

June 8, 1937.

J. H. Q. BURKE

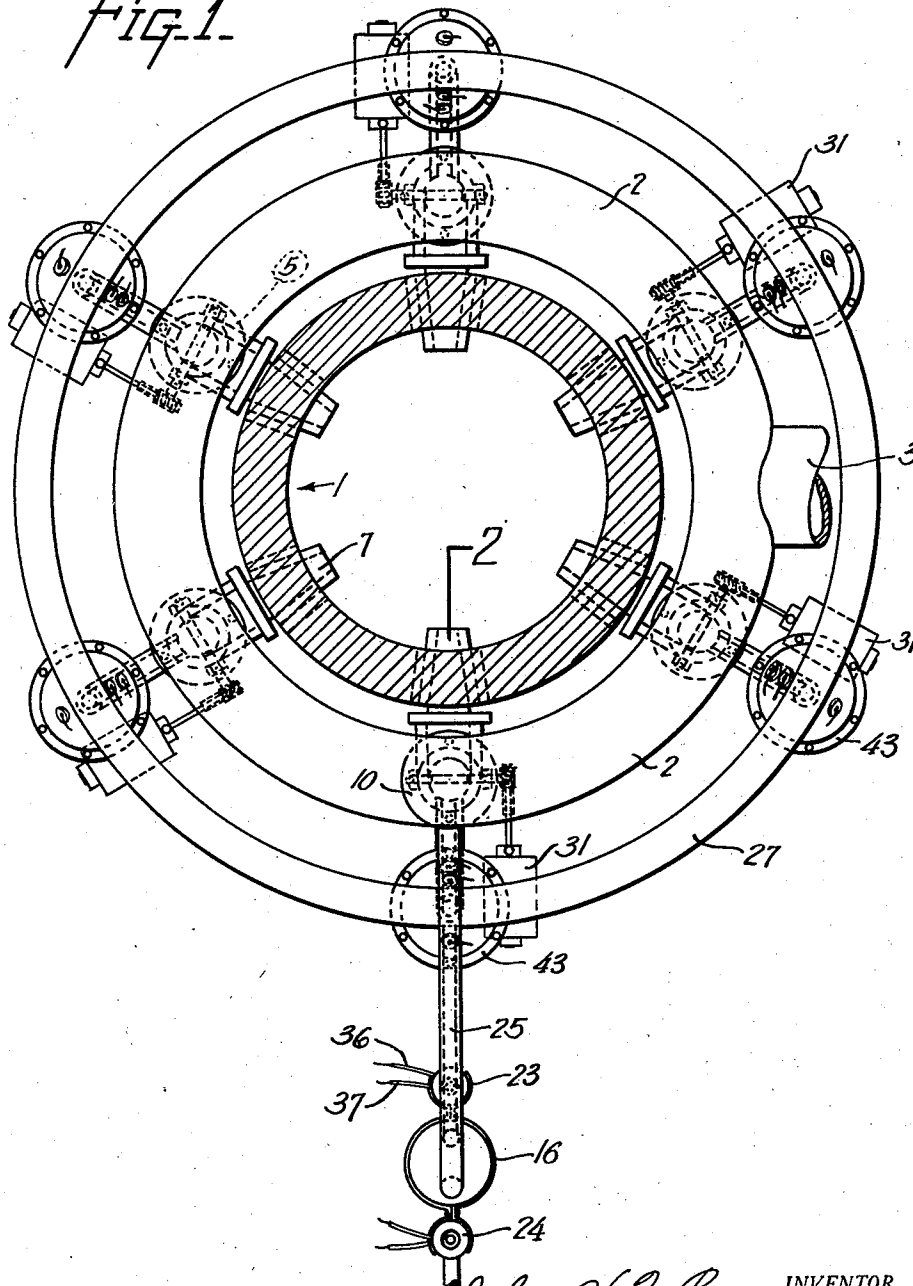
2,083,046

METHOD OF AND APPARATUS FOR AUTOMATICALLY DISTRIBUTING
AIR BLAST TO ORE SMELTING FURNACES

Filed April 19, 1935

3 Sheets-Sheet 1

FIG. 1.



