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Wilt, Jr.

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[54] **METHOD FOR SEALING AND COOLING THE COMPONENT PARTS ASSOCIATED WITH THE MOVING AND STATIONARY MEMBERS OF WALKING BEAM FURNACES**

[75] Inventor: **Charles R. Wilt, Jr.,** Pittsburgh, Pa.

[73] Assignee: **Salem Corporation,** Pittsburgh, Pa.

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[52] **U.S. Cl.** **432/4,** 432/22, 432/64, 432/243

[51] **Int. Cl.** **F27b 17/00**

[58] **Field of Search** ....263/6, 6 A, 52

[56] **References Cited**

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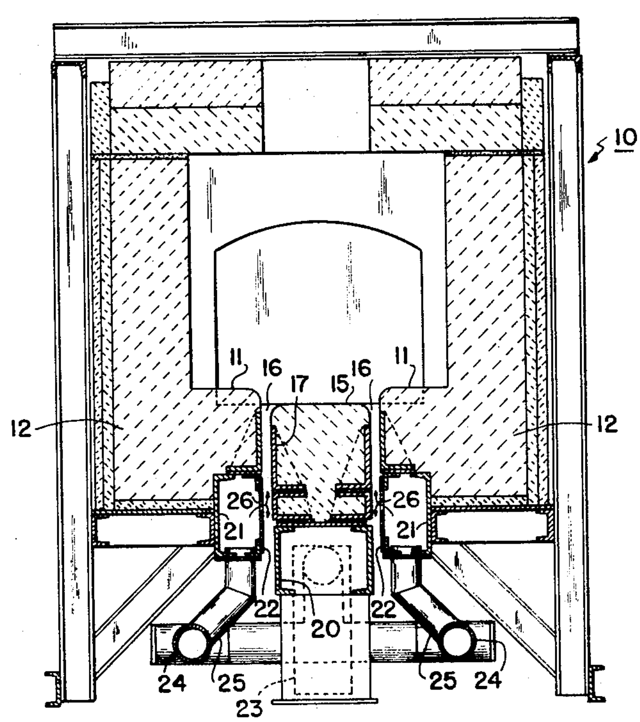
Primary Examiner—Charles J. Myhre

Attorney—Buell, Blenko & Ziesenheim

[57] **ABSTRACT**

A method for sealing and cooling the component slot members between the stationary hearth and movable beam or beams in walking beam furnaces by injecting air into the slot in such a manner that the air jets create a stagnation plane within the slot to maintain an equilibrium with the furnace pressure while impinging on the beam members and simultaneously cooling it.

