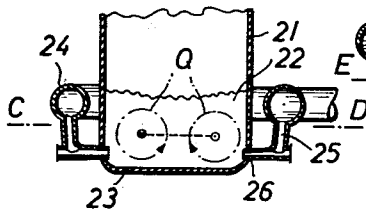


Fig. 5

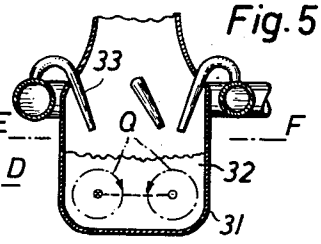


Fig. 4

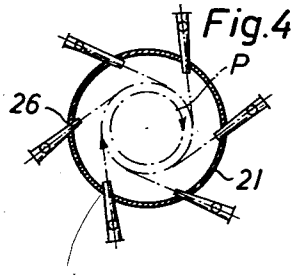


Fig. 6

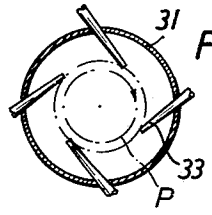


Fig. 7

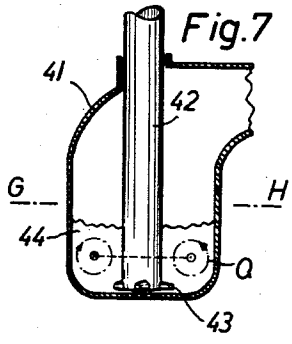


Fig. 9

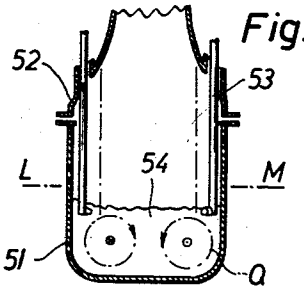


Fig. 8

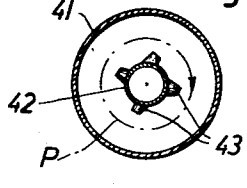
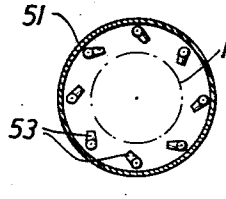


Fig. 10



INVENTOR
ROMAN RUMMEL
BY
Burgess, Dinklage + Sprung
ATTORNEYS

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METHOD AND DEVICE FOR CARRYING OUT METALLURGICAL PROCESSES, PARTICULARLY AIR REFINING PROCESSES

Roman Rummel, 29 Daberger Weg, Bruhl, Bezirk Koln, Germany

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10 Claims. (Cl. 75—51)

This invention relates to a method and a device for carrying out metallurgical processes, and it more particularly pertains to a method and a device for carrying out air refining processes.

While the known converter processes, as for example, the Thomas and Bessemer processes in iron and steel industry are very efficient processes, they have the disadvantage that the quality of the steel produced by these processes falls increasingly short of the current requirements. Moreover, they require a specific composition of the pig iron to be blown and, therefore, limit in many cases the applicability of these processes on a wide basis.

By enriching the air with oxygen, if desired up to almost 100%, and changing over to top blowing, the narrow limits of the composition of the raw material in case of the classical converter processes could be widened to some extent.

In a process which has become known recently, the refining is effected with oxygen or oxygen-enriched air in a rotating vessel to achieve obviously a better agitation of the charge. Introducing part of the blast into the bath and the other part above the bath has the effect of burning the carbon monoxide formed in the decarburization to form carbon dioxide so that a considerable part of the heat thus set free is utilized for the process. A considerable improvement in the quality of the blown steel could be achieved with this process.

It has now been found that, in metallurgical processes, as for example, in the air refining process, the success obtainable with respect to the throughput capacity, the yield and the quality of the finished product is the greater the more uniformly the reaction proceeds throughout the bath with the reacting media rapidly changing their position with respect to each other and with the finished products of the reaction being immediately separated from each other.

In case of the known processes, this condition is met more or less incompletely. The reaction proceeds only in a limited part of the bath volume, which makes the condition of the bath irregular. This can be made up only in part by the motion of the bath which extends by no means throughout the bath. Therefore, the throughput, the quality and the yield are absolutely capable of considerable improvements.