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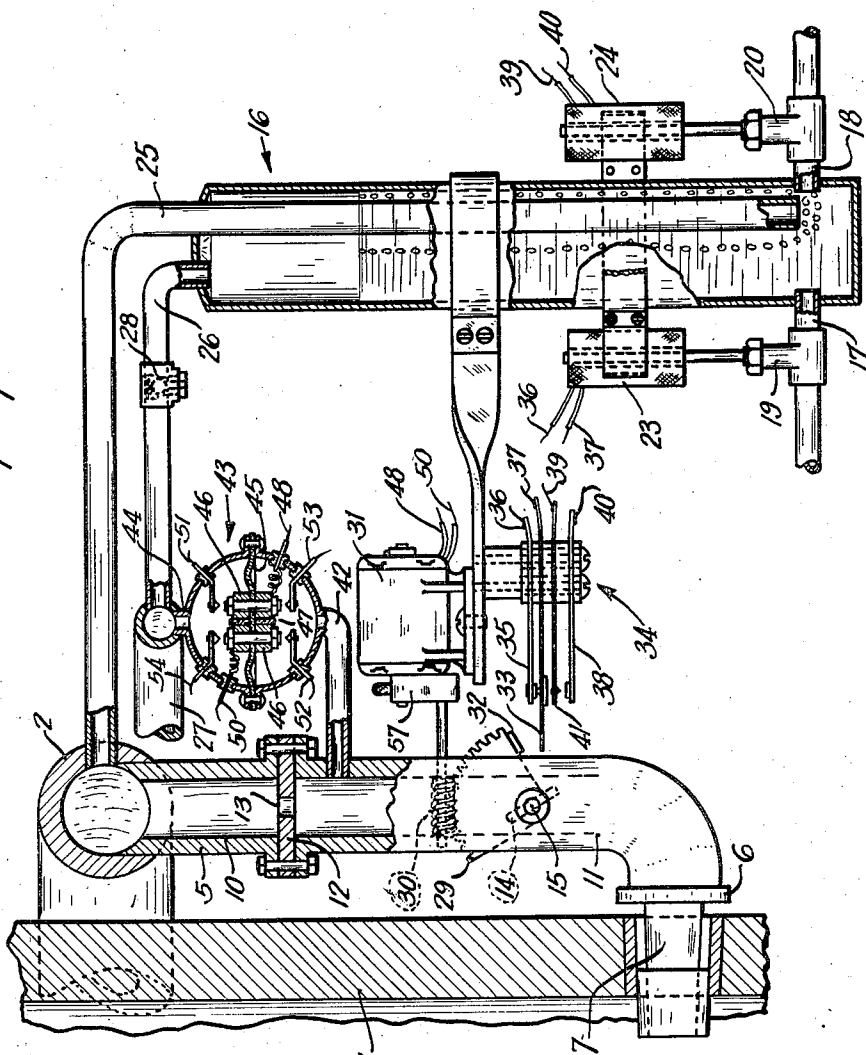
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Filed April 19, 1935

3 Sheets-Sheet 2

FIG. 2-



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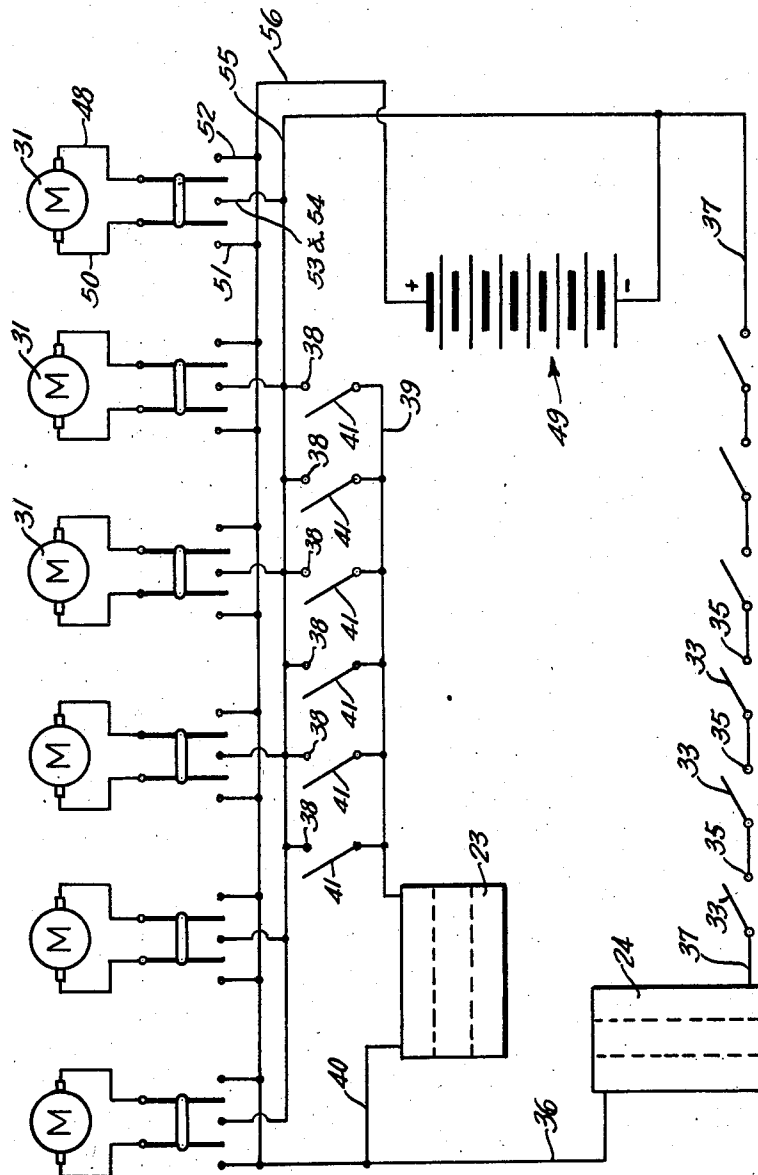
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3 Sheets-Sheet 3