4 Claims, 2 Drawing Figures



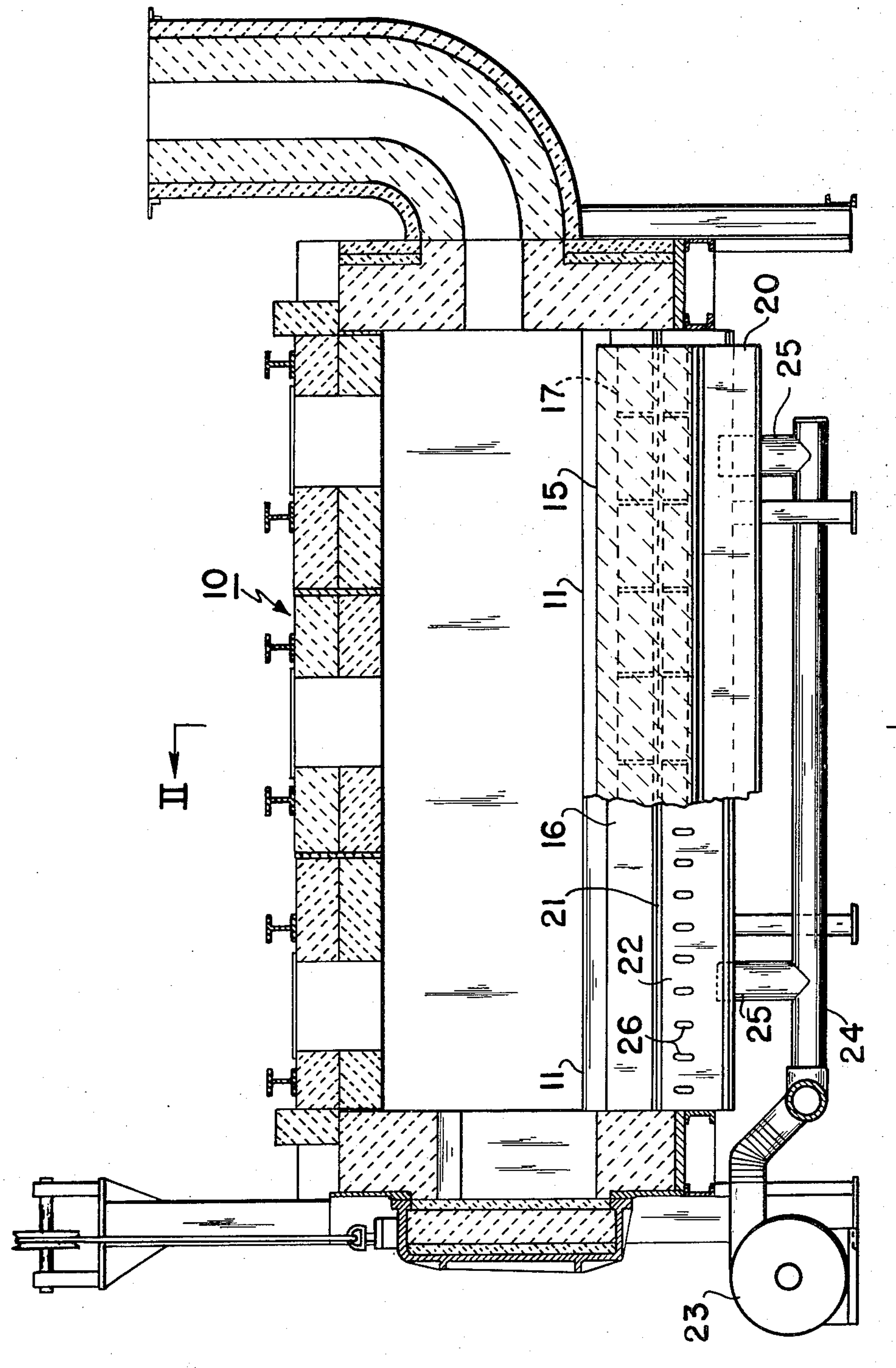


Fig. I

INVENTOR.
Charles R. Wilt, Jr.

