

Jan. 4, 1944.

R. M. GIBSON

2,338,175

BLAST FURNACE

Filed Sept. 25, 1941

4 Sheets-Sheet 1

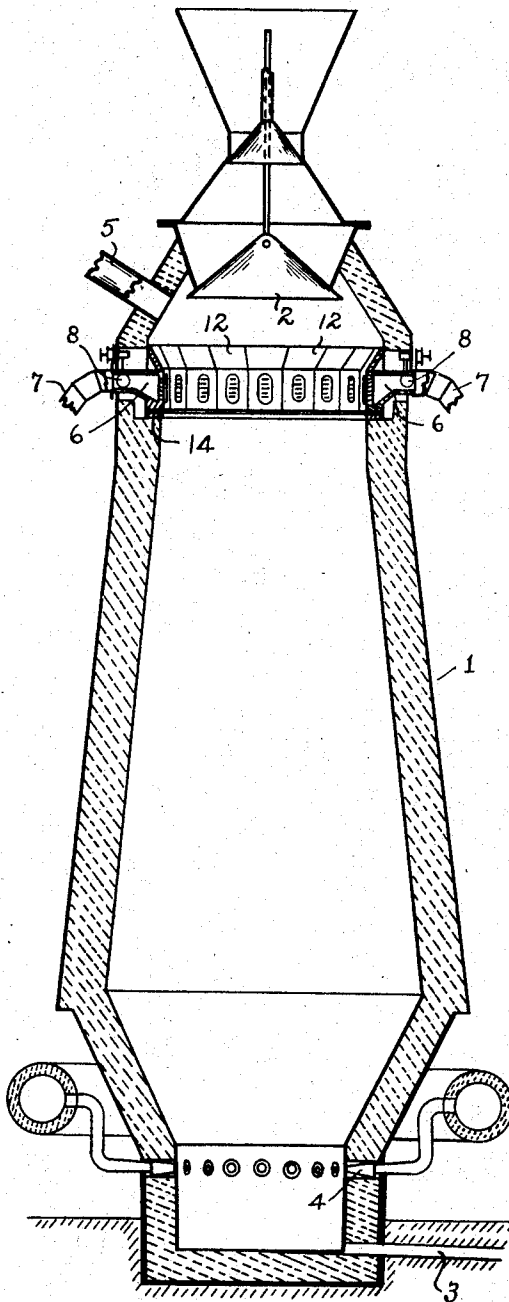


FIG. 1

INVENTOR
Robert M. Gibson
BY *Christy, Parmelee and Strickland*
ATTORNEYS

Jan. 4, 1944.