FIG. 3.



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UNITED STATES PATENT OFFICE

2,083,046

METHOD OF AND APPARATUS FOR AUTOMATICALLY DISTRIBUTING AIR BLAST TO ORE SMELTING FURNACES

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Application April 19, 1935, Serial No. 17,231

14 Claims. (Cl. 266—30)

My invention relates to the automatic distribution of the air-blast to ore smelting furnaces.

In smelting ore in blast furnaces it often occurs that the contents of the furnace forms an obstruction at the exhaust end of one or more of the air inlet pipes or tuyères. Such obstruction causes a partial cooling of the furnace content adjacent thereto, and at the present time no means is had for removing the obstruction except the manual operation of a pry bar or the like. At the present time peep-holes are provided adjacent each tuyère for observing the internal condition of the furnace; also the tuyères are provided with apertures through which a rod may be inserted to remove an obstruction at their inner or exhaust ends. This method requires constant supervision, and in many instances, the obstruction cannot be removed by the mere insertion of a bar through the tuyère.

If the obstruction is not immediately removed when it forms the cooled area continues to increase, and eventually the fire must be killed, the furnace must be completely emptied and cleaned, must be re-stocked, and the fires again lighted and the furnace be brought up to a full blast. This operation requires from twenty to thirty days time, but also entails the loss of several thousand dollars worth of material. It is a conservative estimate that this operation upon the usual sized furnace costs forty thousand dollars.

Another deficiency caused by the presence of cool spots in a furnace lies in the inferior quality of the product produced, and in the unequal distribution of stock. These cost the manufacturer considerable money.

There are many instances when it is possible to remove obstructions and eliminate cool spots in the furnace by relieving or discontinuing the charge of ore and flux to the furnace, and increasing the fuel charge and the air-blast. The furnace is then operated in this condition until the obstruction has been melted away, after which ore and flux are again fed thereinto.

This method is much more satisfactory than the first, and if started soon enough will eliminate the necessity of killing, cleaning, and recharging the furnace. However, it may readily be visioned the large expense entailed by the operation of the furnace at frequent intervals for considerable periods of time, in a condition in which it is producing no remunerative product, is very great. The time which is required to operate an un-loaded furnace in order to eliminate an obstruction of course varies in each instance

in accordance with the nature and the extent of the obstruction. No definite estimate of the average cost per year for each furnace utilizing this method of eliminating obstructions or cool spots can intelligently be given. It is conservative to say, however, that the cost will run into thousands of dollars per year per furnace.

The prime object of my invention is the automatic prevention of the forming of cool spots in a smelting furnace, and a reduction in blast pressure of at least ten percent over that necessary at the present time.

