July 19, 1938. K. STEINBACHER 2,124,437

BLAST FURNACE AND TUYÈRE STRUCTURE AND METHOD OF OPERATION

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Fig. 1.

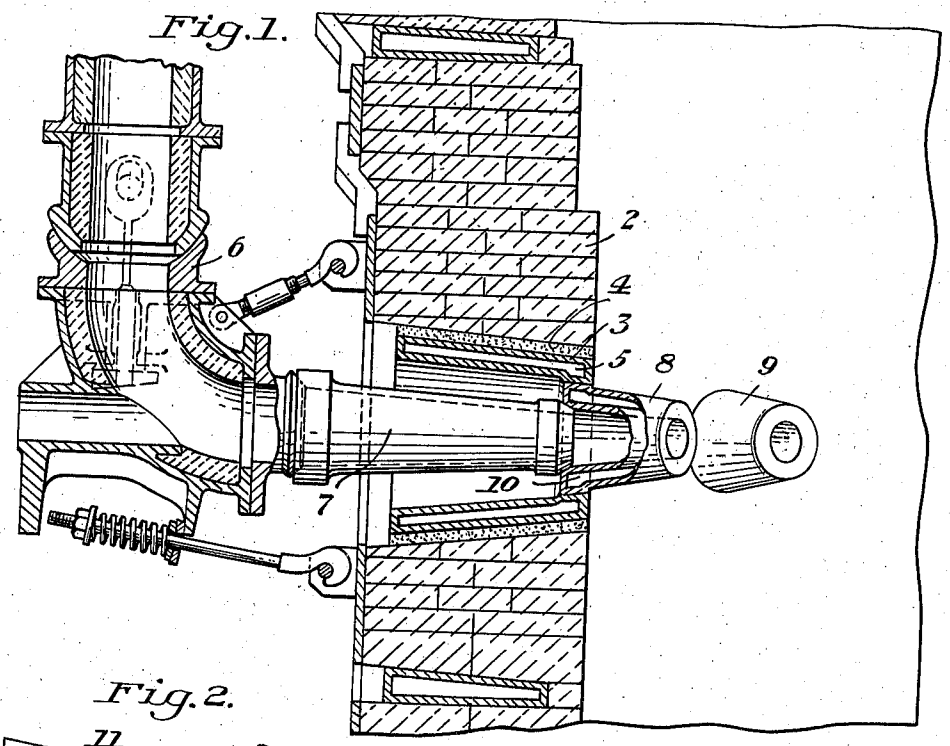



Fig. 2.

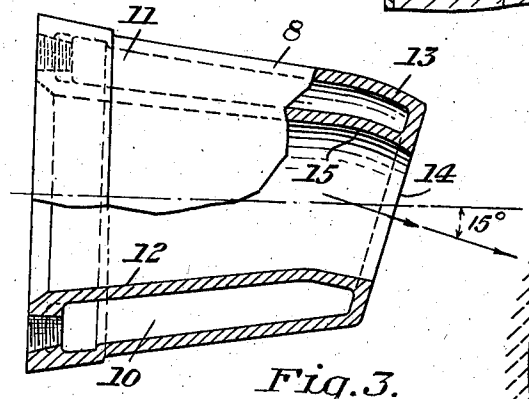



Fig. 3.

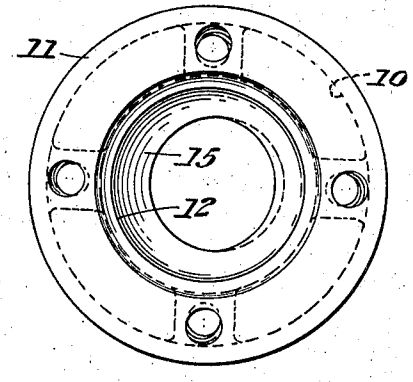
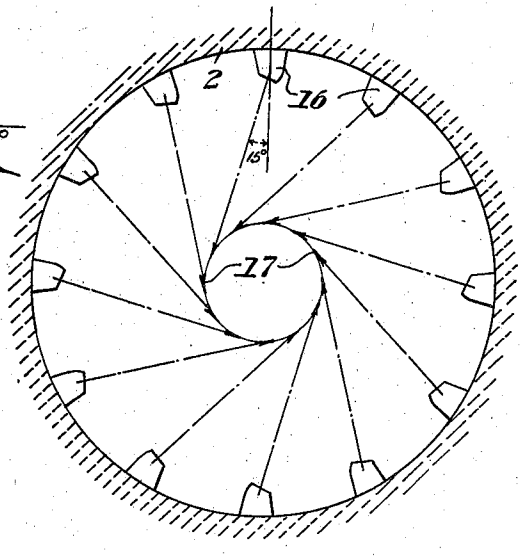



Fig. 6.




