Feb. 26, 1929. 1,703,518

J. P. DOVEL

BLAST FURNACE

Filed July 28, 1927

Fig. 1

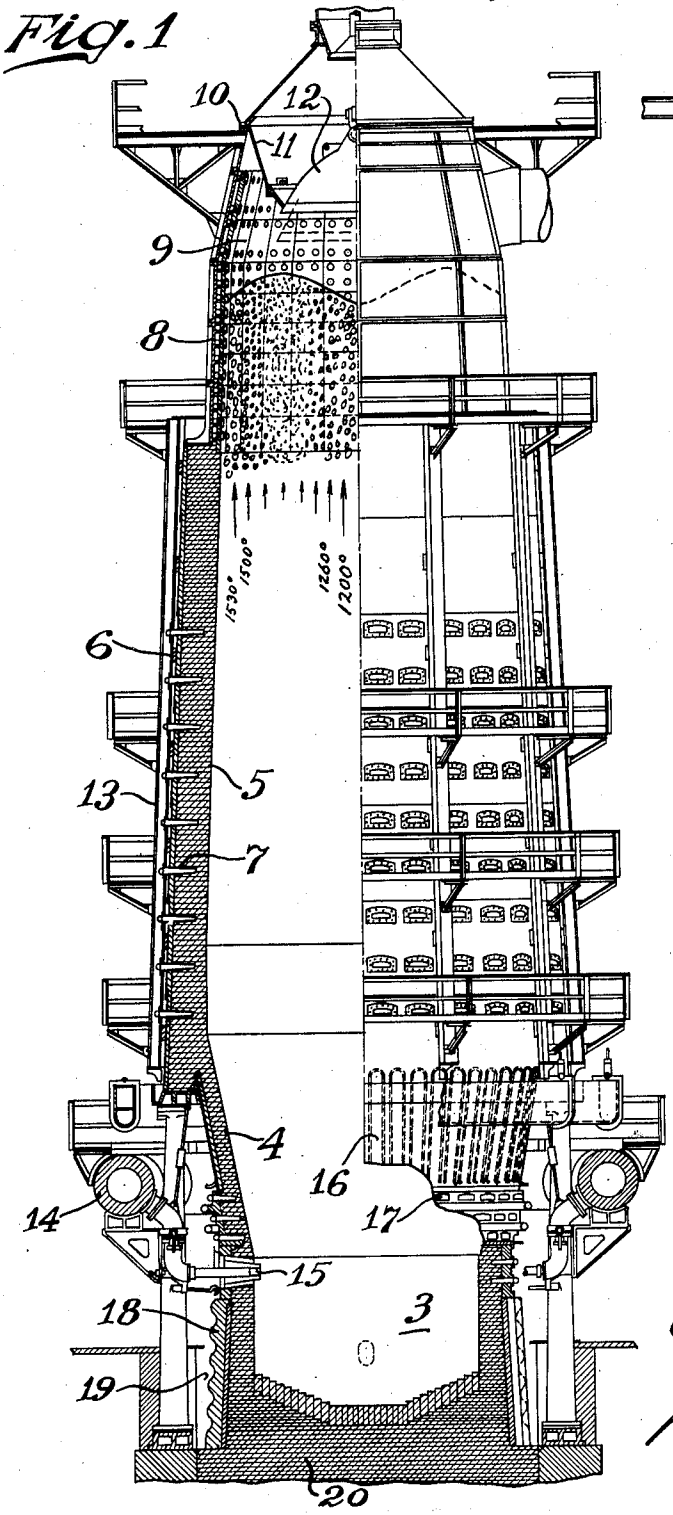
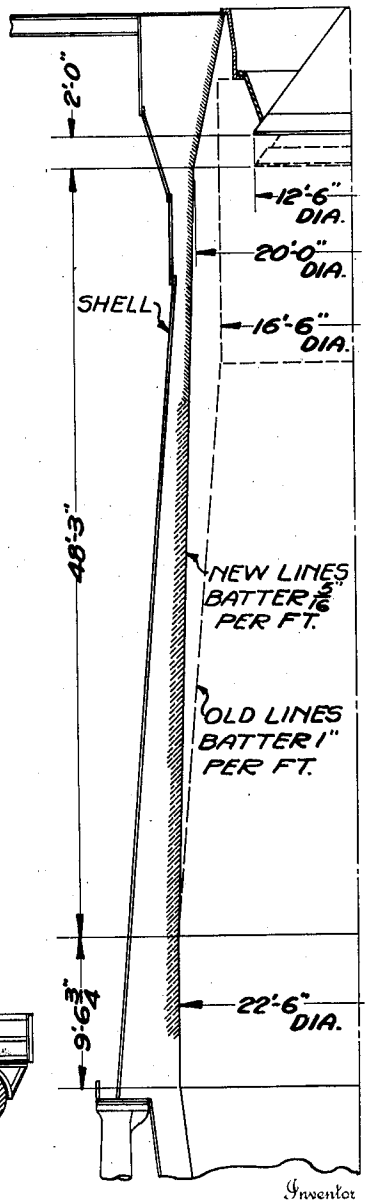