BY
Buell, Blenko & Ziesenheim
HIS ATTORNEYS

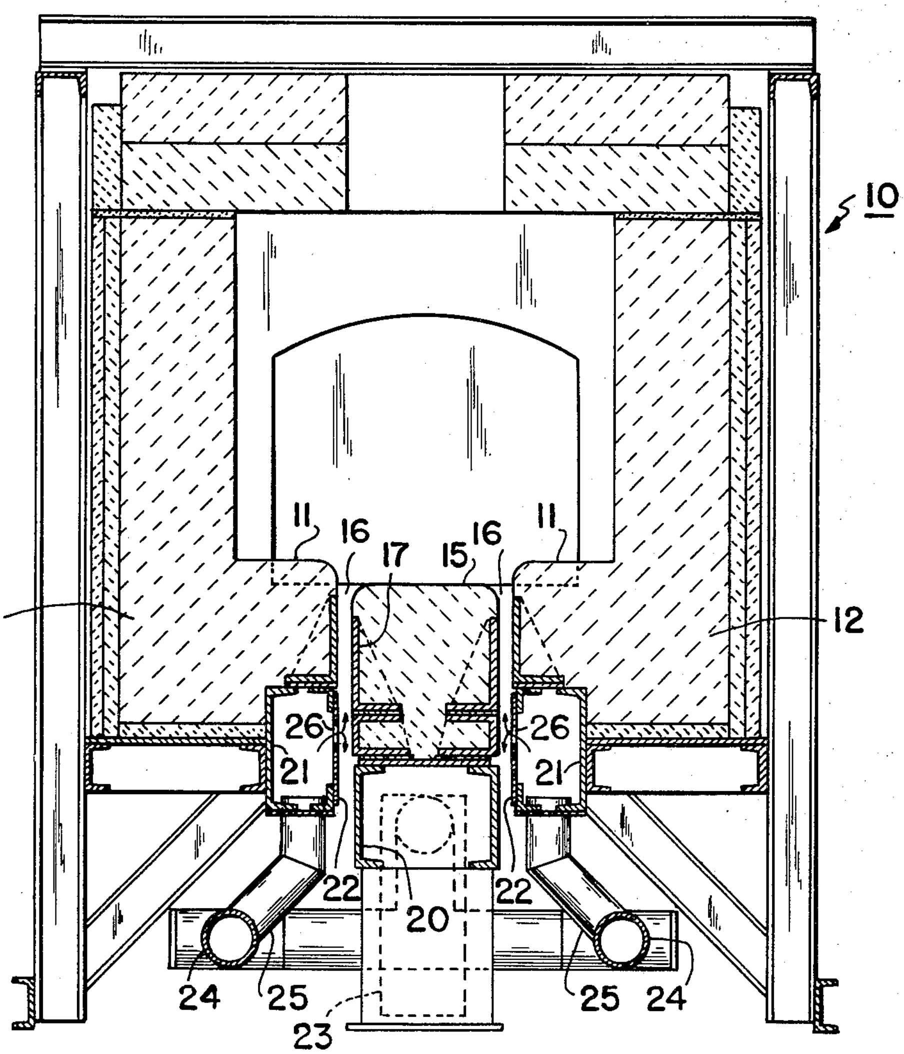


Fig. 2

INVENTOR.
Charles R. Wilt, Jr.

BY
Buell, Blenko & Ziesenheim
HIS ATTORNEYS

METHOD FOR SEALING AND COOLING THE COMPONENT PARTS ASSOCIATED WITH THE MOVING AND STATIONARY MEMBERS OF WALKING BEAM FURNACES

My invention relates to a method for simultaneously sealing and cooling the furnace members and, in particular, to sealing and cooling the moving and associated stationary members in walking beam furnaces.

Walking beam furnaces are designed to move a product, usually a billet, slab, ingot or plate through a furnace while it is being heated and providing a uniformity of temperature to all parts thereof uncommon to water cooled skid furnaces. Examples of these furnaces are found in U.S. Pat. Nos. 1,272,918; 1,973,934; and 3,398,939.

One embodiment of my invention consists of a walking beam type furnace wherein the hearth is divided longitudinally into alternate sections of stationary and moving hearths, i.e., a number of moving islands or beams disposed between stationary members which are designed to move upwardly, forwardly, downwardly, and rearwardly during one complete cycle. The first two movements move the product progressively through the furnace while the last two are designed to reposition the island or beam for the next product movement. The islands may be separated by an elongated slot from the stationary portion of the hearth or there may be elliptical openings through which movable supports raise and lower the work supports. The moving parts of the beam must be unrestricted in their movement while sealed to a furnace chamber in such a manner that the surface quality, temperature, and temperature uniformity of the work piece are unaffected by the sealing device. Further the seal must be reliable, economical and easily maintained.

Various types of sealing arrangements have been proposed including mechanical and liquid seals. The most common seal is the water seal which, generally, comprises a water trough below the slot extending the length of the furnace in which is emersed an elongated blade connected to the movable beam. The water seal is extremely effective in preventing hot furnace gases or furnace atmosphere from escaping through the slot. The water in the trough will cool the trough support members and sealing members but the amount of cooling is limited by the ability of the members to conduct the heat and the length of the conductive paths involved.

Notwithstanding the fact that water is effective both for sealing the slot and for cooling to a limited extend the support members, its use gives rise to a number of very serious problems. In water cooled and water sealed systems it is necessary that the trough and water cooled members be fabricated in conveniently handled lengths. It is difficult to maintain water tight connections between sections of water trough. Additionally, unless the pH of the water is carefully controlled with water cooled members are subject to corrosion and non-filled members are subject to oxidation. Delivering water to the members and taking it away to drains results in extraordinary amounts of expensive plumbing and plumbing equipment. If cooling water is not readily available, it is necessary that the water be recirculated in a closed or open system and that water treating facilities be installed to control its cleanliness and its pH. Where water is readily available it is necessary that the water be cleaned-up prior to dumping into rivers or lakes. It is obvious that the application of water seals as currently practiced contributes to a water pollution problem. The water seals themselves are inevitable traps for material and debris such as iron oxides and refractories falling from the furnace which reduce the effectiveness of the seal, and contribute to the pollution problem. Mechanisms must be provided in water seals in order to make them self-cleaning and these devices contribute to additional installation and maintenance costs. The seals cannot be cleaned or repaired without shutting the furnace down and removing the water therefrom. Accordingly, the water seal is extremely effective in containing the furnace atmosphere but is initially expensive and difficult to maintain and operate.