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BLAST FURNACE AND TUYÈRE STRUCTURE AND METHOD OF OPERATION

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Fig. 4.

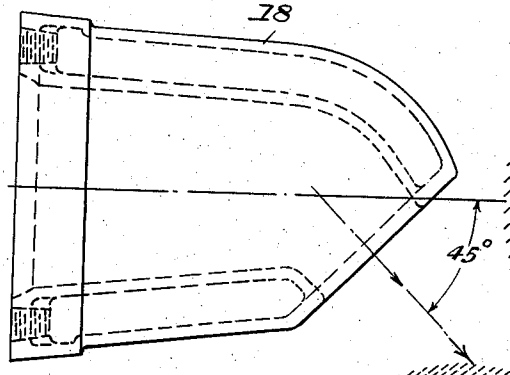
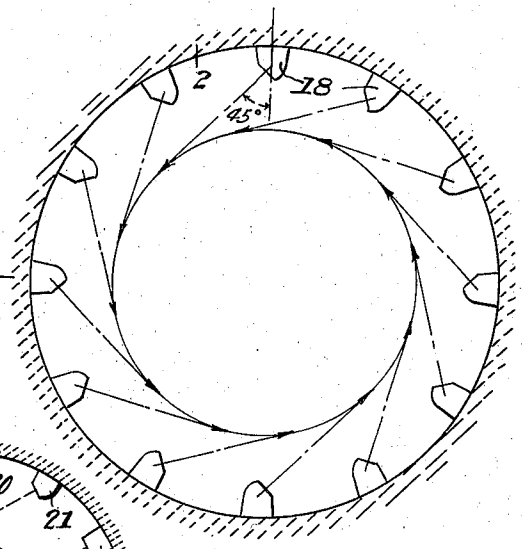



Fig. 7.



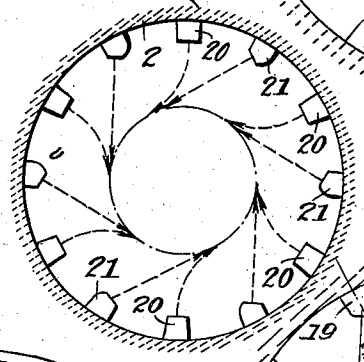
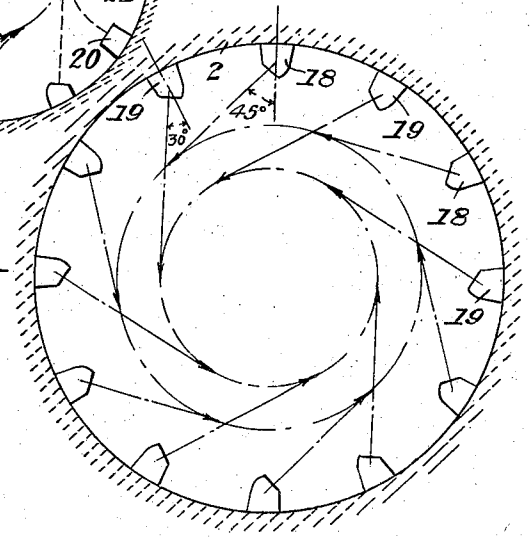




Fig. 9.

Fig. 8.



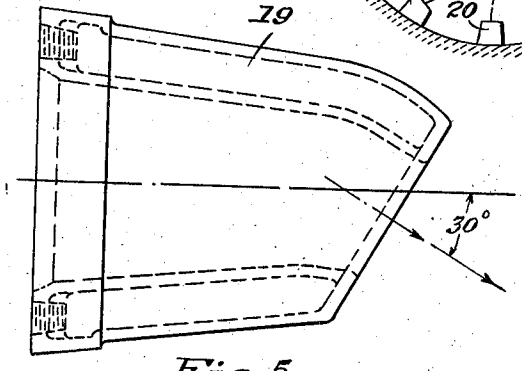




Fig. 5.

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# UNITED STATES PATENT OFFICE

2,124,437

## BLAST FURNACE AND TUYÈRE STRUCTURE AND METHOD OF OPERATION

Karl Steinbacher, Portsmouth, Ohio

Application January 10, 1936, Serial No. 58,517

4 Claims. (75—41)

This invention relates to blast furnace and tuyère structure and method of operation, and more particularly to the art of reducing ore in a blast furnace and controlling the blast characteristics whereby important new and useful results are obtained. A novel blast furnace structure and a novel method of operating a blast furnace are provided. Also a novel tuyère structure useful in accomplishing the desired results is provided.