Fig. 2



Inventor

J. P. Dovel

Attorney

Patented Feb. 26, 1929. 1,703,518

UNITED STATES PATENT OFFICE.

JAMES P. DOVEL, OF BIRMINGHAM, ALABAMA.

BLAST FURNACE.

Application filed July 28, 1927. Serial No. 209,074.

My invention relates to a new and improved method for the construction and operation of metallurgical blast furnaces.

The objects of my invention are to so design the furnace as to materially increase its output, to insure a longer continued operation, to obtain the desired gradual, continuous downward movement of the stock in the furnace, thereby avoiding any hanging of the stock on the furnace walls, and to reduce to a negligible amount the valuable ore and coke that is now carried out entrained in the gas and represents not only a loss in stock but an added expense in the operation.

In approaching the solution of the problems that have confronted the designing of metallurgical blast furnaces, I find that engineers have sought to prevent the hanging of the stock on the inwall of the furnace by working on the theory that the rapid expansion of the area of furnace stack downwardly would cause the stock to move downwardly continuously without hanging. The application of this theory will result in a substantial contraction of the bore of the furnace and that in turn in an acceleration of the gas flow through the stock. Further, in the former standard design of metallurgical blast furnaces effort has been made to conserve and protect the furnace lining by so charging the stock that the zone of most intense heat was removed from the lining and therefore the practice has been to draw this most intensely heated zone toward the center of the furnace. The reason for this has been that no practical means has heretofore been found that would provide a furnace lining that would stand the utilization of the most intense heat around the column of stock and yet, according to my theory of design and operation, such is essential.

One problem to be overcome, therefore, was the provision of means that would enable the furnace lining to withstand the intense heat, and this problem I have solved by the provision and mounting of cooling blocks in accordance with my pending application, Serial No. 663,283, wherein I have shown and described a method of embedding in the furnace lining a multiplicity of cooling blocks which were detachably supported by the furnace jacket and which would operate to cause an agglomerate and highly refractory lining to build itself up within the furnace as the original lining disintegrated or burned away, which agglomerate lining will automatically maintain itself and resist the action of very intense heat.

The next step in the approach to my present process involves the provision of means to counteract the abrasive wear of the stock at the top of the furnace and provide additional area, it having been heretofore considered necessary to employ a very thick lining opposite the zone of contact of the stock being charged so that it would long resist the wear of the stock. In the blast furnace forming the subject matter of my pending application, Serial No. 72,103, I have shown and described a furnace having its upper portion above the zone of highest heat formed by a metallic shell with removable and replaceable wear plates which would take all abrasive wear from the stock and thus permit the furnace diameter at this point to be enlarged by substituting thin for thick linings heretofore considered necessary.

Having thus provided means to withstand the high temperatures and the wear of the stock I was ready to approach the solution of the problem of perfecting the blast furnace design to the end that ideal operation might be obtained and this end is accomplished, briefly, (1) by the designing of the furnace to eliminate or reduce to a minimum the angle or batter of its inner wall, thereby increasing to the maximum permissible extent the cross-sectional area of the upper portion of the furnace, and (2) by so charging the stock that the zone of most intense heat is provided about the column of stock. The results of the change in furnace design and charging methods have been astonishing. In the first place, it has increased the capacity of the furnace from 30% to 50% and it has reduced the flue dust nuisance to a point where the outgoing gases are practically carrying only the dust entrained during the charging of the stock whereby very fine unsintered stock can be furnaced. In a number of furnaces converted to this new design I have reduced the output of flue dust from 538 lbs. to 58 lbs. per ton of iron produced. In attempting to solve the reasons for this remarkable reduction in the flue dust output, I have reached the conclusion that it is the result of the increased stock liner diameter of the furnace which results in so slight, if any, an acceleration of the gases flowing upwardly through the stack that the latter

have a rate of flow which permits them to filter through the natural voids in the stock column whereby they do not entrain the dust in them but tend to leave such dust as may be entrained in the filtering mass of stock. Therefore, one important object of my furnace is to decelerate the gas flow, as contrasted with present practice.

