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Continuation-in-part of application Ser. No. 531,244, Mar. 2, 1966, now abandoned, and a continuation-in-part of 719,300, Mar. 25, 1968, now Patent No. 3,511,194. This application Sept. 5, 1969, Ser. No. 85,516

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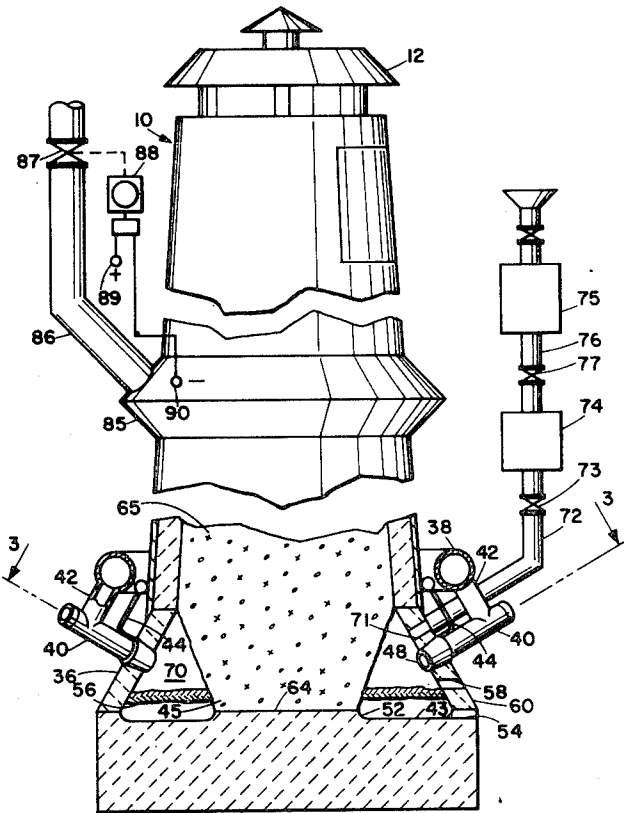
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[54] **VERTICAL SHAFT FURNACE SYSTEM**
10 Claims, 4 Drawing Figs.
[52] U.S. Cl..... **266/25,**
266/31
[51] Int. Cl..... **C21b 7/00**
[50] Field of Search..... **266/25, 27,**
28, 31, 41

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ABSTRACT: A vertical shaft furnace in which the burden or charge is supported at the base of the furnace with an open annular space surrounding the charged material within the hearth, one or more angularly or tangentially disposed downwardly inclined tuyeres for introducing preheated air, with or without added fuel, into the annular space, a bypass line which connects with the base to vent the open annular space and thereby control the degree of heating and location of heating of the burden or charge according to its location within the vertical furnace, the bypass line including valve means for controlling the outlet flow through the bypass line in accordance with the prevailing conditions of the operations, an intermediate takeoff in the vertical shaft furnace for removing volatiles and gaseous byproducts at subatmospheric pressures for subsequent processing or treatment, and valved means for introducing fluxes or other additives into the annular space at the hearth on a controlled or metered continuous basis.