Other objects are to provide apparatus of the class described which is new, novel, practical and of utility; which will be put into operation by an increase in air pressure at the exhaust end of any obstructed tuyère; which will make it possible to operate blast furnaces with at least ten percent less air blast pressure than is now necessary, and will consequently accomplish considerable saving in fuel; which will automatically open the obstructed tuyère and will partially close all other tuyères thus concentrating its equal proportion of blast upon the obstructed tuyère until the obstruction is removed or is melted away by the continued equal proportion of blast upon the single tuyère; which will evenly distribute the air blast throughout a plurality of tuyères at all times; which is so arranged that an automatic adjustment may be had in the differential in pressures required to cause its operation; which is simple in construction and cheap in operation; which is durable; and, which will be efficient in accomplishing all the purposes for which it is intended.

With these and other objects in view as will more fully appear hereinafter, my invention consists in the construction, novel features, and combination of parts hereinafter more fully described, pointed out in the claims hereto appended, and illustrated in the accompanying three-sheet drawings, of which,

Figure 1 is a plan view of the air blast mechanism of a usual smelting furnace, the furnace wall being shown in section, and disclosing my apparatus connected to the mechanism;

Figure 2 is a fragmentary vertical sectional view of a smelting furnace showing a portion of my apparatus installed; and,

Figure 3 is a schematic view of a typical electrical circuit used in connection with my apparatus.

Like characters of reference designate like parts in all the figures.

It is understood that various changes in the

form, proportion, size, shape, weight and other details of construction, within the scope of my invention may be resorted to without departing from the spirit or broad principle of my invention and without sacrificing any of the advantages thereof; and it is also understood that the drawings are to be interpreted as being illustrative and not restrictive.

The inventive idea involved is capable of receiving a variety of mechanical expressions one of which, for the purpose of illustrating the invention, is shown in the accompanying drawings, wherein:—

The reference numeral 1 indicates as a whole the wall of a usual tubular smelting furnace which is surrounded adjacent its lower portion with a usual circular bustle pipe 2 having an inlet pipe 3 through which heated air is delivered from the usual air heating stoves, not shown. The bustle pipe is provided with a plurality of spaced leg-pipes 5 each connected by a usual flanged connection 6 to a tuyère 7 of which there are six shown in Fig. 1. The usual smelting furnace however uses from twelve to sixteen of the tuyères. The previously described structure is usual to smelting furnace air blast apparatus construction.

In installing my device upon the above described structure, I construct the leg-pipe 5 in two sections 10 and 11 (Fig. 2) between which is flangedly connected a water cooled plate 12 having a through perforation or orifice 13. Beneath the orifice plate 12 the section 11 is provided with a water cooled butterfly-valve 14 which is mounted upon a pin or shaft 15 and which is adapted for partial rotation therewith. The shaft 15 is journaled in the walls of the section 11, and the valve is adapted to open and close the bore of the section 11.

At a desired point adjacent the furnace is provided a water tank 16 which is closed at both ends and which has an inlet pipe 17 and an outlet pipe 18 adjacent its lower end. Pipes 17 and 18 are respectively provided with cut-off valves 19 and 20 having actuating stems 21 and 22. The valves are preferably of the needle type and each is equipped with a spring, not shown, for normally holding the needle seated. Solenoids 23 and 24 are provided for moving the stems 21 and 22 respectively for opening the valves.

A pipe 25 leads from the bustle pipe 2 downwardly into the tank 16 to adjacent its lower end. A second pipe 26 leads from the top of the tank 16 to a circular pipe 27 which surrounds the furnace. A bleeder opening 28 is provided in the pipe 26 for permitting a small amount of air to escape at all times.

The following described structure is provided for each one of the leg pipes 5.

A segment gear 29 is rigidly connected to the stem 15 of the damper 14 and is driven by a spiral gear 30 of an electric motor 31. The segment gear has an insulating block 32 which is arranged to contact a blade 33 of a two-way electric switch 34 when the gear reaches the end of its throw which completely opens the damper 14.

The blade 33 is of the spring type and normally closes contact with a terminal 35 which acts through wires 36 and 37 to energize the solenoid 23 to open the valve 19. When the damper is fully open the segment gear forces the blade 33 out of contact with the terminal 35 and in turn forces a blade 41 into contact with a second terminal 38 which through wires 39 and 40 energizes the solenoid 24 to open the valve 20. This

operation, of course, simultaneously de-energizes the solenoid 23 and closes the valve 19. In Figure 3 is diagrammatically illustrated a wiring arrangement for the switches 34 and the two solenoids 23 and 24. It will be understood that one of the segment gears 29, motors 31 and switches 34 are provided for each of the leg-pipes. Also, that all of the blades 33 and terminals 35 are wired in series and therefore all of them must be closed in order to actuate the solenoid 23 to open the valve 19. It may also be seen in Fig. 3 that the contact of any one of the blades 33 with its terminal 38 will energize the solenoid 24 to open the valve 20. Since the construction of the switches 34 is such that both circuits connected thereto cannot be closed at the same time only one of the solenoids can be energized at the same time.