The charging bell in my improved design of furnace is disposed and arranged so as to produce a distribution that will locate the larger and more open portion of the stock column in its center and about the outer periphery of the stock column. Tests by pyrometers in an operating furnace have shown a temperature which increases from the center to the periphery of the stock and this, notwithstanding that the larger stock particles collect both in the center and about the periphery of the stock column. I am of opinion that the higher temperatures exist about the periphery of the stock column due to the fact that it has relative movement to the fixed furnace walls which tends to open up the draft space, thereby accelerating the gas flow upwardly along the furnace lining and producing in this circumferential zone the highest rate of reduction. Obviously, where the column of stock is reducing fastest about its periphery there will be no tendency for it to hang on the furnace walls and this theory has been substantiated in practice where the furnaces have operated for a long period without the slightest indication of any hanging at all, whereas before their design was changed I expected and encountered trouble from the hanging of stock almost daily in the furnace operation. The disadvantages of the hanging and fall of the stock in the furnace are too well known to those skilled in the art to need further comment here to emphasize the importance from an operating point that will result from the elimination of hanging.

One very important feature of my present invention is that due to the filtering action of the furnace and the slow gas travel, very fine stock may be successfully smelted without sintering.

As typical of all blast furnace designs for the embodiment of the principles of design and operation forming the basis of my present application, I show in

Fig. 1 is a blast furnace partly in side elevation and partly in vertical cross-section equipped with the thin water cooled block lining and with the metal lined top with a portion of the cross-section of the stock illustrated to show both the stock distribution, the theoretical rate of gas flow through the stock, and typical range of temperatures radially of the stock.

In Fig. 2 I show diagrammatically the effect of changing a standard refractory lined furnace according to existing practice, shown in dotted lines, to the design in accordance with my invention which is shown in full lines, the figures in this view illustrating typical furnace dimensions.

As shown in Fig. 1, 2 indicates the furnace crucible, 3 the hearth, 4 the bosh, 5 the refractory inwall, 6 the metallic stack jacket, 7 the cooling blocks mounted on the jacket and projecting into the inwall, 8 the outer metal jacket superposed upon the stack shell and carrying internal wear plates 9 detachably connected thereto. 10 represents the furnace top, 11 the lower charging hopper, 12 the main bell which is of such diameter that the stock distributed from it will collect in larger particles at the center and about the periphery of the stock column. The furnace jacket is reinforced by vertical structural iron beams 13 which support and maintain positively the alignment of the top construction. The bustle pipe 14 delivers air to the tuyères 15 in accordance with furnace practice and the bosh is water cooled by elements 16 and cooling blocks 17. The crucible is surrounded by a cast iron jacket 18 which is set in a well 19 adapted to be filled with water. This water will filter into the brick bottom 20 of the crucible and foundations thus serving to protect them from excessive heat.

It will be observed in Fig. 1 that the lining or inwall 5 is much thinner than the usual practice. The thickness of this wall will run from 3 to 4 feet in present practice, whereas in my new design these walls need not be more than from 22″ to 27″. I can employ so thin a lining because as it wears away or disintegrates, which is expected to occur promptly, it is replaced by an agglomerate and highly refractory lining built up from stock particles or semi-fused stock particles and minerals deposited by the gases. An analysis of this built up agglomerate lining shows it to be formed largely of carbon, principally in graphitic form, and alkali minerals, principally potash.