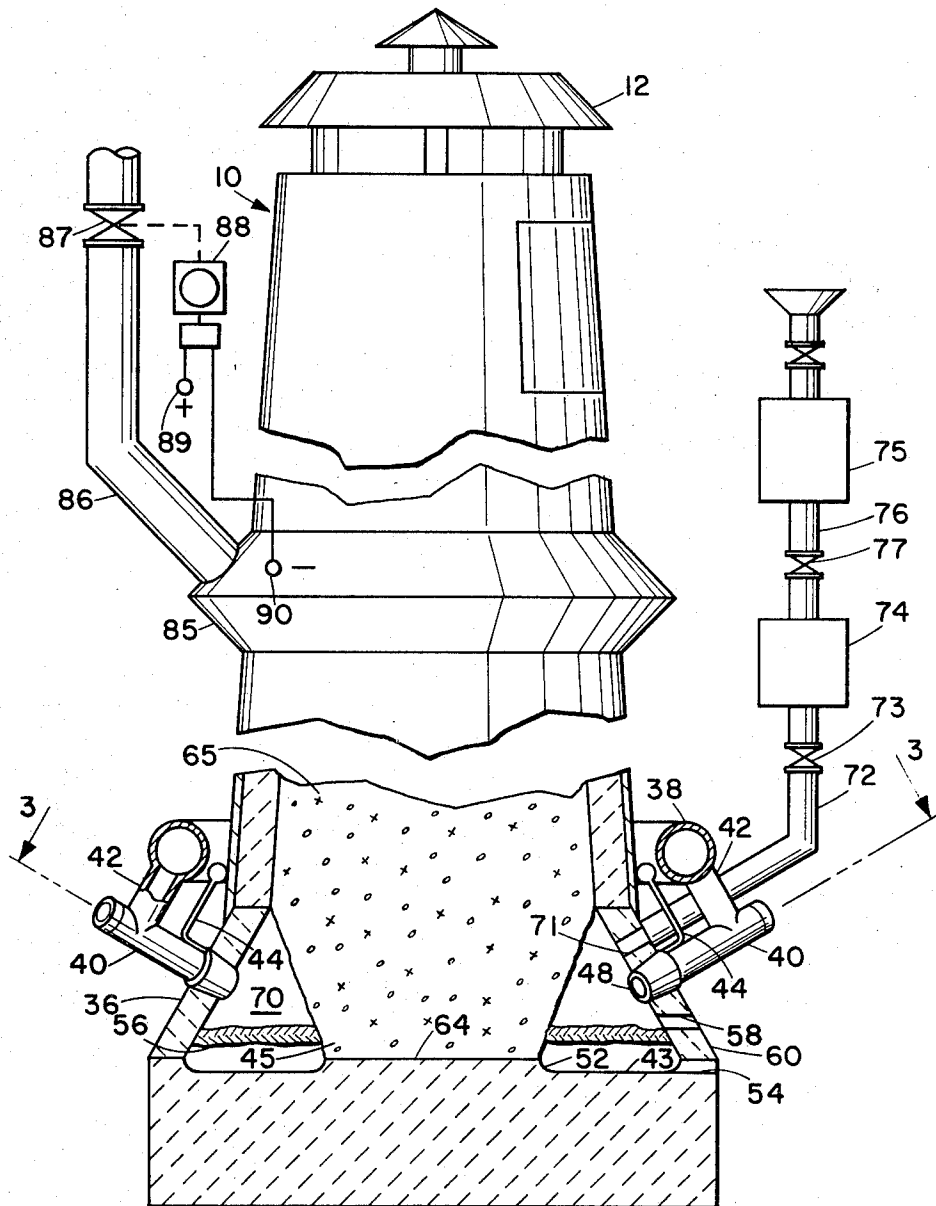


FIG. 1

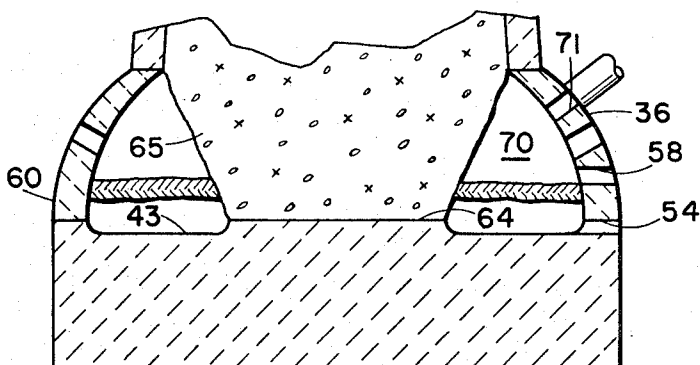


FIG. 4

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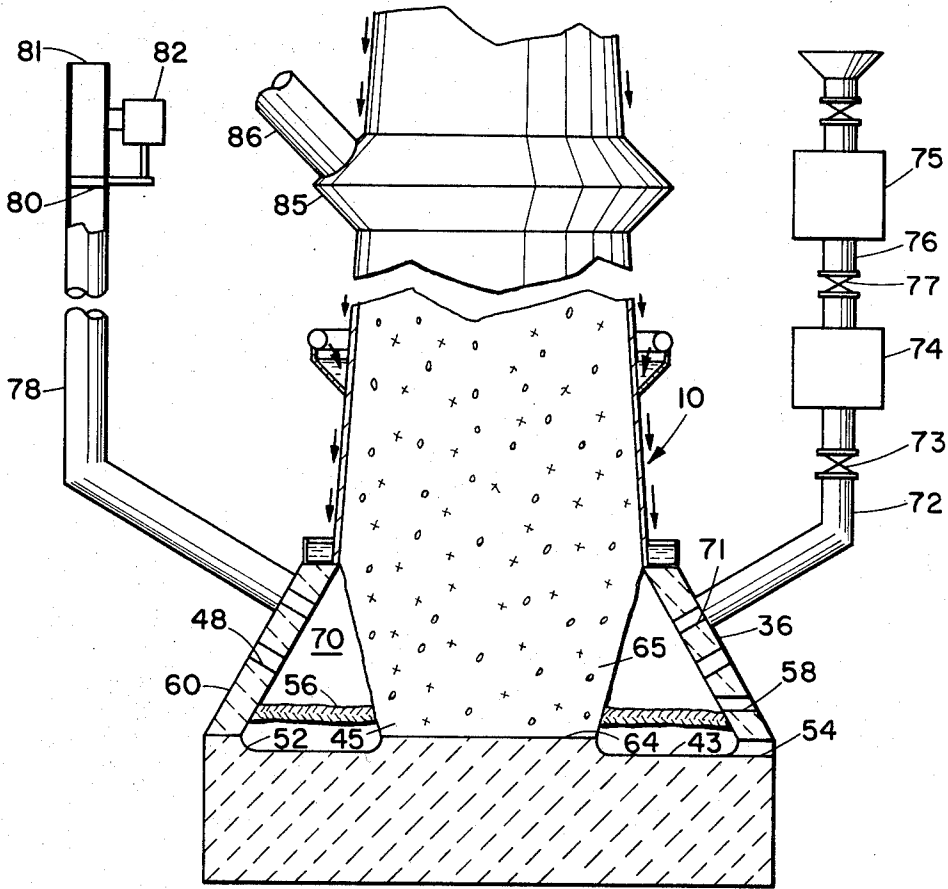