In accordance with the invention, the requirement mentioned above is largely met by introducing the reaction media (e.g. air, oxygen-enriched air or oxygen in case of refining by the blowing process) with uniform distribution over the bath and by maintaining the bath in a turbulent motion extending uniformly throughout the contents of the bath. Both the introduction of the reaction media with uniform distribution over the bath and the uniform turbulence prevailing throughout the contents of the bath can be achieved in a particularly simple manner in a bath which rotates about the vertical axis of the reaction vessel. In accordance with the invention, the process of constant agitation of the bath is still accelerated and intensified by superimposing a second motion on the bath rotating about a vertical axis, said second motion substantially providing a rotation about a horizontal axis. From the geometrical point of view, the bath as a rotational body is formed by a producing plane, the path of the center of gravity of which may approximately represent the axis about which the bath rotates in addition. The resultant of both motions represents a spiral line closed in itself and extending horizontally about the vertical axis of the bath and filling out the entire bath space. The turbulence produced with sufficient velocity of the motion provides for a constant vigorous and uniform agitation of the bath.

The horizontal cross-sectional area of the bath space will usually be of circular form. The line of the center of gravity of the producing cross-sectional area of the bath will then be a circle of about half the diameter of the bath if the producing plane substantially represents a rectangle. In specific cases it may be desirable to give the horizontal cross-sectional area of the bath an elliptic or similar shape if particular patterns of motion of the bath are to be obtained or in case this appears to be useful because of constructional conditions.

The motion of the bath as suggested promotes in a particularly efficient manner the constant change between the bath and the slag at the interface thereof. This change is still aided by the gaseous reaction products emerging from the bath and the sucking effect of the vortex in the center of the bath surface or at the wall of the vessel according to the sense of rotation of the spiral motion.

In accordance with the invention, the turbulent motion of the bath can be maintained by the energy of flow of the reaction media being introduced. By selecting the inlet velocity, the direction and place of introduction of the reaction media into the bath, the motion of the latter is capable of being adapted to the particular course of reaction. By the direct contact of the bath with the reaction media, practically the total flow energy of the latter is imparted to the bath and the most favorable pattern of motion of the bath is obtained. The reaction media used for this purpose are generally in gaseous form such as air, oxygen-enriched air, oxygen or other gases. It is also possible in this manner to carry out processes with liquid reaction media. Solid reaction media present in form of dust or fine grains may be introduced into the bath by means of carrier gases which may also be reaction media. Thus, carrier gases or other gases which do not participate in the reaction act as energy carriers only. In addition, they may also function as heat carriers when introduced in heated state.

A further feature of the process of the invention relates to the introduction of fuels into the reaction chamber. These fuels are completely or partially burned for the purpose of heating up the charge or/and for supplying the heat requirements of the process or/and for reducing the raw materials or the reaction media charged. Gaseous, liquid or solid fuels are suited for this purpose. This measure permits a universal application of the present process. The feed materials may be melted down in the reaction chamber and extensively heated before the metallurgical process takes place. In this manner, the supply of heat is also possible during the metallurgical

process if the reaction is not sufficiently exothermic or if an endothermic reaction is involved. Moreover, the fuels, when completely or partially burned, permit a reducing action to be exerted on the feed materials. This reducing action may serve for pretreating or aftertreating the materials charged and for processing ores simultaneously charged.

Thus, in refining by the blowing process of the invention taken as an example for further illustration, one is no longer bound to pig iron types of a given composition. The heat of combustion of the fuels introduced is capable of compensating the deficiency of silicon, phosphorus or carbon in the pig iron. It is possible, therefore, to process, poor-grade pig iron and steel scrap. The process may also be conducted so as to reduce additions of scale or iron ores to form metallic iron.