The standard blast furnace comprises an upright furnace shaft into which ore, fuel and flux in proper proportions are introduced through a specially constructed opening in the top. Heated air is blown into the furnace near the bottom through devices known as tuyères, the nitrogen of the air, together with the products of combustion and reduction, passing upwardly and escaping at the top of the furnace. Periodically slag and molten metal are drawn off through suitable openings provided below the tuyères.

In a standard blast furnace structure each tuyère is mounted in a holding device, known as a tuyère cooler. Such cooler comprises essentially a tapered or generally conical copper shell through which cooling water is adapted to be circulated. The tuyère is likewise of generally tapered or conical construction, being ordinarily made of copper and having a jacket portion through which cooling water is adapted to be circulated. The tuyère is introduced into the tuyère cooler and held thereby. The tuyère ordinarily projects inwardly of the furnace wall. The axes of the tuyère and cooler are perpendicular or normal to the furnace wall.

Ordinarily the number of tuyères in a blast furnace varies between eight and sixteen. The tuyères are arranged in evenly spaced relation in a single circumferential series in the same plane perpendicular to the axis of the furnace. Thus during operation of the furnace all of the tuyères discharge or direct their blasts straight at the axis of the furnace. This results in building up the static pressure inside the furnace due not only to the resistance offered to the blast by the stock in the furnace but also to the interference of the various blasts or gas streams with one another. The exact path of each blast is naturally determined in a considerable measure by the resistance offered by the stock in the furnace. Consequently the resistance points shift during operation of the furnace, the result being that the desired uniform flow of air or gas is interfered with. This in turn results in non-uniform stock flow.

If the stock flow is not uniform the transfer of heat and the reduction of oxides is not as complete and uniform as it should be, resulting in impairment of the quality of the pig iron being produced. The reduction tends to be carried out in more or less isolated portions of the stock, other portions being less fully reduced, with the result that the pig iron contains an undesirably high percentage of impurities.

I provide for eliminating the tendency of the blasts to interfere with one another and, on the contrary, I control the blasts so that they cooperate with one another to effect more complete and uniform reduction of the ore. I direct the blasts eccentrically of the furnace and so as to create a controlled swirling draft. The blasts are preferably all similarly directed so that the swirling draft will be unimpaired. It may be either clockwise or counter-clockwise, the same result being obtained in either event.

I preferably introduce into the blast furnace a circumferential series of blasts directed eccentrically of the furnace and substantially in a common plane perpendicular to the axis of the furnace and thereby create a controlled swirling inward and upward draft. As the outlet for the gases is at the top of the furnace they will move upwardly, and by proper control of the blast angles I can efficiently distribute the blast throughout a relatively great portion of the stock, eliminating the tendency toward building up of static pressure by reason of interference between the blasts and greatly increasing the efficiency of the process. The result is a superior product and also an increased yield from the blast furnace per operating period.

I am aware that it has heretofore been proposed to direct tuyères at an angle downwardly and laterally toward the hearth of a melting furnace to refine material on such hearth, but this is entirely different from my invention, and, in fact, directing the tuyères downwardly in a blast furnace would bring about undesirable conditions in the furnace which would interfere with proper reduction of the stock and would also tend to reduce the intensity of the draft by creating a force opposite to the direction of movement of the gases. I am also aware that it has heretofore been proposed to direct the blast of a single tuyère or of isolated tuyères toward particular spots in the stock column where an increased reduction effect may be desired. This however, tends rather to interfere with proper carrying out of the operation than to increase its efficiency.

I provide a novel form of tuyère which is relatively simple in construction and inexpensive to manufacture and which is ideally suited for the accomplishment of my improved results. I preferably provide a tuyère adapted to be applied to a standard blast furnace and to be held by the standard type of tuyère holder or cooler whose axis is substantially normal to the furnace wall. Thus my improved results can be obtained without any modification whatever of a standard blast furnace except removal of the tuyères and replacement thereof by my improved tuyères.

In one of its present preferred forms the tuyère has an outer shape approximating the shape of a cone truncated at an acute angle to its axis. The tuyère preferably has a curved bore terminating in the surface of truncation. The tuyère is preferably of such shape as to be contained entirely within the confines of a cone defined by its base portion and has a curved bore whose longitudinally concave portion is formed as a smooth, gradual curve to minimize cross currents in the blast through the tuyère. Preferably at least a portion of the bore is curved so that the direction of the blast is changed in the tuyère. The nose of the tuyère preferably comprises a surface extending substantially at right angles to the direction of the blast as it is discharged from the tuyère and the tuyère preferably has a longitudinally convex outer surface portion facing generally away from the direction of discharge of the blast.

