Aug. 20, 1968 A. AUGUSTINE **3,397,874**

SOAKING PIT AND METHOD OF OPERATING THE SAME

Filed Oct. 28, 1966 3 Sheets-Sheet 1

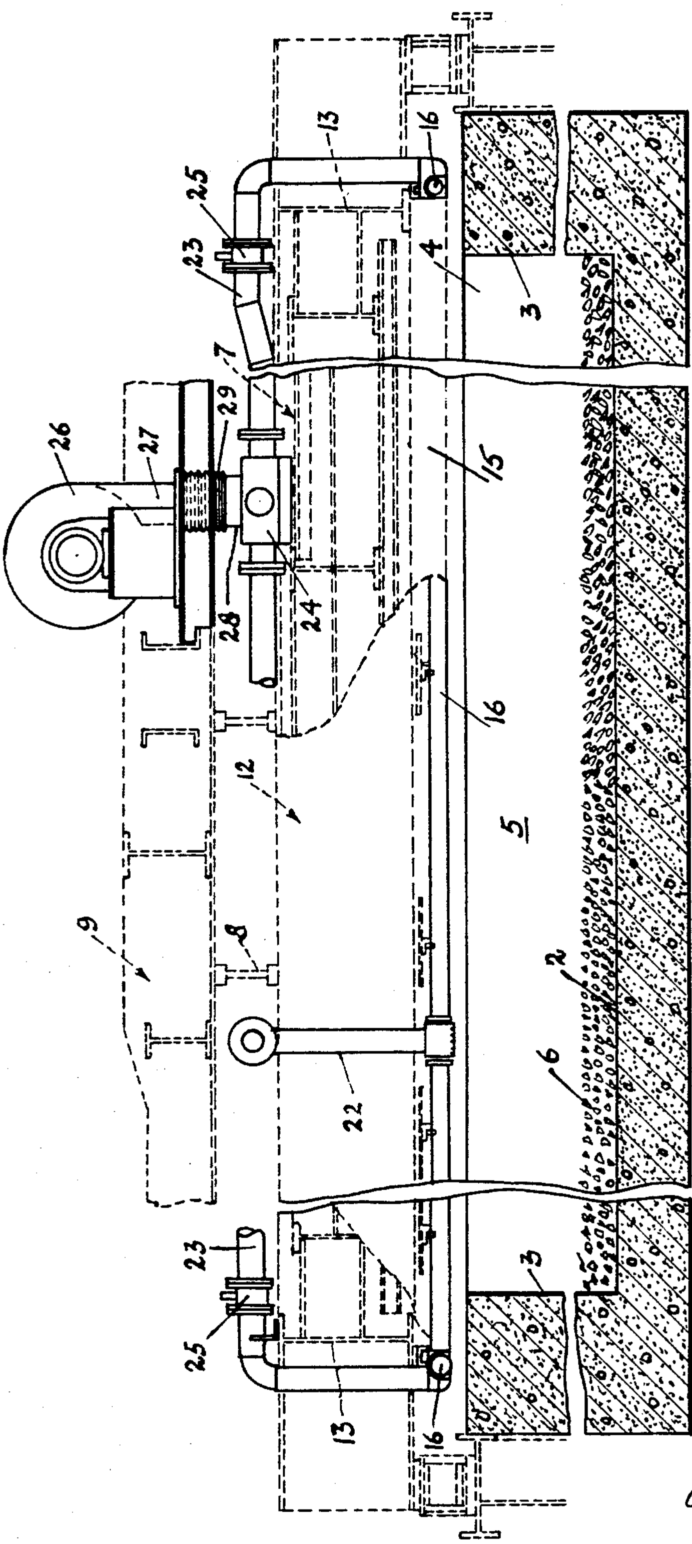

Fig. 1.

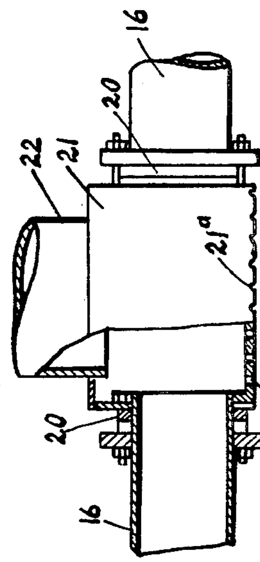

Fig. 5.

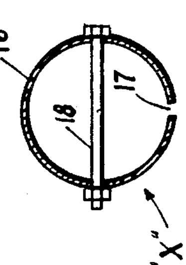

Fig. 7.