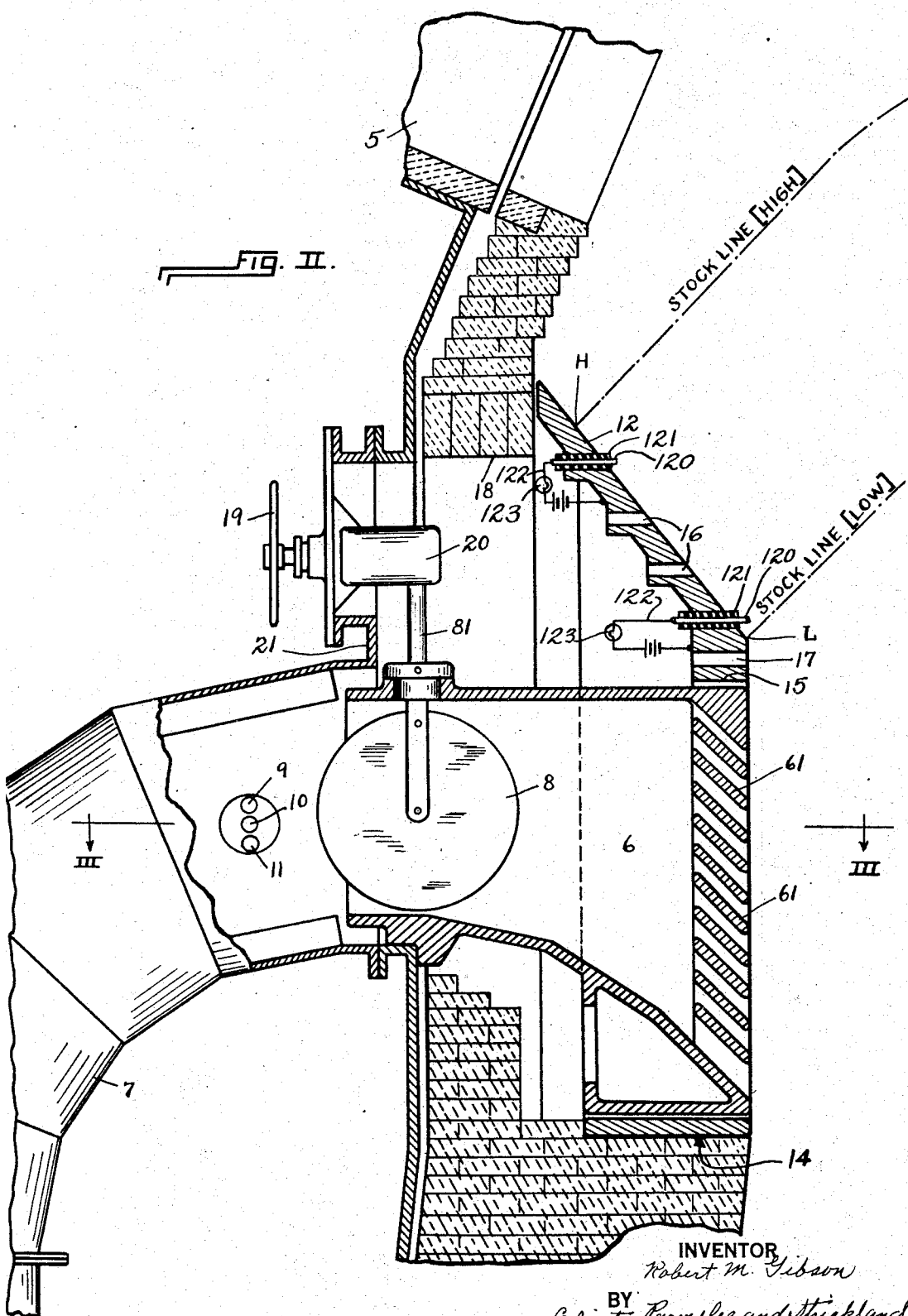
R. M. GIBSON

2,338,175

BLAST FURNACE

Filed Sept. 25, 1941

4 Sheets-Sheet 2



INVENTOR

Robert M. Gibson

BY
Christy, Parmelee and Strickland
ATTORNEYS

Jan. 4, 1944.