My tuyère may have a generally conical base portion and a substantially flat nose surface extending at an acute angle to the axis of the base portion, the tuyère having a bore extending within the base portion and intersecting the flat nose surface. In one preferred form of the tuyère any section through it normal to the axis of the bore is substantially symmetrical in all directions about its center. The outer shape of the tuyère may approximate the shape of a truncated cone with non-parallel bases and with a bore therethrough.

Other details, objects and advantages of the invention will become apparent as the following description of certain present preferred embodiments thereof and certain present preferred methods of practicing the same proceeds.

In the accompanying drawings I have shown certain present preferred embodiments of the invention and have diagrammatically illustrated certain present preferred methods of practicing the same, in which

Figure 1 is a partial central vertical cross-sectional view through a blast furnace of standard construction but having my invention applied thereto;

Figure 2 is a central longitudinal cross-sectional view through one form of tuyère;

Figure 3 is a view of the tuyère shown in Figure 2 viewed from the left;

Figures 4 and 5 are views of modified forms of tuyère; and

Figures 6, 7, 8 and 9 are diagrammatic views illustrating the carrying out of my process.

Referring now more particularly to the drawings, Figure 1 shows a portion of a blast furnace which is standard in every detail except for the tuyère itself. The furnace wall is designated generally by reference numeral **2** and the tuyère holder or cooler by reference numeral **3**. The cooler **3** is generally in the form of a truncated cone and fits within an opening **4** provided therefor in the wall **2**. The cooler has a passage **5** therein through which cooling water is adapted to be passed in well known manner. The axis of the cooler is normal to the axis of the wall **2**. The blast supplying mechanism designated generally by reference numeral **6** is of standard construction and hence need not be described. The blast comprises preheated air and enters the tuyère through a nozzle **7** at high velocity, as well known in the art.

The tuyère **8** is shown as fitted within the cooler **5** in operative position and receiving preheated air through the nozzle **7** to produce a blast within the furnace. Another similar tuyère spaced a short distance around the furnace wall is shown at **9**. There may, for example, be twelve such tuyères uniformly spaced about the furnace wall and all disposed in the same relationship with respect thereto. Each of the tuyères is provided with a passage **10** through which cooling water is adapted to be circulated, as well known in the art.

The tuyère **8** comprises a base portion **11** formed externally in the shape of a right circular cone and having therein a tapered bore **12** (Figure 2). The tuyère is, as above stated, adapted to be held by a standard tuyère cooler as now used in practically all modern blast furnaces. The outer shape of the tuyère is approximately the shape of a cone truncated at an acute angle to its axis as shown, although the outer surface at **13** adjacent the nose of the tuyère is longitudinally convexly curved opposite the general direction of discharge of the blast. As will be apparent, this external curvature of the tuyère as at **13** assists in minimizing the possible interference of the tuyère with the blast of the next tuyère of the series as **9**, especially when the tuyère angle is relatively great (see Figures 4 and 7).

The bore of the tuyère is curved as shown so that the direction of the blast is changed in the tuyère. The longitudinally concave portion **15** of the bore is formed as a smooth gradual curve to minimize cross currents in the blast through the tuyère. The nose surface **14** of the tuyère extends substantially at right angles to the direction of the blast as it is discharged from the tuyère. The tuyère is contained entirely within the confines of a cone defined by its base portion **11**.

Any section through the tuyère normal to the axis of the bore is substantially symmetrical in all directions about its center. This is not exactly true but it is a close approximation. In fact, in its preferred form the outer shape of the tuyère approximates the shape of a truncated cone with non-parallel bases.

The tuyères preferably, although not necessarily, project inwardly past the wall of the furnace, and in the preferred form shown they project radially inwardly. However, on account of the peculiar formation of the tuyères they discharge their blasts into the furnace eccentrically thereof and so as to create a swirling draft in the furnace as indicated diagrammatically in Figure 6. In this figure the tuyeres are designated by reference numeral **16**, the axes of their base portions being normal to the furnace wall and the direction of discharge of the draft being offset 15 degrees from such axes as shown. The blasts are preferably discharged into the furnace substantially in a common plane perpendicular to the axis of the furnace so as to create a swirling draft as indicated at **17**. As above explained, the draft moves upwardly and the effect is to obtain a better distribution of

the draft through the stock with the consequent advantages mentioned in efficiency, increased production and improved product.