INVENTOR.
ALFRED AUGUSTINE.

BY
Christy, Parmelee & Strickland
ATTORNEYS.

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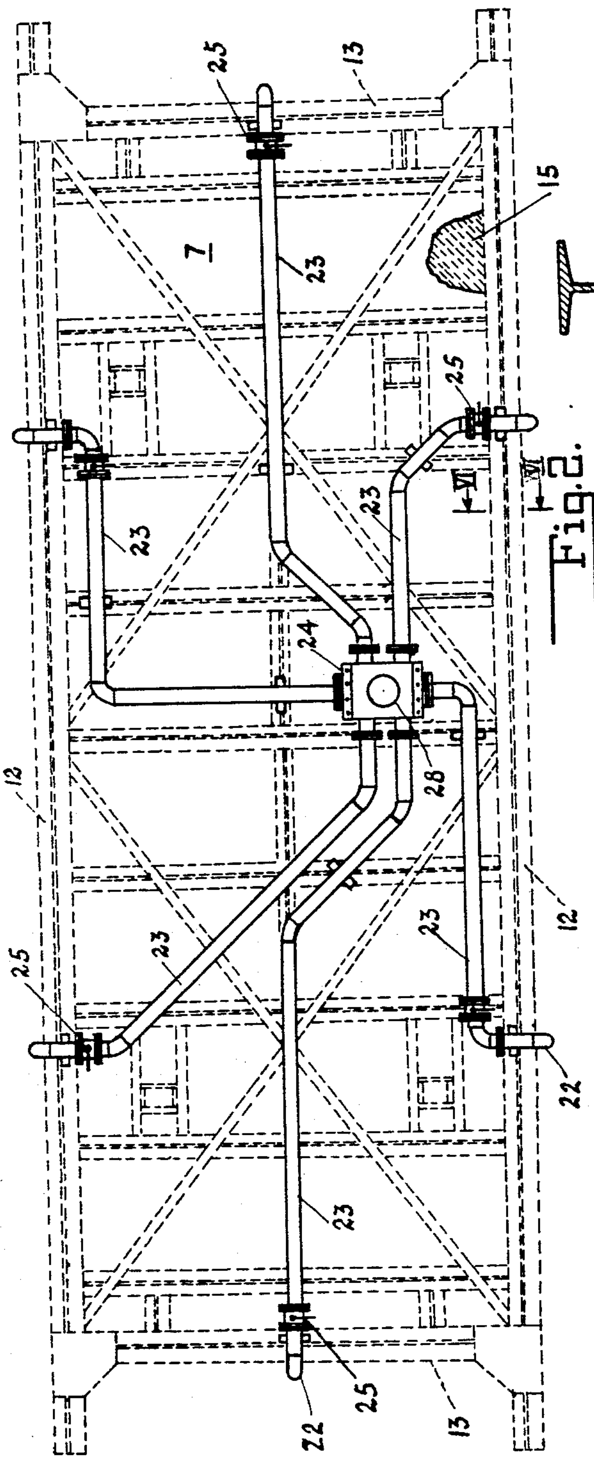

Fig. 2.

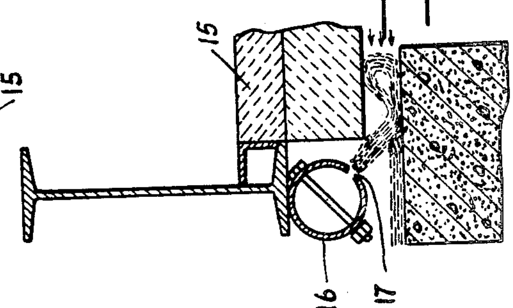

Fig. 6.

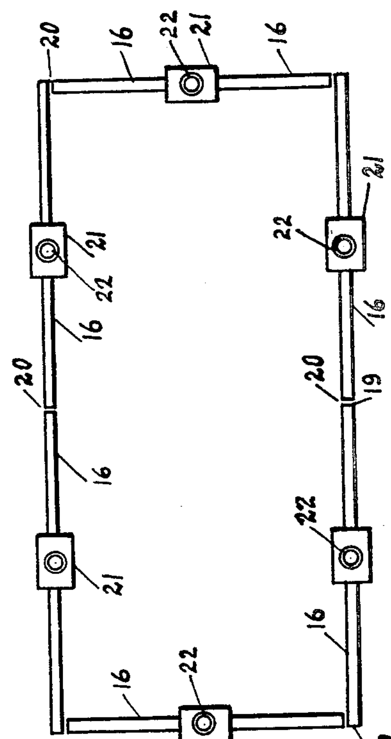

Fig. 4.