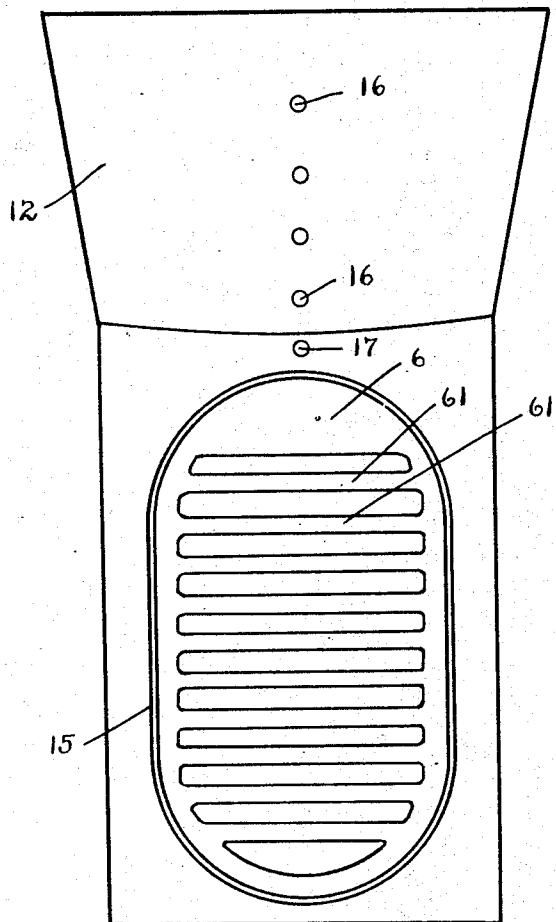
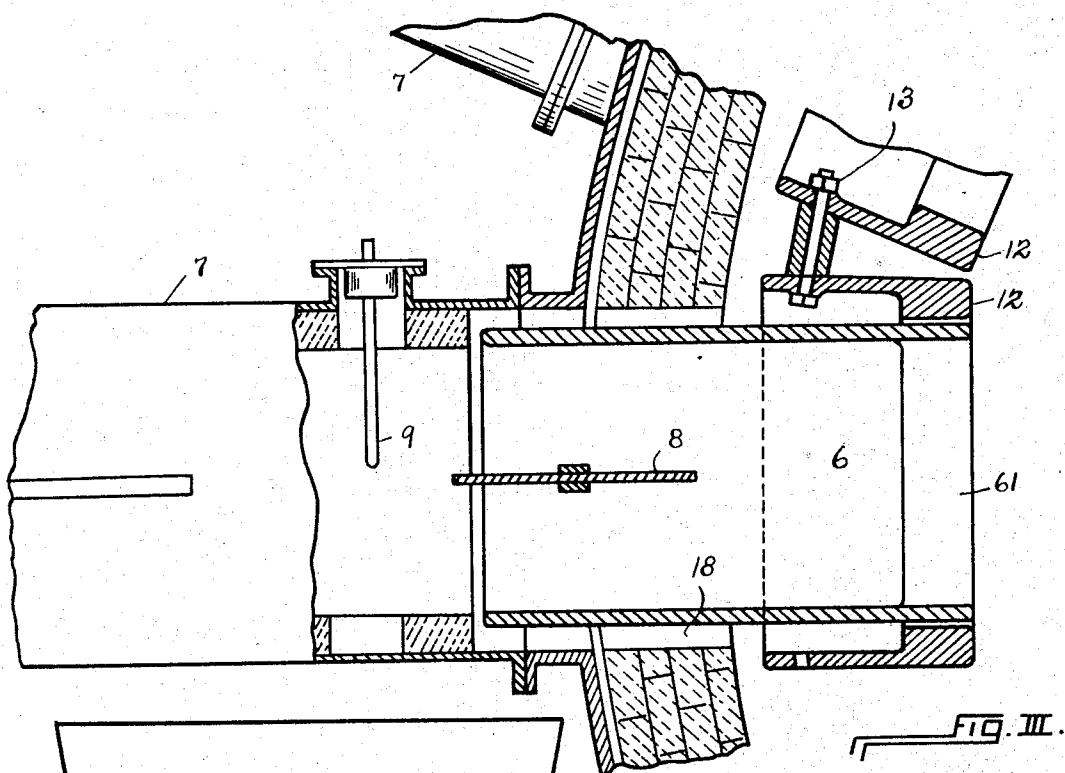
R. M. GIBSON

2,338,175

BLAST FURNACE

Filed Sept. 25, 1941

4 Sheets-Sheet 3



Jan. 4, 1944.

R. M. GIBSON

2,338,175

BLAST FURNACE

Filed Sept. 25, 1941

4 Sheets-Sheet 4

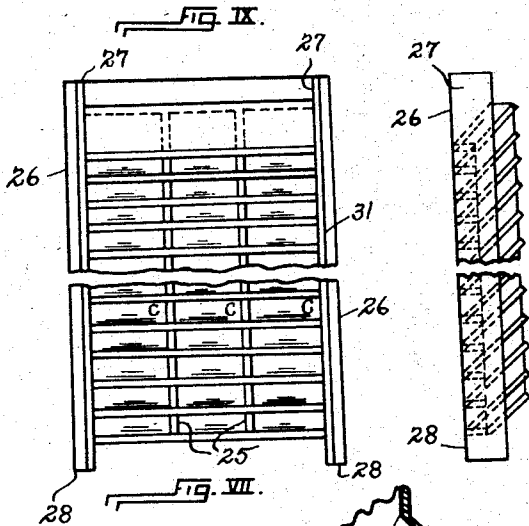
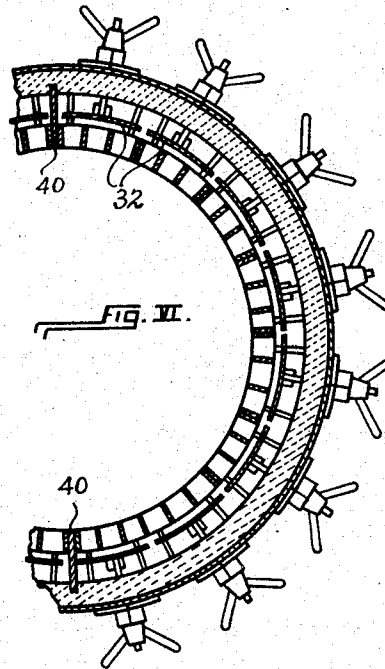
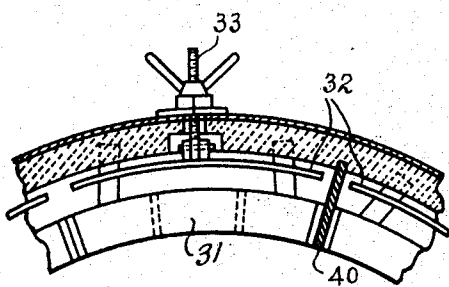