FIG. 2

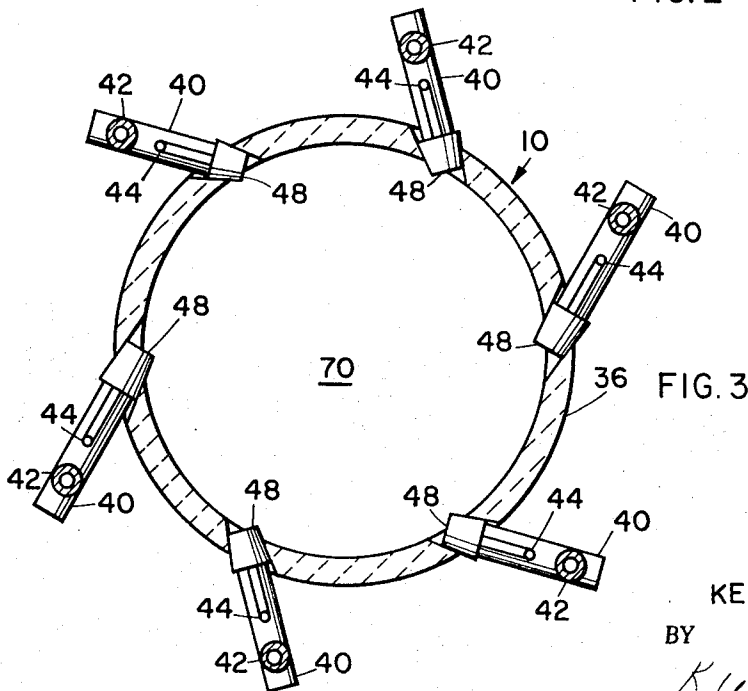


FIG. 3

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VERTICAL SHAFT FURNACE SYSTEM

This application is a continuation-in-part of my pending application Ser. No. 531,244 filed Mar. 2, 1966, now abandoned and of my pending application Ser. No. 719,300 filed Mar. 25, 1968 now U.S. Pat. No. 3,511,194.

This invention relates to an improved process and apparatus in the field of metallurgical operations and more particularly to processes and apparatus for producing molten metals in vertical shaft-type furnaces such as cupolas, blast furnaces and the like.

In the present invention I provide at the hearth zone of the furnace an internal annular space so that blast air, or blast air in combination with some fuel such as a hydrocarbon gas, oil, coal, or the like, may be introduced through the tuyeres and will have a circular flow path around the furnace burden or charge. The blast air will exert a uniform pressure and penetration of the charge and have a subsequent uniform heating and chemical reaction with the charge.

The furnace is further featured by the provision of means at the intermediate portion of the vertical shaft for withdrawing of the hot gaseous products of combustion and volatiles at below atmospheric pressure for further treatment or processing as may be desired, and also a means for the continuous controlled or metered feeding of fluxes or other additives to the annular combustion space in the hearth so that they will be uniformly and effectively dispersed into the charge.

In furnaces which are now in use blast air is directed along a generally horizontal plane and on the radials against the burden and this produces a cavitated zone or "raceway" directly in front of each tuyere and the number of tuyeres is spaced so that the "raceways" will approach an overlapping relation with each other. As a result there is a scalloped design around the periphery of the burden as evidence of this lack of uniformity of treatment of the charge. In order to subject the burden to an even approximate uniformity there must be a number of tuyeres which are equally disposed around the furnace. The multiplicity of the tuyeres produces an expensive item of construction and each is a source of potential trouble and is difficult both to maintain and operate. I find that when hot blasts in the order of 1,500° to 2,000° F. are used there is no practical way to damper the airflow to achieve a uniformity of air distribution or change in airflow through the various tuyeres should it be found desirable.