INVENTOR.
ALFRED AUGUSTINE.

BY
Christy, Parmelee & Strickland
ATTORNEYS.

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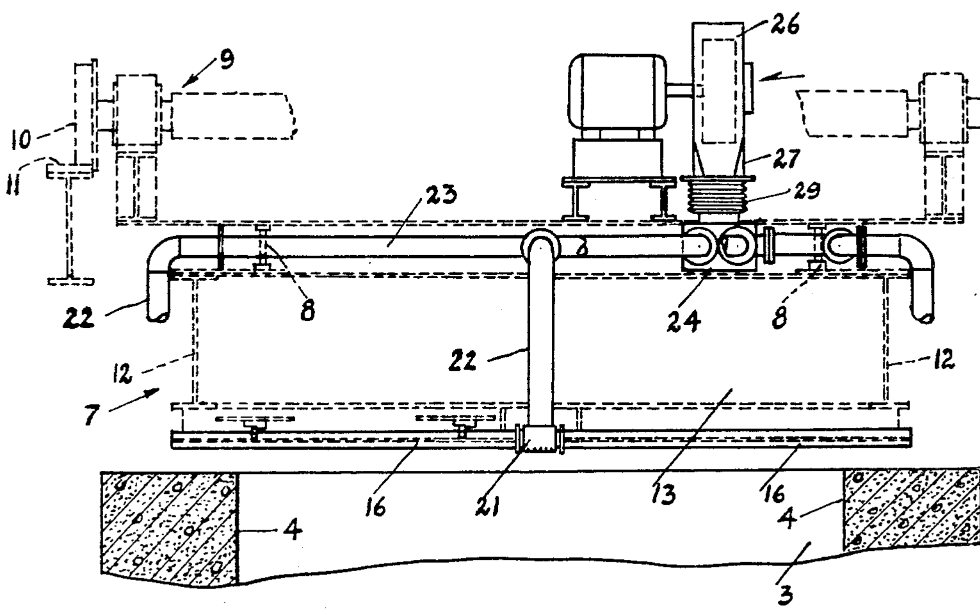

Fig. 3.

INVENTOR.
ALFRED AUGUSTINE.
BY
Christy, Parmelee & Strickland
ATTORNEYS.

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SOAKING PIT AND METHOD OF OPERATING THE SAME

Alfred Augustine, Pittsburgh, Pa., assignor to Loftus Engineering Corporation, Pittsburgh, Pa., a corporation of Maryland

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ABSTRACT OF THE DISCLOSURE

A soaking pit having a cover is provided that is movable horizontally from a position over the pit to a position clear of the pit without the necessity of also raising and lowering the cover as is the case where conventional sand seals are employed. When the cover is over the pit in operating position there is an open gap between the cover and top wall of the furnace around the entire periphery of the furnace. An air duct system extending around the gap projects a high velocity curtain of air across the gap in such manner as to form a pressure barrier against the escape through the gap of furnace gases but the air flows outwardly around the outer periphery of the gap, and not into the furnace. The invention not only eliminates the usual sand seals and the need for raising or lowering the cover, but provides a new method of operating a soaking pit since higher pressures can be maintained under the cover than with sand seals, making it possible to maintain a positive pressure inside the pit from the cover to the level of the pit bottom.

This invention relates to industrial furnaces of the type known as soaking pits, in which metal ingots are heated to rolling temperature, and to the method of operating such furnaces.

Soaking pits have a bottom, and enclosing walls, and they are provided with a cover which is movable from a position over the furnace to a position clear of the top to enable ingots to be placed in the furnace or removed therefrom. As now constructed the cover is suspended from a carriage by which it is traversed into and out of position over the furnace, and the suspension is of a type which enables the cover to be lowered after it is brought into position over the furnace and lifted clear of the furnace when it is to be moved from over the furnace. The top of the furnace is provided about its periphery with a trough to retain sand and the cover has sealing plates depending from its periphery that penetrate the sand in the trough to form a seal between the cover and the top of the furnace when the cover is in closed position. The raising of the cover before moving the carriage is made necessary so that the sealing plates will first be lifted clear of the sand seal and furnace walls. Whether the furnace is completely opened or only partially opened, this lifting of the cover is necessary.

The burner arrangements for these furnaces vary with the shape of the pit. These furnaces are usually rectangular and in recent practice have one-way firing with a fuel burner or burners firing horizontally through one end wall above the ingot charge. Burned gas outlet ports are located below the burner in the same end wall. In some cases they have two-way firing where there are burners and burned gas outlet ports below the burners in both end walls. In any case, because the ingots are charged into and removed vertically from the top, the outlet for burned gases is not through the cover.