FIG. VIII.

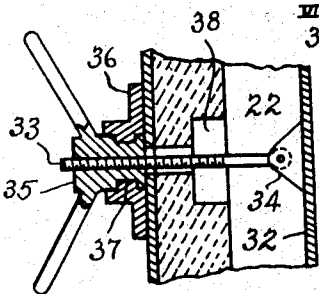
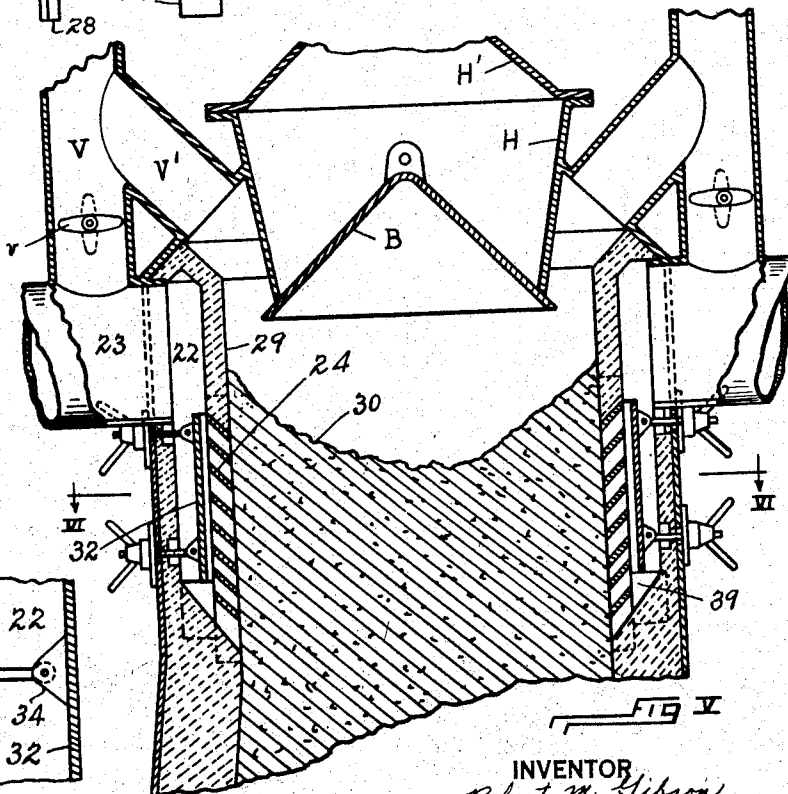


FIG. X.

INVENTOR
Robert M. Gibson
BY
Christy, Parmelee and Strickland
ATTORNEYS

UNITED STATES PATENT OFFICE

2,338,175

BLAST FURNACE

Robert M. Gibson, Pittsburgh, Pa.

Application September 25, 1941, Serial No. 412,255

7 Claims. (Cl. 266-17)

This invention relates to blast furnaces and to smelting furnaces generally that operate on the principle of the blast furnace, and consists in refinements of structure, in consequence of which furnace operation is subject to more extended and accurate control; operation is simplified, expedited, and rendered more uniform; economies of operation are realized, waste is diminished, and the product improved in quality. The invention involves also improvements in method of operation. The application is a continuation in part of an application filed by me May 31, 1940, Serial No. 337,985.