As a means for controlling operation of the respective motors 31, each leg-pipe is equipped with a pipe 42 which connects the leg-pipe at a point below the orifice plate 12 with the bottom portion of a diaphragm housing 43. The upper portion of each of the diaphragm housings 43 are in communication through a pipe 44 with the circular pipe 27.

The housings 43 are each made in two flanged sections which are held together by bolts, and between the sections of each housing is rigidly held a flexible diaphragm 45 of suitable electrical insulating material. The central portion of each diaphragm is equipped with suitable weights 46 made in sections and bolted to the diaphragm. The weights are either made of electrical insulating material or are insulated from each other by insulation 47.

A wire 48 leads from one end of one of the bolts to one pole of the accompanying motor 31 and a wire 50 connects the opposite end of the other bolt to the other pole of the motor. The wires 48 and 50 are insulated from the walls of the housing 43. Resilient contacts 51 and 52 electrically connected to a wire 56 which leads from one pole of a source 49 of direct current electrical energy, (Fig. 3), pass through the housing 43 and are each adapted to contact an opposite end of the two bolts when the diaphragm is moved to that respective end of its throw.

Similarly, resilient contacts 53 and 54 are connected by a wire 55 to the opposite pole of the source 49. The contacts 53 and 54 are so located as to contact the ends of the bolts respectively opposite to the ends contacted by 51 and 52. The contacts 51, 52, 53 and 54 are insulated from the housing 43.

The contacts 51, 52, 53 and 54 together with the bolts of the diaphragm form substantially a pole-changer for reversing the direction of the motors 31 which are preferably to be operated upon a direct current circuit. If alternating current is to be used a slight modification of the switch arrangement of the diaphragms would necessarily be made. This change, however, is well within the common knowledge of electrical engineers, and it is thought an illustration and description of the same would be superfluous herein.

Each of the motors is equipped with a gear box 57 within which are suitable reduction gears, not shown, to reduce the speed at which the spiral gears 30 are driven. This speed is preferably very slow, perhaps ten or fifteen revolutions per minute.

Operation

As a starting point for a description of the operation of the apparatus described hereinabove, consider first that all of the blades 33 of the switches 34 are in contact with their respective terminals 35. The solenoid 23 is therefore being energized and the valve 19 is therefore open and is admitting water to the tank 16. The valve 20 is, of course, in a closed position.

Consider also that the diaphragms 45 are all in an intermediate position and that none of the motors are being energized. This condition could rarely be true, but could exist if the pressure above each of the diaphragms was less than the pressure below them an amount exactly equal to the combined weight of the weights 45 of each diaphragm. It would also be necessary that no obstruction was present in any of the tuyères 7 and that the dampers 14 were sufficiently closed to exactly counteract the differential in pressure above and below the orifice plate 12. For the sake of illustration, we will consider that the weights of each diaphragm weigh three pounds for each square inch of the diaphragm surface, and that there is an eighty-one inch head of water in the tank 16 above the bottom of the pipe 25. Since approximately twenty-seven inches of water exerts a downward pressure of substantially one pound to the square inch, we would have substantially three pounds per square inch less pressure in the circular pipe 27, and consequently in the upper portion of each diaphragm housing 43. With this condition existing the diaphragms would all be in an intermediate position and the motors 31 would all be idle.

With conditions as above described, as the water continues to rise in the tank the pressure in the circular pipe 27 and in the upper portions of the diaphragm chambers decreases. The diaphragms are therefore moved upwardly and contacts are therefore made to start the motors in a direction to open the dampers. When any one of the dampers becomes entirely open the blade 33 is forced out of contact with the terminal 35 and the solenoid 23 is de-energized and the valve 19 is permitted to close. Substantially simultaneously with the closing of the valve 19 contact is made by the blade 41 and terminal 38 and the outlet valve 20 is opened to permit escape of water from the tank. As the water level falls the pressure in the upper chambers of the diaphragm housings is increased and reaches a point at which the diaphragms are forced downwardly to make contact with the contacts 52 and 53 which closes the circuit to reverse the direction of the motors. As soon as all of the segment gears 29 move out of contact with their blades 33, the solenoid 24 is de-energized, the valve 20 is closed, the solenoid 23 is energized, and the valve 19 is opened to admit more water to the tank.