Pits vary in depth, some being considerably deeper than others. The maximum pressure in the furnace is always at the top, because of the hottest gases rising, and the amount of pressure above atmospheric pressure

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is limited by the sand seal to a fraction of an inch of water, something of the order of .06 inch to about .09 inch at the seal level. Since the highest pressure is at the top, immediately under the cover, the pressure decreases downwardly and there comes a level between the top and bottom where the pressure is zero, that is, equal to atmospheric pressure, and below this level the pressure is negative relative to the atmosphere outside the furnace. Soaking pit gases at 2400° F. develops a buoyancy of .012 inch water per foot of height. Then the zero level in a pit fifteen feet in depth, for example, is about 7.5 feet below the cover when the pressure at the level of the top is of the order of .09 inch of water. At a pressure of .18 inch of water top level pressure, the zero pressure level is fifteen feet below the cover and the entire furnace would be at positive pressure. The same conditions may be figured of course for other depths. It will therefore be seen that by increasing the pressure at the top of the furnace, a point may be reached where the entire interior of the furnace is at atmospheric pressure or above. However, if the usual soaking pit furnace which usually range between 10 and 15 feet in depth were so operated, the sand seal would be ineffective, there would be a hazardous condition of "sting-outs," and the sealing plates would require replacement much more frequently than is now the case.

The importance of maintaining the point of zero pressure at the bottom, or having the entire interior of the furnace at positive pressure relatively to the surrounding atmosphere is that when the pressure inside the furnace at any level is negative, air seeking to relieve the partial vacuum is drawn into the furnace through its refractory walls or other source of leakage, and this air, becoming heated, oxidizes the ingots, increasing scale formation.

A further phenomenon of these furnaces, particularly when operating with high velocity burners, is the pulsating character of the flame. Recording devices that register pit furnace pressure fluctuate rapidly, tracing a continuous sinuous path a half inch or more in width. This reflects a condition where the automatic furnace pressure control damper must continuously hunt to maintain even pressure conditions in the furnace.

It may be noted that the maintenance of the sand seals, by reason of warpage and deterioration of the sealing plates on the cover, constitutes a cost of several thousand dollars a year where there is the usual battery of several pits, and this expense does not include down time for the making of repairs.

The present invention has for its principal object to provide a seal for soaking pit covers and a method of operation which will enable higher pressures to be maintained in the pit without the escape of flames from under the cover or the inflow of air into the furnace, and which will substantially reduce the amplitude of furnace pressure pulsations, providing improved stability of the furnace pressure control. A further object is to eliminate sand seals and sealing plates, and in so doing eliminate the need for raising and lowering the cover, thereby also substantially reducing the cost of the carriage and cover arrangement and reducing the time cycle for opening or closing the furnace.

A further object is to provide a seal which may be applied to existing pits as well as to new construction and will reduce the cost of seal maintenance. Moreover it may be adjusted to meet the irregularities in the covers or wall conditions of different furnaces due to camber or sag in the covers or erosion of refractory at the top of the furnace.

These and other objects and advantages are secured by my invention wherein the cover is maintained at all times at a substantially fixed level above the top surface of the furnace wall, this surface being commonly referred to as the curb or coping. The usual sand trough around the curb and seal plates on the cover are omitted. Provision is made for maintaining a curtain of high velocity air across the gap between the cover and the furnace curb. The kinetic energy of the air being converted to pressure creates a barrier in the gap between the air curtain and inner periphery of the gap which is balanced against the internal pressure under the cover so that the air prevents the escape of furnace gases, but the air itself flows outwardly away from the furnace at a moderate temperature, even though the interior of the furnace is heated to incandescence. The air curtain is generated by a duct system around the periphery of the furnace or cover, preferably the cover, to which air under pressure is supplied. This duct system is comprised principally of longitudinally-slit pipe sections with means for adjusting the width of the air discharge slit in each section, and each section is desirably independently rotatable about its axis to adjust the angle of discharge of air therefrom. This is made possible by having the ends of each pipe section received in connectors or plenums through which air under pressure is introduced into the duct system at intervals therearound.