A further advantage in accordance with the invention is obtained by the fact that reaction media, fluxes, alloying additions and/or ores present in fine-grained or dustlike form can be introduced into the reaction chamber by means of gaseous reaction media or inert gases functioning as carrier gases. Due to their small particle size and uniform distribution, they are very rapidly melted down and dissolved in the heated bath. Their reaction with constituents of the bath therefore begins immediately thereafter and proceeds in an extremely short time. Liquid materials may also be blown into the bath in a similar manner. In this case, the carrier gas simultaneously functions as an atomizing agent. If combustible reaction products in gaseous form escape from the bath during the performance of the metallurgical process, they may be burned by combustion agents such as air, oxygen-enriched air or oxygen introduced directly above the bath and uniformly distributed over the surface of the bath. Part of the heat thereby evolved is transferred to the bath thereby obtaining a better utilization of heat.

The process of the invention permits several processes to be carried out in one operation. In addition to metallurgical processes, processes of a physical nature may be carried out. For example, the feed materials, if not introduced in liquid form into the reaction vessel, may first be melted down and then the charge or constituents thereof, such as metal oxides, may be subjected to a reduction. This is followed by the blast refining process and, finally, alloying additions may be introduced into the bath. Of course, preparatory operations such as roasting, evaporation of volatile constituents, production of the slags suitable for the processes, and any other metallurgical process capable of taking place in the liquid phase may be carried out.

The gaseous reaction products formed in carrying out the process are preferably sucked off through heat exchangers and dry or wet dust separators. In the heat exchangers, the gases give off their sensible heat for preheating the reaction media, for steam generation, or the like. The dust separators free the gases from entrained dusts which are advantageously returned into the metallurgical process. The cooled gases freed from dust are passed to further processing if utilizable constituents are contained therein. Pollution problems are not to be feared when venting the gases into the atmosphere.

Several embodiments of the device for carrying out the process of the invention are diagrammatically represented by way of example in the appended drawing. FIGS. 1 and 2 show a longitudinal cross-sectional view and a cross-sectional view along the line A—B, respectively, of a reaction vessel in which the bath is imparted a spiral motion closed in itself and taking place approximately about the circle of the center of gravity of the producing cross-sectional area of the bath. Also provided are means permitting the combustible gaseous reaction products escaping from the bath to be burned directly above the bath. For heating up the reaction vessel or/and the charge or for supplying the heat requirements there are provided means for introducing fuels and combustion agents. These means can also be optionally used for introducing reaction media, fluxes, alloying materials and the like present in dustlike or fine-grained form.

The reaction vessel **1** holds a bath **2** of, for example, molten pig iron supporting a layer of slag formed by limestone and ore. Air enriched with oxygen is blown in through nozzles **4** uniformly spaced apart over the circumference of the reaction vessel and indicated in the drawing by arrows. These nozzles are positioned obliquely to the radius of the cross section of the vessel. Their direction is tangential to an imaginary concentric circle **5** being smaller than the boundary line of the wall of the vessel **1**. Most of the flow energy of the blast blown in is transferred to the bath which is imparted a vigorous agitation. Considering an infinitesimal bath element **6** and resolving its velocity vector **7** into 2 components **8** and **9** in the direction of the radius of the vessel and normally thereto first has the result that the bath element, seen as a projection on a horizontal plane, rotates about the vertical axis of the vessel and simultaneously strives to the center of the vessel. Moreover, since a sucking action is produced at the openings of the nozzles **4** and behind them due to the flowing blast, the bath is also imparted a rotary motion in the direction of the arrow **10** about a horizontal axis **11**. This axis is a circular line extending about the vertical axis of the vessel and formed by about the center of gravity of the producing bath cross-sectional area. From the pattern of motion of the bath there results the path of a bath element in a closed, spirally wound circular line about the vertical axis of the vessel and extending throughout the bath space. Due to the turbulent flow, secondary eddies are developed which are likewise uniformly distributed throughout the bath so that a constant thorough agitation of the bath is obtained. The uniformly vigorous agitation of the bath aids the constant change between the slag and the bath in a very efficient manner so that reactions between the two phases proceed rapidly and uniformly distributed over the interface thereof.

The reaction gases emerging from the bath and principally consisting of carbon monoxide and nitrogen are burned with oxygen-enriched air blown over the bath surface through the nozzles **12** uniformly spaced apart over the circumference of the reaction vessel and are led off from the reaction vessel through the waste gas outlet **13**.