It is one of the important objectives of the present invention to overcome these described problems by the use of an internal annulus which makes it possible to achieve better metallurgical operation with a fewer number of tuyeres. Depending, of course, upon the diameter of the furnace there may be as little as one tuyere; or in a larger furnace the same metallurgical effect can be achieved with as few as two or three tuyeres. Whatever the number actually is, however, there can be a substantial reduction over the number previously required thus achieving an economy in furnace construction and more uniform operation. Even when there is more than one tuyere used, the balanced flows through the individual tuyeres are no longer as critical as it once was since the air and air pressure equalizes throughout the internal annulus to produce a highly desired uniform treatment to the charge.

It is a further important object of the present invention to achieve a better control of the heat in the slag and molten metal in the furnace well. During the starting up of furnace or cupola operation the metal produced is often too cold to use as a casting metal. It is the practice either to "pig" such metal or pour it into sand beds until the proper metal temperatures have been achieved for a suitable casting temperature. The cool metal can be reclaimed by passing it again through the cupola but this is an item of cost which the present invention proposes to eliminate.

In order to construct the annulus at the hearth zone of the furnace I produce a flaring of the hearth section, thus producing an annular space which surrounds the charge in the furnace well. This annular space may also be provided with a suitably lined purge or vent line leading from a point near the

top of the annulus to atmosphere or into the furnace air pollution control system. The line shall be valved so that it can be fully closed, fully opened or adjusted to any intermediate position between the two extreme positions of full close and full open. During initial heat up when fuels such as gas, oil or coal are introduced through the tuyeres along with the blast, the tuyeres serve somewhat on the order of burners. At startup, when the furnace well together with the slag and metal may be cold, the fuel and air are injected with the vent line open to some degree. Opening of the vent line permits the release of heat within the hearth zone but also permits the spent hot gases to escape through the at least partially opened vent line.

It is conventional practice to pass the air and hot gases up the shaft and through the charge so that the charge becomes heated. By heating the charge in this manner there is produced a melting which in turn causes a dilution of cold material in the well and it is necessary to drain such mixture from the well until proper temperatures have been achieved. With the use of a vent or bypass line, such hot gases do not pass through the charge to any appreciable extent so that melting thereof is retarded while the hearth with its slag and metal are being heated to proper operating temperatures. It is, therefore, an important feature of the present invention to be able to manipulate a vent line by use of a vent valve and consequently control the composition of the materials in the well as well as the operating temperatures thereof during heat up and during regular operation as well. In this way many important advantages can be achieved in the way of improved operation of the furnace during heat up as well as regular operation.

It is a still further objective of the present invention to increase the rate of heat transfer and to improve the rate of chemical reaction between the slag and metal at their interface. It is the present practice to create such improved chemical reaction outside the furnace in a vessel known as a "shaker ladle" this is not a completely satisfactory arrangement both by reason of the extra operation required and also by reason of the inherently slower reaction rate than is provided by means of the present invention. What the present invention proposes is a novel direction of hot blast air, or air and fuel which strikes or impinges against the surface of the slag at such an angle that the kinetic energy of the blast impels the slag and metal in a rotational sense around the channel formed between the furnace wall and that portion of the burden which rests on the furnace bottom. The described rotation of materials is highly advantageous because of the turbulence produced between the metal and the slag at their interface and this is found to produce an accelerated rate of heat exchange and chemical reaction.

The described arrangement further makes it possible to add fluxing materials to the slag within the annular space either through the tuyeres or special openings and in this manner it is possible to correct quickly any undesirable metal condition. In order to most effectively accomplish the objective effectively achieving prompt control over the conditions of operation I provide means for so introducing additives into the hearth area that they are dispersed in the swirling flow created by the tuyere system and carried uniformly and quickly to all parts of the charge. This is done by providing means for introducing the desired additives above the tuyeres on a continuous metered basis, desirably from a pressurized chamber. For example, in the event there is either an excess of phosphorus or sulfur it is possible to make an addition of lime, sodium hydroxide, or the like, directly into the slag by direct injection and such correction can be made almost immediately. Normally, the addition of such corrective materials to the top of the charge at the top of the vertical shaft might take as many as two or three hours to effect the necessary correction to the materials in the well; introduction through doors provided in the sidewalls of the hearth does not provide immediate and effective disposal of the additive, and does not allow continuous metered feeding, when desired; the present invention, however, is such that time delays are reduced to a matter of a few seconds and good dispersion is accomplished.

By means of the improved rotational and diffusion effect obtained by the unique agitation of the materials it is possible to add additional heat and get more rapid chemical reactions to the materials while not unduly accelerating the melt rate of the conventional burden.

A further important feature of the present invention is that I can use cast iron chips and fines in such a way as to achieve their almost complete recovery in subsequent melting operations. Normally it was not possible to return these materials to a cupola without briquetting and even then large portions were found to be unsuitable for briquetting. Even where such expedients were used the briquettes were not normally structurally strong enough to withstand handling consequently a large portion of it was blown out of the stack thus being lost to the system and also becoming a source of atmosphere pollution.