In the accompanying drawings Fig. I is a view in vertical section of a blast furnace, of typical form and structure, in which the features of my invention are embodied; Fig. II is a view to larger scale showing fragmentarily and in vertical section an upper portion of the furnace wall and the structure of my invention in place within it. Fig. III is a view in horizontal section, on the plane indicated at III-III, Fig. II. Fig. IV is a front elevation of the assembly of parts shown in Fig. II. Figs. V-X illustrate an embodiment of the invention in modified form. Fig. V is a view in vertical section through the upper part of the blast furnace and corresponds to the showing afforded in Fig. II. Fig. VI is a view in horizontal section on the plane indicated at VI-VI, Fig. V. Fig. VII is a view in front elevation of an off-take louvre unit. Fig. VIII is a view of the same unit in side elevation. Fig. IX is a fragmentary view in horizontal section through the furnace wall and showing the louvre unit in plan from above. Fig. X is a view on yet larger scale showing in horizontal section the damper and the means for adjusting it.

The essentially columnar blast furnace 1 of circular horizontal cross-section (Fig. I) is provided at its otherwise open top with a charging bell 2, and at its base with a draw-off port 3; near the base tuyères 4 arranged in circumferential succession extend through the walls, and from the furnace near the top though beneath the bell leads the bleeder pipe 5 to the stack.

The furnace substantially filled with the material of the charge is maintained in prolonged and continuous operation; molten iron is from time to time withdrawn at 3, and the charge of raw materials is maintained by intermittent introduction through the bell-controlled top. The height to which the charge rises within the furnace varies; and in Fig. II the range is diagrammatically indicated by two broken lines that bear

the legends, "Stock line (low)" and "Stock line (high)."

My invention consists in the provision at the upper end of the furnace, and preferably immediately below the level that marks the lower limit of the normal range in the height of the charge (the level defined at I by the "Stock line (low)"), a succession of circumferentially arranged gas ports 6 that lead horizontally through the furnace wall, that severally through downcomers 7 communicate with the stoves (not shown), and that severally are controlled, each by a damper 8.

In the installation illustrated by way of example in Figs. II, III, and IV the furnace at the level of these gas ports, is 20 feet in internal diameter and 28 feet in external diameter; the ports are sixteen in number; and each forms part of a unit (more particularly to be described), that is 3 feet wide and approximately 9 feet high. The port itself has a mouth of the oval shape shown in Fig. IV, that is 3 feet 9 inches high and 2 feet 10 inches wide. The mouth of the port is screened by louvres 61. From the oval screened mouth the port tapers outwardly (from right to left, Fig. II) to a circular section, approximately 2 feet 7½ inches in diameter. At its outer end the port is continuous with the downcomer 7 of equal internal diameter. A damper 8 is conveniently set at the outer end of the port 6, and takes the form of a butterfly valve, rotatable upon a vertical axis, and the axis of valve rotation coincides with the diameter of the port. Thus, it will be seen that the wall of the columnar furnace includes near its upper end, a ported zone arranged and adapted both to the sustaining of the charge and to the escape of gas; and that resistance to the free flow of gas may be varied in each port relative to the others.

It is manifest that, by the provision of a plurality of gas ports circumferentially arranged at the upper end of the furnace, and by the provision of dampers that control gas flow through such ports severally, the draft conditions within the furnace and through the furnace charge may be controlled and varied, to afford compensation and correction of irregularities that develop as furnace operation progresses; and it is manifest that such control is gained without diminution of the volumes of air that enter the charge through the tuyères at the bottom of the furnace. By placing in the stream of gas that flows through each port proper testing apparatus, such as a thermocouple 9, an Orsat apparatus 10, and a piezometer 11, the temperature, the composition

(and particularly the ratio of CO to CO₂), and the volume of the emerging stream may be specifically observed, and comparison of conditions in the several streams will afford the operator advice, that he may make such valve adjustments as will maintain optimum conditions of draft through the furnace charge.

Further features of invention are found in the specific form and refinements of the stock-line armor that forms part of the installation here illustrated, and with this stock-line armor the gas ports are structurally combined in units, that are severally applicable to and removable from their places in the furnace structure.

The stock-line armor is, as the name implies, a belt of resistant material built within the furnace at the stock line, and of a material such as to endure the grinding action of the in-fed materials that make up the furnace charge more effectively than the brick of which the furnace walls elsewhere are formed.