The nozzles **14** and **15** are provided for introducing fuels and combustion agents and optionally for introducing reaction media, fluxes, or alloying additions. They are alternately arranged and equidistantly spaced over the circumference of the reaction vessel and directed onto the bath surface at an angle of less than 90° and preferably of 45 to 60°. Moreover, they are positioned obliquely to the radius of the vessel similar to the nozzles **4**. The fuels are introduced through the nozzles **14** and the combustion media, e.g. air or oxygen, are introduced through the nozzles **15**. The nozzles **14** may also be designed as burners through which the fuel is blown into the reaction vessel together with the combustion agent in the relative proportions desired. There is formed a hot flame with good turbulence which is brought into intimate contact with the bath surface. If required, reaction media or fluxes influencing the viscosity of the slag, ores or alloying additions in fine-grained form are blown into the bath through the nozzles **15** by means of gaseous reaction media or inert carrier gases.

The functions of the different nozzles will be adapted to the particular requirements and may be different from those described in the above example. Thus, for example, reaction media, fluxes and the like may be introduced into the bath through the nozzles **4** together with the blast. The functions of the nozzles **12**, **14**, and **15** may be exchanged at will if required or appearing to be more favorable by the particular conditions.

For feeding the charge materials in molten or solid form, one or several working doors **16** are provided. The

discharge of the reaction vessel is effected through tap holes **17** for the metal, e.g. steel, and through tap holes **18** for the slag. Several tap holes, especially for the slag, are preferably arranged at different levels of the reaction vessel. The reaction vessel may also be provided with a tilting device so that its content can be discharged in known manner by dumping. In this case, the supply of the reaction media and materials to the nozzles is effected in conventional manner through pipe lines extended through the supporting trunnions of the reaction vessel.

The nature of the lining of the reaction vessel is to be adapted in known manner to the charge materials and the operating conditions. Depending upon the materials being processed, the lining is either made basic, acid or neutral with consideration given to the operating temperatures encountered. A longer life can be achieved by cooling the outer wall. This purpose is served by a double jacket or a tubular system through which a cooling medium is circulated. Suitable cooling media include air, water, and other gases and liquids. The reaction vessel may also be constructed as a steam boiler.

The further embodiments represented in FIGS. 3 through 10 show several selected arrangements of nozzles which are suitable for carrying out the process of the invention. They are limited to those nozzles which bring about the agitation of the bath. All of the other devices already mentioned above have been omitted for better clarity.

FIG. 3 shows a longitudinal cross-sectional view of a reaction vessel **21** and FIG. 4 shows a cross-sectional view of the same vessel taken along the line C—D of FIG. 3. In this reaction vessel, the bath **22** is maintained in agitation by introducing reaction media immediately above the bottom **23** of the vessel. Branch lines **25** for the reaction agents extend from an annular line **24** to the nozzles **26** terminating obliquely to the radii of the reaction vessel. The motion of the bath obtainable thereby is indicated by the arrows P and Q.

FIG. 5 shows a longitudinal cross-sectional view of a reaction vessel **31** and FIG. 6 shows a cross-sectional view of the same reaction vessel taken along the line E—F. In this reaction vessel, the refining process is effected by blowing the blast onto the bath **32** with the blowing direction of the nozzles **33** being chosen at a steep angle and obliquely to the radii of the reaction vessel. Accordingly, the bath is imparted a rotary motion (in the direction of the arrow P) and simultaneously a rolling motion (in the direction of the arrow Q), which effects intimate agitation and by which new surfaces are constantly offered to the blast.