The tuyère angle, that is to say, the angle between the axis of the base portion of the tuyère and the angle of discharge of the blast therefrom, may be varied as desired. In Figure 4 is shown a tuyère 18 similar in all respects to the tuyère 8 except that the tuyère angle is 45°. In Figure 5 is shown a similar tuyère 19 but having a tuyère angle of 30°. The tuyère angle will be selected in accordance with the size of the furnace, the number of tuyères and the conditions of operation.

In Figure 7 is shown the draft effect produced by using tuyères 18 with a 45° tuyère angle. Of course this figure, as well as Figures 6 and 8, only gives a fair approximation of the result obtained, as the draft will spread out as it leaves the tuyère so that substantially the whole of the stock column will be subjected to the draft before the gases have risen far. I have found that for different conditions different tuyère angles are desirable and these may be determined by trial.

In Figure 8 there is shown diagrammatically a blast furnace having a series of tuyères 18 having a 45° angle and a series of tuyères 19 having a 30° angle, the respective tuyères 18 and 19 alternating around the furnace. This provision is found to be desirable in some cases as assisting in spreading out the draft and thereby increasing the efficiency of the furnace, as indicated in Figure 8. In other cases, however, it is desirable that all the tuyères have the same tuyère angle, as the use of tuyères with different tuyère angles creates some impedance in the furnace due to crossing streams. The best tuyère angle or angles for any installation may be determined by trial.

In some cases it may be desirable to use straight and angled tuyères in the same furnace, either alternately or otherwise, although this would be the exception rather than the rule. Such a furnace construction is shown in Figure 9, in which straight tuyères 20 and angled tuyères 21 are disposed alternately about the furnace. It is my present belief that the use of straight tuyères is definitely detrimental and that angled tuyères should be used entirely. Moreover, I consider it important that the tuyères be directed substantially in, or at least not downwardly relatively to, a horizontal plane perpendicular to the axis of the furnace and passing through the axes of the base portions of the tuyères. As stated above, if the blasts are directed downwardly the efficiency of the furnace is greatly reduced and undesirable conditions are brought about.

While I have shown and described certain present preferred embodiments of the invention and certain present preferred methods of practicing the same, it is to be distinctly understood that the invention is not so limited but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A blast furnace having a circumferential series of tuyères discharging their blasts into the furnace eccentrically thereof and so as to create a swirling draft in the furnace, certain of said tuyères discharging their blasts at one predetermined acute angle to the furnace wall and other of said tuyères discharging their blasts at another predetermined acute angle to the furnace wall whereby to control and distribute the draft.

2. A method of operating a blast furnace, comprising introducing thereinto a circumferential series of blasts directed eccentrically of the furnace and substantially in a common plane perpendicular to the axis of the furnace, certain of said blasts being directed at one predetermined angle to the furnace wall and other of said blasts being directed at another predetermined angle to the furnace wall, and thereby creating a controlled swirling inward and upward draft.

3. In the operation of a blast furnace for the production of pig-iron in which stock is charged in at the top and flows downwardly within the furnace and molten pig-iron is tapped off at the bottom and in which the blasts discharged into the furnace by the tuyères mingle free from interruption by any projecting interior furnace part, the improved method of increasing the uniformity of stock flow downwardly within the furnace and consequently increasing the efficiency and yield of the furnace, which comprises introducing into the furnace through its wall at its lower portion a generally circumferentially arranged series of blasts, directing at least a plurality of said blasts so that when discharged into the furnace they respectively move in a direction at an angle to a normal to the furnace wall, generally horizontally and in the same general direction with respect to the furnace wall and so as to create within the furnace a controlled swirling and upward draft which efficiently distributes the composite blast throughout a relatively great portion of the stock.

4. A blast furnace for the production of pig-iron in which stock is charged in at the top and flows downwardly within the furnace and molten pig-iron is tapped off at the bottom, the furnace having at its lower portion a series of openings in its wall arranged generally circumferentially thereof with tuyère holders arranged in such openings, the tuyère holders having tuyère receiving portions tapering from larger to smaller dimension in the direction from the outside toward the inside of the furnace and being arranged with their respective axes substantially normal to the furnace wall, and tuyères having tapered portions disposed within the tuyère receiving portions of the tuyère holders whereby the tuyères are held in place, the respective axes of said portions of the tuyères being disposed substantially normal to the furnace wall, at least a plurality of the tuyères being so constructed as to discharge their blasts into the furnace angularly with respect to their respective axes, generally horizontally and in the same general direction with respect to the furnace wall and so as to create within the furnace a controlled swirling and upward draft which efficiently distributes the composite blast throughout a relatively great portion of the stock, resulting in increase in the uniformity of stock flow downwardly within the furnace and consequently increased efficiency and yield of the furnace.

KARL STEINBACHER.