The stock-line armor of this installation is made up of a plurality of sections 12 resting upon a step 14 (Fig. II) formed in the masonry of the furnace wall, and bolted together as indicated at 13 (Fig. III) to form a circumferentially continuous belt. The armor extends throughout the range of normal variation of the stock line (between the points L and H, Fig. II), in an obliquely disposed surface. This surface is so disposed as to sustain in substantially perpendicular direction the impact upon it of in-fed charge material. From substantially the level indicated by the point L, Fig. II, the belt of armor extends downward, and the face of this downwardly extended portion is vertically disposed. This downwardly extending portion of the armor belt covers the region in which the air ports are placed. The sections of the armor correspond in number with the air ports; each armor section is windowed, as at 15; and through the window of each armor section extends one of the air ports 6.

Through the upper portion of the belt of armor, and in the portion which in normal operation lies within the range of stock-line variation (between points L and H, Fig. II), extend orifices 16 in which may be set instruments for detecting the approximate point within the range, at which the stock line at any particular moment lies. This may be accomplished by placing within the orifices terminals of electric circuits, so arranged that the circuits are completed only through the body of stock lying upon the face of the armor belt. Suitable detection instruments will be responsive to currents flowing in circuits so established. In Fig. II I have shown in one of the orifices 16, a suitable detecting instrument which includes an electrode 120, of metal surrounded by a tube 121 of suitable insulating material such as porcelain. The electrode tip projects into the furnace to contact the body of the descending charge and the opposite end is connected in circuit through lead 122 to any suitable indicating apparatus such as a light 123 which in turn is grounded to the armor belt. In practice a number of such indicating arrangements are spaced around the periphery and serve to indicate the height of the stock line and whether the stock line is level.

Below the line of the lowest of the ports 16 and above upper edges of the windows 15, the belt of armor is penetrated by a circumferential row of ports 17, and through the ports 17 jets of water are projected. Means for projecting jets of water through ports 17 are diagrammati-

cally indicated in Fig. II by a nozzle 170. This injected water wets the circumferential portion (and the circumferential portion only) of the charge, and the material descends in wet condition across the louvre-screened mouths of the ports 6. The streams of gas as they flow to the ports carry fine and powdered material of the furnace charge, and the layer of wet material that descends across the face of the ports acts as a filter, arresting such fine material, preventing its escape on the gas streams, and carrying it to the reaction zone in the lower part of the furnace.

The sections 12 of the stock-line armor and the gas ports 6 are conveniently made as castings, preferably of 0.50 carbon, cast steel, and their designs are such as to afford a structure free of warping.

The furnace wall is ported at 18, and through these ports (or, if preferred, through the open top of the furnace), the sections 12 of the stock-line armor may be introduced and brought to position, and then bolted together, to form a circumferentially continuous belt. The gas ports 6 may be introduced in and secured in place in the windows 15 when stock-line armor has been applied. The downcomers 7 are independently secured to the furnace structure, and the flanges 21 of the uppermost portion of downcomers 7 are extended to form complete closures externally of the ports 18. Internally the ports are covered by the armor belt.

The stem 81 of damper 8 may be turned by means of a hand wheel 19. A block within a casing 20 may be rotatable on the axial line of stem 81, and rotatable in response to the turning of the hand wheel, and the connection between the block and the stem 81 may be such as to allow relative movement in the direction of the axis of the stem, while effecting rotation of the stem in response to rotation of the block. In such arrangement tolerances are found for slight departures from minute accuracy in relative positions, whether those incident to assembly, or those consequent upon thermal expansion and contraction.

Turning to the embodiment of the invention that is illustrated in Figs. V—X, the furnace wall in its upper portion is made hollow, to afford the annular off-take chamber 22. This chamber constitutes a manifold for the off-take pipes or downcomers 23, which lead therefrom. Into this off-take chamber and in its lower part the gas ports from the furnace chamber lead. These gas ports are screened by louvres 24. The louvres are formed of sections, and the sections extend in side by side arrangement circumferentially of the furnace, filling an otherwise substantially continuous orifice through the furnace wall to the off-take chamber 22. As in the structure first described, these louvre sections are preferably made of cast-iron. In such a structure as is illustrated in Fig. V, the vertical spacing between the louvre plates may advantageously be two inches, and the total area of the louvre space should preferably equal or somewhat exceed the internal cross-sectional area of the furnace shaft, and the louvre structure is made of sufficient vertical height to afford such proportions. Figs. VII, VIII, and IX show a louvre unit or section. This unit comprises three vertical rows of louvre cells C, defined by vertical stiffening ribs 25, and framed between two end posts 26 that preferably are provided with extensions 27 and 28, by which

means the units may be anchored in the inner wall 29 of the off-take chamber.