The invention may be more fully understood by reference to the accompanying drawings illustrating a present preferred embodiment of the invention, and in which:

FIG. 1 is a side elevation of a soaking pit, cover and cover carriage wherein the soaking pit is shown in longitudinal section and the cover is shown in side elevation, portions of the pit and cover being broken away to better illustrate the invention;

FIG. 2 is a top plan view of the cover and air supply system detached from the carriage;

FIG. 3 is an end view of FIG. 1 with only a portion of the carriage being illustrated, the top only of the furnace walls being shown in section;

FIG. 4 is a schematic view showing one arrangement of the air duct system removed from the cover;

FIG. 5 is an enlarged detail of the connection between one of the air supply ducts and the duct system around the cover, the view being partly in section and partly in elevation;

FIG. 6 is an enlarged section through one of the slit pipes of the duct system with the outline of the top of the furnace wall and the adjacent part of the cover, the section being in the plane of line VI—VI of FIG. 2; and

FIG. 7 is a detail view showing an end view of one of the slit pipes.

In FIGS. 1 and 3 of the drawings there is illustrated more or less schematically a soaking pit furnace of rectangular shape having a bottom **2**, end walls **3**, and side walls **4** which are formed prinicpally of refractory, and which enclose the furnace pit **5**. Generally there is a layer of loose refractory material **6** over the bottom of the furnace on which the ingots or similar objects to be heated are set. The end walls and side walls terminate in a substantially flat level surface, herein sometimes referred to as the coping or curb.

In the construction shown, the cover designated generally as **7** is suspended by links **8** from an overhead carriage **9** that has wheels **10** for movement along a track **11** at each side of the furnace. In some cases it may be desirable to eliminate the carriage and put the wheels and their driving gear directly on the cover, a modification made possible by this invention.

The construction of the carriage and its driving mechanism form no part of the present invention, but it may be explained that it is common in the art to provide remotely controlled motors on the carriage for traversing the cover endwise from a position over the furnace to a position at one end thereof with other motors on the carriage for lifting and lowering the cover for clearing or entering the sand seals. It will later be seen that this invention eliminates any need for this raising and lowering of the cover. Soaking pits of this type are charged by traversing the cover to an open position and introducing the ingots through the open top of the furnace, and in like manner the ingots, after being heated, are removed through the top after the cover has been removed.

The cover **7** itself comprises a rectangular steel framework that includes longitudinally-extending side beams **12** and cross beams **13** at each end. The steel framework, which may take various forms, supports a continuous refractory cover-forming body only fragmentarily indicated at **15** in FIGS. 2 and 6.

As shown in FIGS. 1 and 3, the cover, when it is in closed position, is over the open pit with the sides and ends of the covers projecting part way over the coping or rim of the furnace, and spaced above it an average distance under ideal conditions of about 1½ inches. In practice this distance may vary since the length of the pit is usually in excess of 20 feet, and of somewhat lesser width. Under these conditions the metal framework will be subject to expansion and contraction, and it is customary in the art to put a bow or camber in the beams **12** and to a less extent in the cross beams **13** so that when the cover is cold it bows upward to a slight extent, and as it elongates under increased temperature it may therefore straighten without sagging. By reason of this and by reason of erosion or spalling that may occur along the rim of the furnace this distance of 1½ inches does not remain ideally constant and may vary from point to point along the length and width of the furnace.

In the construction shown there is a duct system supported on the under side of the structural members **12** and **13** and recessed so that the duct is shielded by the cover from exposure to heat radiated from the interior of the furnace through the gap between the cover and furnace rim. This system is comprised principally of pipe sections **16** having a longitudinal slit **17** therealong. This is best shown in FIG. 6. At intervals along the length of each pipe section there are diametrically-extending bolts **18** with nuts at one end thereof. By tightening or loosening these nuts, the width of the slit **17** may be varied, the tightening of the nuts tending to close the slit, whereas if the nuts are loosened the pipe tends to spring back or may be forced back to its normal diameter. Wedges may be used in the slits **17** to gauge the degree of closing or opening. One end of each pipe section is closed as indicated at **19** in FIG. 4, while the other end is received in a gland portion **20** of a connector **21** which also constitutes a plenum chamber. In the particular arrangement shown in the drawings, there are two of these split pipe sections at each end of the cover extending horizontally from the connector **21** at the middle of the cover. At each side of the cover there are two of these connectors **21**, each with two pipe sections **16**, one of which extends in a direction opposite the other. At the mid point of the furnace the confronting closed ends of the tubes are practically in end-to-end contact. The connectors **21** may each have a series of small openings **21a** in closely-spaced relation arranged in a row along the bottom of the connector.