In the present invention, however, such materials can be introduced into the annular space which is provided at the base of the hearth and material losses are not experienced. Because of the extreme fineness of these materials they will quickly melt and become a useful product. Escape of any portion of the fines is prevented because in the process of starting up the stack they are quickly filtered out and captured by the burden.

These added fine materials have a cooling effect at the hearth because of their high heat absorption and consequently it is possible to add appreciable heat at the hearth without increasing the temperature in the well. These difficulties are successfully overcome by means of rotating the slag and metal and because of the further ability to use tuyere fuel with the air to maintain proper well temperature. It has been previously tried in conventional cupola operation to add fines and chips but this has not been successful in the past because of the rapid cooling of the hearth and also because of the practical difficulty of evenly distributing the fines through each tuyere. It is frequently the case that these chips and fines are saturated with cutting oils and water from machining operations and so must be briquetted before charging. When such oils were driven off as vapors by the furnace heat this merely added to air pollution problems; but in the present invention it is only necessary to remove the water content since the oils have a fuel value and instead of being a nuisance are completely burned in the hearth zone in the present invention. With hearth injection on a controllable basis the present invention can make valuable use thereof.

It is an important feature of the present invention that the annular space at the hearth zone permits the addition of certain materials at the hearth zone rather than through the stack. In this way, the composition of the output material can be more quickly and precisely controlled and variations in composition can be more readily attained than when the material is charged through the stack. Moreover, the usual losses which occur where certain alloys are charged through the stack will not result. For example, where additions of ferrosilicon are made in conventional operation this is accompanied by substantial oxidation losses and such losses are entirely circumvented in the present invention. The 15-50 percent loss which is normally encountered when ferrosilicon is charged through the stack because of oxidation to silica is entirely eliminated in the present invention. Furthermore, intermittent additions without effective dispersal through bottom doors have led to lack of uniformity in the material being processed or lost time waiting for uniform distribution to take place. In the present invention where such alloy materials are added in the hearth on a continuous metered basis directly into the tuyere stream, the necessary heat to compensate for their cooling effect can readily be generated in order to maintain the correct tapping temperature.

Another important feature of the present invention is that the cupola-type furnace can utilize pelletized ore, sintered ore and partially reduced ore as a portion of the charge and in this respect, the cupola resembles in certain aspects and techniques a blast furnace operation. In the present invention, by means of the use of an annulus in which any of a combina-

tion of fuels can be injected through the tuyeres and combusted with the release of heat, such gases become converted by contact with the coke to carbon monoxide and hydrogen, thus giving control of gases to be generated for the gaseous reduction phase within the shaft.

Another highly important feature is the provision of a takeoff manifold or gas collection ring positioned at an intermediate location on the vertical shaft whereby the hot gases of combustion and volatiles generated in the course of the operation are withdrawn from the stack and made available for further treatment or processing before release. This feature, for example, makes it possible to utilize in place of the high grade of metallurgical coke heretofore deemed to be essential, much less expensive coal which is coked or charred as it progresses downwardly through the stack with the volatiles being removed at the gas collection ring.

The foregoing advantages are ones which directly proceed from the novel use of an annulus at the base of the shaft in conjunction with the other features pointed out above and with such arrangement, it is possible to use in combination therewith the novel combination of tuyeres which are so constructed and directed as to achieve the necessary agitation at the bottom of the furnace between the slag and molten metal interface.

There is thus achieved an improved release of heat and penetration of the material within the charged column and as a result there is a substantial improved uniformity over present furnace capabilities. A further advantage is the use of tuyere angle and fuel which can be injected through the tuyeres in order to achieve circulation of slag and iron for promoting improved reaction between the two and also to control with greater precision and advantage the metal output of the furnace.

The above and other objects and features of the above invention will become apparent from a consideration of the following description which proceeds with reference to the accompanying drawings wherein:

FIG. 1 is a section view taken through the base of a cupola, showing the tuyeres and bustle pipe together with continuous material feeding means above the tuyeres;

FIG. 2 is an enlarged section view showing the addition of a valved line providing for the release of heat within the hearth zone and with a cooling arrangement added therein;

FIG. 3 is a section view taken on line 3-3 of FIG. 1; and

Fig. 4 is a further embodiment showing how the base of the cupola may be modified in a further embodiment of the invention.