It is of great importance for the proper operation of this furnace, that the louvre cells be at all times of operation at a level below the lowest level reached by the stock line along the furnace wall. This is indicated in Fig. V, wherein the irregular line 30 indicates the lowest stock line, sloping downwardly from the side wall of the furnace chamber, or hold toward the center thereof.

It will be noted that the annular off-take chamber 22 extends a considerable distance above the upper limit of the louvre cells, and that the off-take pipes 23 have egress from this chamber at a higher level than the highest louvre space.

The reason for having the louvres at all times below the stock line, is to cause the gases about to leave the furnace to pass through the smelting stock just introduced, in such manner that this stock will act as a constantly renewed filter medium, to take from the outstreaming gases in more or less completeness the dust and fines that otherwise would escape.

It is generally recognized in the art that a uniform distribution and flow of the gases through the smelting stock of the furnace improves the efficiency, and therefore the capacity, of any furnace of this character. Such uniform distribution is, however, difficult to maintain, because of the unequal porosity of the charge, and a tendency exists toward the formation of "pipes," (that is to say, localized lines of draft) in the charge that is in course of smelting. Excessive velocity of the gaseous products of the smelting operation along the inner wall of the furnace, is liable prematurely to burn out the lining thereof, with the consequence that time and expense are wasted in making repair. Such excessive and localized drafts may to a certain extent be reduced or corrected, by selectively diminishing the flow of air through certain of the tuyères. Such control, however, is done with diminution of the theoretical capacity of the furnace, since diminution of air, means diminution in the magnitude of the essential reducing operation.

Excessive velocity of the gaseous streams within the furnace charge, and particularly along the inner walls of the furnace where it is most detrimental, is in the furnace of my invention in both of the forms that are here shown, controlled by means of adjustable dampers. In the form shown in Figs. V—X, for each louvre unit 31 a damper 32 is provided. This damper is arranged externally of the unit of louvre plates and within the off-take chamber 22. It is of substantially the height of the unit of louvre plates, and is curved to correspond to the curved formation of the louvre unit, which in turn is curved in conformation to the curvature of the furnace wall. These dampers 32 are adjustable on the radial lines of the furnace, and by such adjustment effect variation in the effective areas of the individual louvre units. Various means to operate these dampers will readily suggest themselves. The drawings show threaded bolts 33, hingedly secured to the outer face of the damper as at 34, and provided with threaded wing nuts 35, rotatably mounted in split bearings 36, secured in any desired manner, such as by welding, to the outer shell of the blast furnace. Preferably the nuts and bearings are provided with labyrinthine cells 37 to reduce leakage to a minimum. The wall of the furnace is recessed at 38 to receive the hinge connections 34 when

the damper is drawn fully away from its corresponding louvre unit. In the drawings (Fig. V) each damper unit is shown to be provided with two adjusting bolts, but the number may, of course, be varied to suit the size of the damper unit. To facilitate the operation of the damper units and to relieve the adjusting bolts of the weight of the damper units, these units rest upon iron saddles 39 suitably mounted on the outer wall of the off-take chamber 22. The surface upon which the saddles rest is steeply inclined inwardly, so that dust falling thereon will return to the furnace hold.

When a blast furnace is provided with two or more off-take pipes, it may be found desirable to subdivide the annular off-take chamber into sections corresponding in number to the number of off-take pipes, this by means of partition walls 40, to prevent the formation of cross currents within the off-take chamber, and thus to afford better distribution of the outflowing gases to the off-take pipes or downcomers. By closing the louvre units of a so-divided section of the off-take chamber, the flow of gases through the corresponding off-take pipe or downcomer may be cut off, allowing repairs to be made that otherwise would require the shutting down of the furnace.

Another important advantage of retaining within the furnace the fines and the dust, is that this finely divided material makes the charge more dense, and this greater density has effect in diminishing the tendency to the formation of pipes or localized lines of drafts through the charge. This condition, combined with the control obtainable by damper adjustment, enables the furnace operator to maintain a much more uniform distribution of the gases throughout the body of the charge (and that independently of tuyère control), than may otherwise be achieved.