By adjusting the glands **20**, the individual sections of pipe may be rotated in the connector so as to adjust the position of the slot or slit **17** to direct air at the desired angle toward the furnace rim or coping. Each connector **21** has a down pipe **22** secured thereto, each down pipe forming the terminal portion of a feeder line **23** leading from a plenum chamber **24** that is positioned on the cover. There is a butterfly valve or other flow control valve **25** in each of these feeder pipes, these valves being here shown as being at the tops of the respective down pipes **22**.

It will thus be seen that each connector **21** supplies air to two split duct sections **16** and there is a separate feeder pipe leading from the plenum chamber **24** to each connector.

In the particular arrangement shown where the cover is suspended from the carriage, air is supplied to the plenum **24** by means of a motor-driven blower **26** supported on the carriage with its outlet **27** connected at the inlet **28** of the plenum **24** through a flexible duct **29** of the bellows type. Under ideal conditions where the curb or coping of the furnace is in good smooth condition, and where the cover maintains a substantially uniform spacing between the cover and the curb, it is desirable that the pipes **16** be set in the approximate position shown in FIG. 6 where the discharge of air through the slot **17** against the curb is directed downwardly and inwardly to substantially bisect a vertical line drawn from the outer edge of the cover to the curb. In the particular instance shown, this angle is approximately 30° off vertical so that the resulting curtain of air is not vertical, but projects inwardly under the cover. When the air encounters the curb, it appears that a substantial part at least is deflected upwardly and inwardly, its kinetic energy being transformed to pressure, thereby forming a barrier or dam in the gap between the inner and outer peripheries of the gap between the two confronting surfaces. The air then escapes to the outer periphery of the gap. This pattern of air flow is evidenced by a visible demarcation between refractory on the furnace rim being at a visibly glowing temperature along a line inwardly in the gap from the line where the air actually impinges on the rim at some point between the air curtain and the inner periphery of the gap. At any rate there is no "sting-out" of flame or hot gases where this condition prevails, and a piece of paper held in the stream of outflowing air at the edge of the curb is not charred by the air, although it may, after a period of several minutes, become charred primarily from the radiation of heat from the interior of the furnace. Likewise one's hand may be brought close to this position without serious discomfort.

As a specific example, the arrangement above described was applied to a pit having an overall depth of about 14 ft. on the bottom of which was placed a layer of granular magnesite about 15 in. in depth. The pit was of rectangular shape having an interior length of 27 ft. and a width of 9 ft. The cover from the center line of the pipe **16** at one end to the center line of the pipe **16** at the other end was approximately 29 ft. 2 in. and the width of the cover from the center line of pipe **16** at one side to the center line of the corresponding pipe at the other side was 11 ft. 2 in. The perimeter of the cover overhangs the perimeter of the rim, but not to the full outer periphery of the furnace walls which were of such thickness that they extended outwardly beyond the center lines of the pipes or ducts **16** at both the sides and ends, in the relationship shown in FIG. 6. In this installation the overall length of the combined pipes **16** and the connectors representing the perimeter of the cover at the center line of the pipes **16** was about 80 ft. 8 in.

The pipes constituting the duct system around the periphery of the cover were 3 in. inside diameter, and the maximum opening of the slot was ⅛ in. The inside diameter of the feeder and down pipes was 4 in. The openings **21***a* in the connectors were about ⅛ in. spaced about one diameter apart. The pipes **16** at the corners practically abut so that there is no break in the air curtain.

The blower was driven by a 7½ horsepower motor operating at a speed of 3600 r.p.m. and was rated to produce 2300 c.f.m. at 10 oz. pressure in the plenum **24**, and in this example was so operated. The valves **25** between the feeders and the down legs **22** were adjusted to provide a pressure in each of 3.5 oz. and an internal static pressure was maintained in the pipes **16** of 2.3 oz. The furnace was operated with a charge of ingots in the usual manner. In the particular instance referred to, the curb had been spalled in some places and the cover, upon heating, developed uneven spacing between the cover and the curb, but in general the distance of the gap separating the cover and furnace curb was about 1½ in. In no case was the space more than 3 in. With an initial furnace pressure under the cover at the seal of about .09 in. of water, there was initially some sting-out. Where there was a bad condition of spalling, the pipes **16** were rotated slightly to increase the angle of discharge of air further in toward the furnace pit, or the nuts on the bolts **18** of certain sections were adjusted to restrict the slit from ⅛ in. to $\frac{1}{16}$ in. By making these adjustments or combinations of them, all sting-out was eliminated. The use of slits **17** is preferable to the use of closely-spaced small holes, similar to holes **21***a* in the connectors, which would be used in pipes **16**, but small holes do not provide the ease of adjustment.