Referring now to the drawings, and particularly FIG. 1, a cupola designated generally by reference numeral 10 serves as a vertical shaft furnace adapted for the melting and refining of material such as zinc, iron, lead or the like. In the case of ferrous material I effect its conversion into foundry grade iron or hot pig iron at the base thereof. The invention is not limited to production of cast iron for foundry use, this being only one of several different applications of the invention. One such may be the melting of steel scrap, with much reduced carbon pickup, for charging oxygen blown furnaces, electric furnaces, and the like. The cupola, or vertical shaft, is a relatively inexpensive steel shell, refractory-lined structure, or it may be an unlined water-cooled steel shell except for refractory lining in the hearth zone and well, having a top 12 and loaded at its top in any of various suitable manners, as, for example, by skip hoist, buckets, belt conveyors, or the like (not shown) all of which are encompassed within the present invention. There is charged to the cupola any of a combination of scrap, pig iron, iron oxides, alloys, etc. in whatever quantities are desired and a mixture of such materials can then be combined with the flux and coke or coal and raised to the upper end of the cupola for charging therein through a charge opening. At the bottom end 36 of the cupola is a bustle pipe 38 and a plurality of tuyeres 40 through which is injected a mixture of air from line 42 and fuel from line 44, the two materials being added in the desired ratio, then directed inwardly into the space 70 con-

verging on the well 43 and impinging against the burden 45 and slag 56 (FIG. 2). The ratio of the two materials can be regulated in by a suitable control valve structure (not shown) which can determine the rate of inflow of the combustible combination as well as the ratio of the materials.

The tuyere openings 48 as indicated in FIG. 2 project slightly downwardly toward the well 43 of the cupola. At the well 43 of the cupola is a recess 52 wherein is collected a layer of the metal and a tap opening 54 is provided to effect release of the molten metal which is generated within the recess 52. An overlying layer of slag 56 (FIG. 2) may be removed through an emergency tap opening 58 or in conjunction with the metal through tap hole 54.

It should be noted, from FIGS. 1 and 2, that at the bottom end of the vertical shaft furnace a wall section 60 flares outwardly in the shape of a frustum of a cone or it might be on the order of a hemisphere so that as the burden descends, it takes support through a tapered frustoconical portion 65 which rests on the bottom portion 64 of well 43, leaving an annular open space 70 (FIG. 2) wherein is injected the blast air or air with some hydrocarbon fuel. The air injected from line 42 can be preheated or it can be ambient. The advantage of the present invention is that it enables the generation of much higher heat releases than was the case in prior art cupola operation. One of the reasons why it is possible to generate higher heat release is that the burden more efficiently absorbs the heat and consequently, the greater order of heat has less tendency to raise the temperature of the refractory brick which forms the walls of the hearth zone. Consequently, higher heat releases are attainable because the thermal destructive temperature point of the materials of construction are not attained.

It should also be noted that the tuyeres are located so that they are not touched by the metal, slag or the burden as in conventional cupolas and blast furnaces. A further direct consequence of the use of annular combustion zone 70 is that fuel and combustion-supporting gases can mix and burn in this open space. Referring to FIGS. 3 and 4 the tuyeres are disposed tangentially or at least angularly (or nonradially) and extend downwardly at regularly spaced circumferential locations. One of the effects of disposing the tuyere passages and openings as indicated in FIG. 3 is that there is produced a circumferential flow of combustion-supporting gases directed downwardly against the well of the cupola, effecting a substantial agitation and rotation of the melt and thereby effecting an improved heat exchange between the interface of the slag and metal and more efficiently serves to accelerate the refinement of the metals. The improved interfacial relationship because of this rotation and agitation minimizes or eliminates the need for a subsequent "shake ladle" operation.

Located in the upper wall 60 of the hearth is an opening or openings 71 through which fluxes, or other additives or materials can be fed on a continuous and controlled or metered basis through connecting conduit 72 containing valve 73 and leading to a storage chamber 74 containing the material to be fed into the combustion area. The storage chamber 74 is desirably normally maintained under a slightly positive or above atmospheric pressure to assure positive feed of the material into the furnace. The chamber 74 is replenished as need be with material from charge hopper 75 through conduit 76 which is equipped with valve means 77. The location of the openings 71 above the position of the tuyeres causes the in-feed of material to be introduced into the swirling air or gas stream from the tuyeres and be carried to all parts of the combustion area in widely dispersed condition so as to effect immediate and effective distribution and assimilation by the charge within the hearth. Such effective assimilation cannot be accomplished in a comparable way by the admission of materials to the charge intermittently through doors provided in the hearth walls.

Referring to FIG. 2, there can be included with the cupola a stack having an outlet opening 81 controlled by a throttling butterfly valve 80 with a power-actuated operator 82.

During the startup of operations the valve 80 can be fully opened thereby providing for greater access of flue gases outwardly through the stack than upwardly through the burden 45. Consequently, the heat which is generated within chamber 70 is confined essentially to the bottom of the cupola. Since a minimum of the overhead burden is melted, the bottom of the cupola is not rapidly flooded with cool metal and slag. Since the cupola does not need to be tapped during the heatup period owing to the desirable occurrence of flooding from the upflow of heat into the burden, under initial warmup conditions, there is not generated as much scrap from tapping the openings 54 and 58, therefore less scrap is generated during the heatup.