The structure of Fig. V includes also features of conventional design that have not been described in detail. They are generally known in the art. V and V' are vents; v are the butterfly valves for the furnace; H is the furnace hopper; H' is the gas hood thereof; and B is the charging bell.

The arrangement is such as to maintain a zone of reaction of high efficiency and of an intensity well distributed throughout the breadth of the furnace. In operation the attendant by observation of the instruments, has knowledge of conditions within the furnace; he is able to detect irregularities of operation; and immediately to make correction. The fines are in a large measure carried to the reaction zone, and the loss and the nuisance of escaping flue dust are in large measure prevented.

I claim as my invention:

1. In a smelting furnace of columnar form adapted to be charged from above and aerated at the base, a plurality of ports formed in circumferential succession in the furnace wall adjacent the top of the column, stock-line armor formed of a plurality of sections mounted on the furnace wall and united in a belt and covering on the inside the ports in the furnace wall, each section of such belt of armor being windowed, a plurality of gas ports set one in each of the windows of the belt of armor, a plurality of downcomers each covering on the outside one of the ports in the furnace wall, with which downcomers the gas ports are in the assembly severally in communication, and means for regulating flow through each gas port severally.

2. In a smelting furnace of columnar form adapted to be charged from above and aerated at the base, with walls adapted to sustain a furnace charge, a belt of stock-line armor mounted on the furnace wall near the upper end of the column, and including an upper portion with inclined surface and a lower portion with vertical surface, and a plurality of gas ports extending through the furnace wall and through the lower portion of stockline armor, and arranged in circumferential succession around the furnace wall, the said belt being provided in its upper inclined portion with horizontally extending ports arranged in vertical succession and adapted to receive means for detecting the position of the stock-line from time to time in the course of furnace operation.

3. In a smelting furnace of columnar form adapted to be charged from above and aerated at the base, with walls adapted to sustain a furnace charge, the invention herein described, which consists in the provision of a plurality of gas ports arranged circumferentially of the furnace wall, and opening through the furnace wall adjacent the top of the column and below the normal stock line, and forming in the furnace wall a ported zone, gas-penetrable charge-sustaining means arranged in each port, and means for regulating the flow of gas through the ports severally.

4. In a smelting furnace of columnar form adapted to be charged from above and aerated at the base, with walls adapted to sustain a furnace charge, the invention herein described, which consists in the provision of a plurality of gas ports arranged circumferentially of the furnace wall, and opening through the furnace wall adjacent the top of the column and below the normal stock line, and forming in the furnace wall a ported zone, a bank of louvre plates arranged in each port adapted to sustain the furnace charge and to permit the escape of gas, and means for regulating the flow of gas through the ports severally.

5. In a smelting furnace of columnar form adapted to be charged from above and aerated

at the base, with walls adapted to sustain a furnace charge, the invention herein described, which consists in the provision of a plurality of gas ports arranged circumferentially of the furnace wall, and opening through the furnace wall adjacent the top of the column and below the normal stock line, and forming in the furnace wall a ported zone, gas-penetrable charge-sustaining means arranged in each port, means for regulating gas flow through the ports severally, and a succession of water injection ports circumferentially arranged in the structure at a level higher than the gas ports.

6. In a smelting furnace of columnar form with walls of masonry having an annular off-take chamber formed within the walls and at the upper end of the column, an offtake pipe with which the offtake chamber is in constantly open communication, and a plurality of outflow apertures arranged circumferentially of the columnar furnace and leading from the hold of the furnace to the said offtake chamber, the invention herein described, which consists of individual and severally operable flow-controlling means associated with each of said outflow apertures.

7. In a smelting furnace of columnar form with walls of masonry having an annular off-take chamber formed within the walls and at the upper end of the column, a plurality of off-take pipes with which the offtake chamber is in constantly open communication, and a plurality of outflow apertures arranged circumferentially of the columnar furnace and leading from the hold of the furnace to the said offtake chamber, the invention herein described, which consists of partitions subdividing the offtake chamber into a circumferential series of chambers the said offtake pipes being severally in communication with different chambers of such circumferential series, and the said outflow apertures leading severally to different chambers of such circumferential series, and severally operable flow-controlling means associated with each of said outflow apertures.

ROBERT M. GIBSON.