After a period of operation the pressure inside the furnace was increased so that the pressure at the seal inside the furnace was .15 in. of water and there was still no evidence of sting-out. This pressure at the seal of .15 in. of water was more than adequate to produce a positive pressure in the pit to the full depth of the loose material at the bottom of the pit.

It was observed that when the furnace was in operation there was a straight line of demarcation apparent on the coping or curb of the furnace a short distance inwardly from where the air impinged, the refractory being red inside the line and black outside the line, indicating that the air current was uniformly effective, and that the hot gases were not lapping out quite to the point of impingement of the high velocity air stream against the refractory.

The shape and dimensions of the furnace above described is typical of most soaking pit furnaces. Generally they are rectangular and generally they range between 10 and 15 ft. in depth so that the conditions of operation in the above example would be applicable to most soaking pits. For soaking pits of greater depth than 15 ft., one skilled in the art may be required to make some changes. A deep pit, for example, may have greater dimensions in which greater fan capacity would be required to maintain the desired velocity of the air curtain, but on the basis of the information herein given, one skilled in the art would have no difficultay in adapting such a furnace for the practice of the invention.

While I am aware that so-called air curtains have been used in various environments such as doorways through which passage of persons or objects occurs with considerable frequency, such installations commonly operate in the plane of the opening and are not angled inwardly as in the present invention, and ordinarily atmospheric pressure prevails both inside and outside the doorway. So far as I am aware, it has heretofore never been considered that such a curtain would be effective to enable the pressure inside a soaking pit to be increased above the normal pressure and prevent sting-outs at the higher pressures. In the examples above referred to, it was also observed that whereas the burner pulsated with rapid explosions such as to cause the pressure-recording indicator to oscillate rapidly over a band wider than ½ in. with a conventional sand seal, the same recorder, when the air curtain was substituted, reduced the magnitude of the oscillations to perhaps around $\frac{1}{16}$ in. and the furnace pressure control was noted to be much smoother and quieter, and the stack damper, instead of continuously hunting, stayed much more uniformly at one position. Apparently the barrier generated by the air curtain provided a resilience or elasticity which the sealing plates and sand seal could not provide.

It will be seen that with this invention the kinetic energy of the air is utilized to oppose the escape of gases from the interior of the furnace, and the nice balance of pressures that would be required with a static air seal is not necessary. The cost of continuously operating the blower is less than the cost of maintaining the seal plates and sand seal of a conventional cover in operating condition, and is much more successful in eliminating sting-outs. The scale on the ingots being heated appeared to be of less thickness than with the conventional sand seal and to test this out a companion soaking pit of identical construction but having the conventional sand seal was operated along side of the one having the present invention experimentally applied thereto. This is perhaps due to the more effective prevention of escaping combustion gases with the seal of the present invention and the reduced influx of air at levels below the level of zero or atmospheric pressure explained above.

The invention simplifies the construction of the carriage and cover because of the elimination of expensive hoisting mechanism for raising and lowering the cover which in itself weights several tons, since the cover can be traversed without any vertical movement being necessary. Time lost in repeated raising and lowering of the cover is eliminated. Closer integration between the carriage and cover becomes possible to a point where they may be combined into a unitary structure in new furnace construction.

While I have shown and described a preferred embodiment of my invention and a method of operating the same, it will be understood that various changes and modifications may be made. In some cases it may even be desirable to project the air stream from the slitted duct sections upwardly from ducts located in the top of the furnace wall with air impinging against the cover. Also, the soaking pit herein described is of a type commonly used for heating steel, but the invention is applicable to soaking pits as used in other industries, as for example, aluminum, when lower temperature and different firing methods are employed.

These and other changes and modifications may be made within the contemplation of my invention and under the scope of the following claims.

I claim:

1. A soaking pit comprising a pit furnace having a bottom and surrounding walls forming an enclosure in which objects are placed to be heated,

a cover structure coextensive with the area of the enclosure and projecting over the rim of the furnace walls when it is in closed position for confining combustion gases therebeneath,

means for supporting the cover for horizontal travel from a position over the furnace to a position clear of the top of the furnace,

said cover-supporting means being arranged to hold the cover in closed spaced relation to the rim when the cover is in furnace-closing position whereby there is a continuous open gap under the cover above the rim of the furnace, and

means arranged for projecting a continuous curtain of air across said gap around the furnace between the rim and cover in such manner as to form a pressure barrier in the gap between the air curtain and the inner periphery of the gap to prevent the escape of hot gases between the cover and the rim of the furnace but with the air escaping only at the outer periphery of the gap.