By reference to Fig. 2, the dotted lines indicate the design of the inwall of a standard furnace having a bosh diameter of 22′ 6″, a top diameter of 16′ 6″, and an angle or batter to the inwall of about 1″ to the foot. Such a furnace when redesigned in accordance with my improved method of construction will have the inwall running upwardly of even diameter for about 15 ft., and above this point tapering, if desired, at about $\frac{5}{16}$ths of an inch to the foot up to the stock line where the furnace diameter will be found to be approximately 20′. This gives a very small reduction in diameter of only 2′ 6″ from the widest to the smallest diameter of the shaft. The existing bell having a 12′ 6″ diameter could be used and its marginal edge being more remote from the shaft inwall it would hold the zone of fine material at the same distance from the axis of the shaft and the added space between this zone and the shaft would permit the

heavier stock particles to roll down and collect against the inwall of the shaft, thereby providing a more porous arrangement of stock surrounding the stock column.

In a furnace of the type described, I have shown by the arrows in Fig. 1 the rate of gas flow, the length of the arrow indicating the rate of flow through each portion of the stock, and below these arrows I have arranged pyrometer readings with a center temperature of 1200° F. and about one-third of the way out to the shaft increasing to 1260° F., and then in the next one-third increasing to about 1500° F., and along the shaft inwall the temperature is increased to 1530° F.

It is to be noted that the increased mass of stock provided at the top of the stock column has another advantage, namely, it will effect a rapid cooling of the gases, thereby reducing their volume and reducing their rate of flow, which obviously will assist the filtering action and will have the important result of materially decreasing the temperature of the outgoing gases, thereby reducing the coke consumption of the furnace.

An important object of my invention lies in the readiness with which it is available for the redesigning of existing furnaces to obtain the improved operating results above pointed out, as the existing shells can be retained and the lining readjusted and inserted to suit the conditions of such furnaces yet to produce therefrom the operation contemplated by my invention.

In the operation of this furnace, due to the retarded rate of gas flow and the filtering action of the stock, the production capacity of this furnace after change in design will be increased from 30% to 50%, and it is operated with the greatest ease and will produce a very uniform product, using fine unsintered ore if desired. In the operation of four furnaces of this type up to March, 1927, only .19 of one per cent of the total output was off grade.

Another advantage of my improved method of construction and operation of the furnace wherein the maximum reduction occurs adjacent to the wall of the shaft is that I avoid the formation of pockets of molten metal which tend to run down the wall and cut the bronze, bosh plates, coolers and tuyères.

The size of the bell and of stock used should be calculated to produce an increased ratio of voids through the center and about the periphery of the stock column so that the more rapid central and marginal reduction occurring would not only prevent the stock hanging on the inwall but would also avoid an unreduced center mass of the stock wedging against the converging walls of the bosh. For ideal operation the stock column should have a balanced rate of reduction between its central and marginal portions. Satisfactory results are obtained where the area at the base of the bell is approximately one-third of the stock line area. The ratio of voids, which governs the ratio of reduction, at the margin and center can be controlled by the percentage of coarse to fine material in the charge which must be determined empirically, having regard to the available raw material.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. The method of operation of a blast furnace which comprises maintaining the upflow of gases through the furnace stock column adjacent the wall of the stack at a velocity as high as through any other portion of the stock column, and chilling the stock elements touching the wall to form a self-replaceable stack lining.

2. The method of operating a blast furnace which comprises maintaining the furnace stock column with relatively large void areas adjacent the wall of the stack and in the center forming a relatively dense annulus of material remote from the furnace wall whereby the higher rate of gas flow is along the wall of the stack and through the center of the stock column, and chilling the stock elements touching the wall to form a self-replaceable stack lining.

3. The method of operating a blast furnace which comprises so charging the stock thereinto that a higher temperature exists adjacent the wall of the furnace stack than exists farther interiorly of the furnace, and maintaining a self-replaceable stack wall from refractory materials in the furnace charge.

4. The method of operating a blast furnace which comprises maintaining the furnace charge in a column having a relatively dense annulus of material interiorly of the furnace and lessening in density toward the inner wall of the furnace stack, and chilling the material touching said wall to form a self-replacing lining.

5. The method of operating a blast furnace which comprises maintaining the furnace charge in a relatively dense annular column bearing loosely against the inner walls of the furnace stack, supplying air upwardly through the stack for combustion whereby a higher temperature and higher rate of gas flow occurs through the center and along the walls of the stack than through the dense annular column, and cooling the walls of the stack to agglomerate refractory elements in the descending stock and to maintain the wall of the stack at a substantially uniform thickness.

In testimony whereof I affix my signature.

JAMES P. DOVEL.