FIG. 7 shows a longitudinal cross-sectional view of a reaction vessel **41** having a central introduction of the refining or reaction medium through the conduit **42**, and FIG. 8 shows a cross-sectional view of the same reaction vessel taken along the line G—H of FIG. 7. The lower end of the conduit **42** terminates in nozzles **43** equidistantly spaced laterally at the circumference of the conduit and terminating obliquely to the radii of the vessel. The motion of the bath **44** is again indicated in the drawing by the arrows P and Q. The line **42** may be arranged displaceable. With the nozzles positioned about halfway up the bath level there are obtained two superimposed rolling motions in opposite directions with simultaneous rotation of the bath. With the nozzles positioned at a higher level, the rolling motion is opposite to that represented in the drawing. Whether the one or other position is preferable depends upon the duration required of the contact between the bath and the blast. This is decisively influenced by the velocity of the reaction and the viscosity of the bath, both of which are generally dependent upon the temperature. If, moreover, the nozzle-carrying conduit **42** is rotated, the rotation of the bath in the direction of the arrow P can be intensified.

If the nozzle-carrying conduit **42** is extended through a liftable cover of the reaction vessel, it is capable of being pulled out completely. The resulting opening may serve for charging and, in case of a tiltable construction of the vessel, for discharging.

FIG. 9 shows a longitudinal cross-sectional view of a reaction vessel **51** and FIG. 10 shows a cross-sectional view of the same reaction vessel taken along the line L—M of FIG. 9. Through the cover **52** of this reaction vessel, blast lances which are capable of being displaced lengthwise and rotatable and equidistantly spaced over the circumference of the cover are sunk into the bath **54** from above. They may also be designed in such a manner as to terminate above the bath so that the blowing process is effected from above. Here again, the position of the nozzles in accordance with the invention produces the characteristic motion of the bath indicated by the arrows P and Q. The cover **52** is liftable and may be pulled out and removed with the blast pipes, thereby making the bath accessible. The discharge is effected by tilting the vessel.

The examples illustrated in the drawing are not complete. Any conceivable combination of the embodiments described above is possible with consideration to be given to the nature of the processes to be carried out, the type of charge materials, etc.

Depending upon the type of materials being processed and the temperature encountered, the nozzles are made of materials which withstand these influences. If high temperatures are encountered, use is generally made of nozzles made of steel or copper which are preferably studded and provided with a coat of suitable material or slag present in carrying out the process. In the latter case, the nozzles are immersed in the molten slag. By water cooling, the nozzle becomes coated with a solid layer of slag which is retained by the studs.

What is claimed is:

1. A method of effectively carrying out metallurgical processes including converting processes, which comprises injecting reaction media into a circular zone, containing a bath of molten raw materials, from uniformly distributed sources with respect to the main axis of said zone, forcing said media both in a rotary direction oblique to the radius of said zone and in a direction forming a tangency with said axis of said zone, whereby to maintain said bath in uniform turbulent motion substantially in rotary direction around said axis, and also forcing said media in a circular direction with respect to which said axis is tangential, whereby to impart uniform distribution of said media throughout said bath.

2. A method according to claim 1, wherein a fuel is additionally injected into said zone being completely combusted therewithin.

3. A method according to claim 1, wherein a reducing fuel is additionally injected into said zone being partially combusted therewithin, the fuel additionally reducing the raw materials and the reaction media in said zone.

4. A method according to claim 1, wherein an additive material in finely divided form is injected together with said reaction media by means of a carrier gas.

5. A method according to claim 1, wherein said reaction media is present in finely divided form.

6. A method of effectively carrying out metallurgical processes including converting processes, which comprises injecting reaction media into a circular zone, containing a bath of molten raw materials, from uniformly distributed sources with respect to the main axis of said zone, forcing said media in a closed curve spiral direction which is oblique to the radius of said zone and to which the axis of said zone is tangential, whereby to maintain said bath in uniform turbulent motion substantially in a rotary spiral direction around said axis and also in a circular direction with respect to which said axis is tangential, and to impart uniform distribution of said media throughout said bath, combustible reaction products forming in and emerging from the bath being burned with a combustible gas intro-

duced from a source directly over the bath and uniformly distributed over the surface thereof.

7. A method according to claim 4, wherein said additive material is an alloying component capable of forming an alloy with the main raw material component.

8. A method according to claim 5, wherein said reaction media is injected by means of a carrier gas.

9. A method according to claim 8, wherein said carrier gas is an inert gas.

10. A method according to claim 8, wherein said carrier gas contains oxygen.

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