So long as there is no obstruction at any of the tuyères, the water in the tank will hover at a depth directly governed by the total volume of wind being forced into the furnace, the dampers will hover at a near open position, and the motors will run continuously in first one and then the other direction, alternately opening and closing the valves 19 and 20.

However, should a complete and sudden obstruction occur at one of the tuyères, the pressure below the orifice plate 12 in that particular leg-pipe would be increased to a point equal to that above the orifice plate, and since whatever water was present at that time in the tank would be act-

ing to reduce pressure upon the top of all diaphragms, the diaphragm of the obstructed tuyère would be instantly moved upwardly and its particular motor would be started in a direction to open its damper. When this particular damper is completely opened the valve 19 will be closed and the valve 20 will simultaneously be opened. As the water lowers in the tank, the pressure upon the top of all diaphragms increases. Due to the orifice plates in the leg-pipes of the unobstructed tuyères, their diaphragms will be held in a downward position which will cause their motors all to run in a direction which is closing their dampers. The partial closing of the other dampers will, of course, increase the air feed to the obstructed tuyère. The air pressure delivered to the obstructed tuyère will continue to increase and the air delivered to the other tuyères will continue to decrease until the back pressure caused by the partially closed dampers of the unobstructed tuyères equals that caused by the obstruction in the obstructed tuyère, at which time the obstructed tuyère will receive the same volume of air as the others.

When the point is reached at which the back pressures are equalized as above described, the diaphragms of the unobstructed tuyères will be forced upwardly and their motors reversed, however, they will again be reversed before the pressures have changed materially and their dampers will consequently hover adjacent their positions at the time at which the pressures became equalized.

When this condition has existed for a sufficient period of time to burn out the obstruction in the obstructed tuyère, the pressure below the diaphragm of that tuyère will become less than that above it. Consequently the diaphragm will move downwardly to reverse the motor and the blade 33 will again contact the terminal 35. The valve 20 will then become closed and, as soon as the pressures re-arrange themselves throughout all of the diaphragms so as to close all of the switches in the circuit of the solenoid 23, water will again be introduced into the tank.

It will be understood that with my automatic control installed, no great obstruction is permitted to accumulate at any tuyère, and that only a short period of forced draft upon an obstructed tuyère will be necessary to remove such an obstruction. It will also be seen that the automatic control will ordinarily prevent the accumulation of any obstruction.

As hereinabove stated the wiring diagram shown and described is only typical and illustrative, and may be carried out with any desired number of circuits. Any desired wiring arrangement which will accomplish the opening of the obstructed tuyère and the partial closing of all other tuyères may be used.

With my apparatus in use a reduction in the required blast pressure carried by the bustle pipe is permitted because the dampers are automatically operated. This permits the use of tuyères having greater air exhaust openings. The only attempt heretofore made toward proper air blast distribution has been in the reduction in the size of the air blast exhaust openings.

In common blast furnace practice of today, the drop of pressure at the tuyère will be two pounds or more, while with our apparatus the drop in pressure should not be over one-tenth of a pound. It will be readily seen that the pressure will be reduced at least ten percent, which means a

saving of at least ten percent of the present steam costs.

Other means than those shown and described herein may be found practical for providing the desired automatic manipulation of pressure between the air supply main and the diaphragms 45.

Obviously, the invention is susceptible of embodiment in forms other than that which is illustrated in the accompanying drawings and described herein, and applicable for uses and purposes other than as detailed, and I therefore consider as my own all such modifications and adaptations and other uses of the form of the device herein described as fairly fall within the scope of my invention.

Having thus described my invention, what is claimed and desired to be secured by Letters Patent, is:

1. In apparatus of the class described, the combination with the usual bustle-pipe, leg pipes and tuyères of a blast furnace, of a perforated plate member carried by each leg-pipe for reducing a portion of its bore, a valve carried by each leg-pipe at the outlet side of said member, means for actuating said valves independently, and automatic means to maintain substantially an equal air pressure within all leg-pipes at said reducing members.

2. Organization as described in claim 1, and means for automatically adjusting the actuating means to operate upon different amounts of pressure.