It frequently happens, in the cupola operation, that the cupola may be idle for a day or two at a time, or longer, and it is during the restarting of operation that there is a considerable generation of scrap. With the present invention, because of the ability to confine the heat at the startup of cupola operation to the base, (and for all practical purposes bypassing the burden through venting of the heat through the stack 78 with the valve 80 fully opened) such wasteful operation is successfully avoided. As the cupola starts to resume operation, the valve 80 can be successfully throttled and eventually the operator 82 effects full closing of the valve 80 and all of the combustion gases travel upwardly through the chamber 70 through the burden under normal cupola operation and maximum thermal efficiency.

At an intermediate point of the vertical shaft portion of the furnace is a gas collection ring 85 from which a line 86 passes to convey the gases of combustion and volatiles as desired for further treatment or processing. The line 86 contains a valve 87, and the valve 87 contains a pressure control device 88 with suitable barometric control sensor in the gas collection ring 85 to maintain a subatmospheric pressure sufficient to keep the uprising gases from the base of the gasifier from exiting at the upper end of the stack and causing any portion of the outflow to leave through the line 86. Device 88 has sensing outlets at 89 to atmosphere and at 90 within the gas collection ring 85 and at 87 within line 86. These signals are fed centrally to the device 88 which has a servo outlet leading to the valve 87 for maintaining the suitable valve setting whereby pressure conditions are maintained such that subatmospheric pressure always exists at the upper ring end 85 to keep all of the gases flowing through line 86.

In operation, the cupola 10 is charged with whatever combination of materials is desired, in the form of scrap, iron, ore or combinations thereof together with the desired amount of flux and coke or coal. Such materials, after having filled the cupola to the desired height, are then, are then converted to the desired type of metal. It might be nodular, malleable or something other than pig iron. At the start of operation, the valve 80 of the stack 78 is fully opened and the bustle pipe 38 receives a flow of heated air which may be combined with fuel added through line 44 and the desired ratio and the inflow suitably regulated to the desired amount. The adjusted mixture is injected through tuyere openings 48 into the annular chamber 70 where it effects at uniform pressure a substantially uniform penetration of the burden 45 and ascends within chamber 70. The high heat releases which are attainable by reason of the novel structure makes it possible to effect conversion of the scrap steel, ore, iron or combinations of such materials at accelerated rates. Furthermore, it is possible to inject into the chamber 70 quantities of fuel gas, oil and solid carbonaceous materials if so desired and in this way it is possible to replace a portion of the coke burden which, being substantially more expensive, makes the cupola operation of my invention inherently more economical. Also, I can add cast iron fines and chips, ferrosilicon, turnings, etc. directly through openings 71 thereby making it possible adjust the composition of the cupola output promptly within a closely regulated range with uniform dispersion and distribution throughout the hearth charge. Also, there is no need to wait for an appreciable time to make such adjustments of composi-

tion and causing generation of scrap until the adjustments are made.

When the valve 80 is opened, all of the combustion gases, for all practical purposes, are vented through the stack 73 and only a negligible part of the gases rise upwardly through the burden 45 so that the cold bottom of the cupola during the startup operation receives substantially all of the heat. The heat is confined to the bottom since none of the heat from the uprising gases passes through the burden; consequently, there is prevented any occurrence of flooding of too cool materials at the bottom of the cupola. The burden rests at the base 64 and the high heats generated within chamber 70 are uniformly "seen" by it to the extent that the burden defines one side of the chamber 70. These higher heats make it possible to use burdens which are inclusive of scrap and without causing injury to the refractory lining of the cupola. As the bottom of the cupola is heated, the valve 80 is gradually closed, throttling the outflow of combustion product and a portion of the combustion product starts to travel upwardly through the burden 45 until such time as the cupola is ready to resume normal operation, at which point the valve 80 is fully closed and all of the combustion gases rise upwardly through the cupola. A balance is effected which precludes the possibility of flooding at the bottom of the cupola.

The openings 48 are disposed at an angle (FIG. 3) and downwardly as indicated in FIGS. 1 and 2 and the combined burner flows are complementary to produce a swirling action around the interior of the chamber 70, thus agitating the interface between the slag 56 and the molten pig iron at the base recess 52, more efficiently effecting refinement and heating of the metal.

The presence of the chamber 70 also makes it possible to controllably determine the optimum fuel-to-air ratio and therefore both by reason of the higher temperature and the controlled tendency of the atmosphere to produce a reducing atmosphere it is possible to control the composition of the metal.

The positioning of the openings 71 above the tuyeres along with the associated means for metering under pressure a continuous and controlled flow of additives to the hearth zone assures an effective dispersal and assimilation of the materials to the charge for a prompt and even correction or adjustment or maintenance of the desired conditions of operation and properties and composition of product.

The collection ring 85 permits the use of coal in place of more expensive coke and allows for utilization and recovery of any values, thermal or chemical, to be derived from further processing or treatment of the effluent volatiles and gases of combustion by reason of their removal at this point.