2. A soaking pit as defined in claim **1** in which said last-named means is arranged so that the air flow forming the curtain is angled inwardly toward the furnace pit from said means for projecting air across the gap, whereby the kinetic energy of the air is transformed into pressure to form a barrier inwardly of the angle of incidence of the air against the surface toward which it is directed.

3. A soaking pit as defined in claim **1** in which said last-named means comprises a peripherally-extending duct system comprising sections of longitudinally-slitted pipes,

connectors for delivering air to said pipes, feeder pipes leading to the connectors,

means for supplying air under pressure to the feeder pipes, and

means for regulating the air flow through each feeder pipe.

4. A soaking pit as defined in claim **3** wherein means is provided for varying the width of the slits in said slitted pipes.

5. A soaking pit as defined in claim **3** in which said slitted pipes are rotatably adjustable about their respective longitudinal axes.

6. A soaking pit as defined in claim **3** in which said duct system, connectors, feeder pipes and means for supplying air to the feeder pipes is mounted on said cover.

7. A soaking pit as defined in claim **3** in which the connectors are perforated to project an air curtain therefrom throughout their lengths.

8. In the combination with a soaking pit having an open top furnace with a bottom and vertical walls enclosing a pit, and a cover that is supported for movement from a position over the furnace to a position clear of the open top of the furnace with the cover at a level spaced from the top of the furnace, there being spaced confronting surfaces on the cover and top of the furnace walls when the cover is over the furnace, with a gap around the furnace ranging between about 1½ inches and 3 inches between the confronting surfaces, the invention comprising:

a duct system arranged to project a curtain of air across the gap between the top of the furnace structure and the cover inwardly at an angle to a direction normal to the confronting surfaces entirely into the gap about the perimeter of the walls and cover when the cover is positioned over the furnace,

said means comprising a series of separate pipe sections, each section having a longitudinal slit extending therealong,

means for supplying air under pressure to said pipe sections, and

means for regulating the pressure in some of said pipe sections relatively to the others.

9. The method of operating a soaking pit having a bottom, side walls and an open top and a cover removably positioned over the top with the periphery of the cover overhanging the top of the furnace walls but spaced between about 1½ inches and about 3 inches from the top of the side walls of the furnace leaving an open gap around the furnace between the top of the furnace walls and the cover, the steps of operating the furnace with a pressure above atmospheric pressure under the cover at the level of the gap, and confining the hot gases from escaping through the gap by maintaining a thin curtain of moving air across said gap around the entire perimeter of the gap in such manner as to form a pressure barrier in the gap between the air curtain and the inner periphery of the gap with the air flowing to the outer periphery of the gap.

10. The method defined in claim **9** wherein there is a decreasing pressure gradient from the cover downwardly and the pressure under the cover is maintained sufficiently high that the pressure inside the furnace is above atmospheric pressure to a level close to the bottom of the furnace.

11. The method defined in claim **9** wherein there is a decreasing pressure gradient from the cover downwardly and the pressure under the cover is maintained sufficiently high that the level where the pressure inside the furnace is at least atmospheric pressure at the lowest point in the furnace.

12. The method of operating a soaking pit as defined in claim **9** in which the pressure in the furnace at the level of the gap is in a range between about .05 and 0.15 inch of water.

13. In a furnace having a bottom and vertical refractory walls enclosing a pit with the tops of the vertical walls providing a rim surface around the entire periphery of the furnace, the furnace having a refractory cover for the pit supported for movement into and out of operative position over the pit, the cover having a peripheral surface which extends over the rim surface of the side walls in spaced confronting relation thereto when the cover is in operative position providing a peripheral gap between said surface, the invention comprising:

(a) a duct means extending around the furnace arranged to discharge an effectively continuous curtain of air therefrom across the gap from one confronting surface toward the other at a velocity sufficient to impinge against the opposite confronting surface and at an inwardly-directed angle such that it impinges said confronting surface between the inner and outer boundaries of the gap, whereby the kinetic energy of the air is converted to pressure to block the escape of furnace gases while the air escapes outwardly from the gap,

(b) and means for supplying a controlled flow of air to said duct means.

14. The invention defined in claim **13** wherein said duct means is recessed from direct exposure to heat radiated through the gap from the interior of the furnace.

15. A furnace as defined in claim **13** wherein said duct

is located on the cover around the exterior thereof and has air discharge openings therein arranged to project a curtain of air across the gap at the outer periphery of the gap but angled inwardly.

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JOHN J. CAMBY, *Acting Primary Examiner.*