3. In apparatus of the class described, the combination with the usual leg-pipes and tuyères for introducing air-blast into a blast furnace, of a valve for opening and closing each leg-pipe, and automatic means for partially closing the valves of all other leg-pipes and opening the valve of one leg-pipe when the differential in pressures is greater at the tuyère of the one leg-pipe than at the tuyères of the others, said means including: an element in each leg-pipe reducing the bore thereof, a pressure chamber for each leg-pipe, a slightly movable diaphragm in each chamber separating it into two compartments, an automatic manipulated air pressure conveyor leading from the air supply of each leg-pipe from opposite sides of its element to said chamber and into opposite compartments thereof, and electrical connections controlled by the movement of said diaphragms for actuating one of the valves to a partially open position and simultaneously actuating all of the other valves to partially closed positions.

4. Organization as described in claim 3, and automatic means for automatically adjusting the differential of pressure in each compartment of each chamber upon which the diaphragms will operate.

5. Organization as described in claim 3, and means for automatically regulating the differential in pressure permitted before the valves are actuated.

6. Organization as described in claim 3, and means for automatically regulating the differential permitted before a diaphragm and the valves become actuated, said means including: an automatically regulated pressure conveyor connected in common with all similar compartments of all of the chambers, said compartments being the ones which are in turn connected to the various leg-pipes at the exhaust sides of said reducing elements, an automatically regulated air container in communication with all of the compartments which are in communication with the leg-

pipes at the exhaust sides of the reducing elements, and means for automatically increasing and decreasing the pressure in said container.

7. The method of removing obstructions from air blast furnaces which consists of: normally maintaining and distributing from a common supply an equal volume distribution of air blast to all air inlets of the furnace regardless of the blast pressure; increasing the amount of air delivered to an obstructed inlet when the obstruction occurs; and, simultaneously decreasing air delivery to the other inlets, until an equal amount of air is being delivered to all inlets, including the obstructed one.

8. The method of removing obstructions from air blast furnaces which consists of: normally maintaining and distributing from a common supply an equal volume distribution of air blast to all air inlets of the furnace; increasing the amount of air delivered to an obstructed inlet when the obstruction occurs; simultaneously decreasing air delivery to the other inlets; and again maintaining equal distribution of the air to all of the inlets until the resulting increased pressure has removed the obstruction.

9. The method of removing obstructions from air inlets of air blast furnaces which consists of delivering air from a common supply to all of said inlets at varying volumes directly proportionate to internal pressures within the furnace at the delivery ends of the various inlets.

10. The method of operating a blast furnace which comprises delivering a substantially constant quantity of air thereto under a necessarily varying pressure and temperature, distributing said air in equal volume to each of the various air inlets of the furnace, and automatically maintaining this equal volume distribution regardless of the varying passage areas of the individual inlets, thus assuring an equal volume of air passing through the delivery ends of said inlets into said furnace at all times regardless of the pressure, temperature, and volume of the total air supply.

11. The method of equalizing the volume delivery of air from the delivery ends of the air inlets of a blast furnace which comprises automatically varying the individual air passage areas between said delivery ends and the source of air supply inversely in proportion to the change in the individual passage areas of the respective individual delivery ends of said inlets.

12. An automatic air blast distributor for blast furnaces comprising: means for varying the air passage areas into each tuyère of the furnace, and automatic pressure controlled means for regulating said first mentioned means, responsive to a change in passage area through any one of the said tuyères, and adapted to equalize passage areas through all the tuyères when one is obstructed.

13. The method of removing obstructions from tuyères of air blast furnaces which consists of increasing the blast delivery passage area to the obstructed tuyère, decreasing the blast delivery passage area to all unobstructed tuyères to such an extent that the blast issuing from each of their mouths is substantially equal to the blast issuing from the mouth of the obstructed tuyère, while maintaining the normal air blast delivery into all delivery passages, thus greatly increasing the blast pressure at the point of obstruction; maintaining this condition until the obstruction is burned out; then restoring normal delivery passage areas to all tuyères.

14. The method of removing obstructions from the tuyères of air blast furnaces which consists of reducing the feed passage area to each unobstructed tuyère to an area equal to the passage area through the obstructed tuyère at the point of obstruction, and at the same time increasing the feed passage area to the obstructed tuyère and maintaining normal blast delivery to the feed passages of all tuyères, thus greatly increasing the blast pressure at the point of obstruction in the obstructed tuyère.

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