It will therefore be seen that the present invention is usable and is highly advantageous not only in increasing the scope of usable materials in the production of metal, but also makes it possible to generate higher temperatures and produce a metal of greater quality and uniformity of product.

Referring to FIG. 4 the base or bottom end 36 of the cupola instead of having a frustoconical-shaped wall section 60, can be constructed with a curved or sector cross section in order to produce a space 70 which is both annular and surrounds the bottom end of the burden as in the previous embodiment (FIG. 2). The burden 65 rests on a bottom portion 64 of base 43 the same as in the previous embodiment and in all other respects the operation is the same as previous.

Also, referring to FIGS. 1 and 2, the stack can be either water cooled or it can be refractory lined depending upon design requirements. In the case of water cooling, there are usual spaced weirs and a flow of liquid coolant which progresses downwardly abstracting heat and protecting the outer wall of the cupola.

What is intended in these embodiments is the use of an annular or other suitable shaped opening in the well of the cupola which permits the uniform penetration of the burden by the heated combustion gases produced within the chambers and there is uniform penetration of heat into the burden at the

base of the cupola. Moreover, the open space permits the supplying of injectants to control the composition of the product and also, it further permits the use of a bypass line to control the heat up when the cupola operation is first initiated. These various advantages are obtainable with each of the described embodiments. It has further been found that the cupola can be made more economical to operate because of the elimination of occurrence of waste from cold tapping and the higher temperatures are obtainable well within the temperature limitations of the refractory materials of which the cupola is constructed.

Although the present invention has been illustrated an described in connection with a single example embodiment, it will be understood that this is illustrative of the invention and is by no means restrictive thereof. It is reasonably to be expected that those skilled in this art can make numerous revisions and adaptations of the invention to suit individual design requirements and it is intended that such revisions and adaptations will be included within the scope of the following claims as equivalents of the invention.

I claim:

1. A metallurgical furnace having a base, a vertical shaft portion and at the base thereof a large cross section hearth which defines an open, annular space completely surrounding the charged stock within the hearth, a plurality of tuyeres, one disposed at each of a plurality of circumferentially spaced intervals disposed at the base of said furnace and inclined downwardly and directed angularly so that the respective outflows are complementary in effecting both agitation and swirling action within the annular space surrounding the charged stock, bypass means for controllably throttling an outflow of gaseous combustion product from within said annular open space to regulate the distribution of heat between said space and the overhead burden within said furnace, means for directing a combustible flow into said open annular space through said tuyeres, and means for adding materials to the annular open space surrounding the charged stock to be dispersed by the blast from the tuyeres.

2. The furnace in accordance with claim 1 wherein the means for adding materials to said annular open space comprises an opening in said hearth wall positioned above the horizontal line of the tuyeres, a conduit connecting said opening to a closed chamber, and valve means for controlling the rate of flow from said chamber to said opening.

3. The furnace in accordance with claim 2 wherein the chamber for feeding material to the furnace hearth is pressurized.

4. The furnace in accordance with claim 1 including means intermediate of the top and bottom ends of the vertical shaft portion for withdrawing the hot gases of combustion and generated volatiles.

5. The furnace in accordance with claim 4 in which the withdrawal means on the vertical shaft comprises a collection ring surrounding said shaft.

6. The furnace in accordance with claim 5 including means for maintaining a negative or subatmospheric pressure at said collection ring.

7. The furnace in accordance with claim 5 including control means operable to maintain a subatmospheric pressure sufficient to cause a substantial portion of the outflow gases to flow through said collection ring.

8. A metallurgical furnace having a base, a vertical shaft portion and at the base thereof a large cross section hearth which defines an open, annular space completely surrounding the charged stock within the hearth, a plurality of tuyeres, one disposed at each of a plurality of circumferentially spaced intervals disposed at the base of said furnace and inclined downwardly and directed angularly so that the respective outflows are complementary in effecting both agitation and swirling action within the annular space surrounding the charged stock, bypass means for controllably throttling an outflow of gaseous combustion product from within said annular open space to regulate the distribution of heat between

said space and the overhead burden within said furnace, means for directing a combustible flow into said open annular space through said tuyeres, an opening in said hearth wall positioned above the horizontal line of the tuyeres, a conduit connecting said opening to a closed chamber, and valve means for controlling the rate of flow from said chamber to said opening, a collection ring intermediate of the top and bottom ends of the vertical shaft portion for withdrawing the hot gases of combustion and generating volatiles and means for maintaining a negative or subatmospheric pressure at said collec-

tion ring.

9. The furnace in accordance with claim 8 wherein the chamber for feeding material to the furnace hearth is pressurized.

10. The furnace in accordance with claim 9 including control means operable to maintain a subatmospheric pressure sufficient to cause a substantial portion of the outflow gases to flow through said collection ring.

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