The present invention overcomes or eliminates many of these problems and at the same time reduces the cost of both operation and maintenance of the seal and cooling system. My method of sealing and cooling the slot and members respectively utilizes low pressure air. I have found a method for simultaneously using a plurality of jets of air directed into the slot to create a stagnation plane for sealing a furnace to the outside as well as cooling the structural support members located within the slot. Not only have I found that both an effective seal and cooling method can be obtained with air but I have unexpectedly found that the work piece in the furnace has a greater top to bottom temperature uniformity in the region of the slot than as common with water type seals.

Air has long been known to be effective as a seal as well as carrying out other associated functions in industrial furnaces; see, for example U.S. Pat. Nos. 713,288; 1,911,394; 2,269,645; 2,819,889; 3,270,655 and 3,397,874. I have found a method for sealing a moving island and a stationary member in a walking beam furnace with an air stream that overcomes the many problems associated with water and mechanical seals without sacrificing work surface quality, temperature, and temperature uniformity within the furnace.

I prefer to introduce a plurality of air jets, closely spaced, emitting from a plenum and flowing across the slot and impinging upon the refractory support members. A normal impingement against the beam members will split the individual air streams in such a manner that there is air flowing both up the slot and down the slot; that is, to and from the furnace. I regulate the velocity of the air emitting from the holes so that after the air stream divides the kinetic energy of the stream flowing toward the furnace is slightly more than is required to stagnate and form a stagnation plane with the gasses attempting to flow from the furnace. A turbulence exists at the stagnation plane which causes minor intermingling of the furnace gas with the air from the seal. The seal air rebounds from the stagnation plane and flows downward and mixes with the other portion of the divided air jet. The furnace gases also rebound from the stagnation plane and re-entered the furnace carrying only a minor portion of the seal air. Since the furnace gases are normally higher in temperature than the work being heated and there is little dilution and lowering of the gas temperature by virtue of mixing with the seal air, the rebounding gases are still hotter than the work being heated and the turbulence created tends to produce uniformity of work temperature in the area of the rebounding gases. While it is not required, I prefer to have a slight flow of seal air into the furnace to prevent a discharge of the products of combustion and furnace gases into the area below the furnace which under certain circumstances might provide an unacceptable working condition to the operators or those servicing the equipment. This also insures that there will be no overheating of the furnace support members and equipment used to operate the movable beam. Under these normal operating conditions the air seal will result in air rebounding from the slot containing some products of combustion because of the slight mixing of the furnace gases and the seal air at the stagnation plane. In the region between the air jets and the furnace proper I have measured oxygen contents of the furnace gas and seal air mix at 18%. However, below the air jets the oxygen content by virtue of secondary mixing is much higher. Temperatures of the rebounding air and furnace gas mix being discharged below the furnace were always low and skin comfortable.

In addition to eliminating the need for a water trough and water cooled members my invention has another unobvious advantage over known types of seals. Quite frequently the slot between the movable and stationary members will fill with broken refractories, oxides of the metal being heated, or other debris that might be present within the furnace which will hinder the operation of the beam. In order that such an obstruction may be removed when using either a water seal or a mechanical seal it is necessary to shut down the furnace and disassemble the seal. With my invention the seal can be cleared by external mechanical means without shutting down the furnace or losing the effect of the seal in any portion of the furnace.

Other advantages and features of my invention will become apparent from a perusal of the detailed description taken in connection with the following drawings of which:

FIG. 1 is a side elevation, in section of a typical walking beam furnace with means for utilizing the method of my invention, and

FIG. 2 is a front elevation in section of the furnace at line II—II of FIG. 1.

Referring to FIGS. 1 and 2 a walking beam furnace **10** includes a hearth **11** made from suitable refractory material **12**. Furnace **10** includes a walking beam or island **15** which is made from suitable refractory material. The beam is movable to a position above the hearth level to move a work piece which spans the island. The island and the hearth are separated by a slot **16** which extends substantially the length of the furnace. Running the length of furnace and contiguous with the slot are alloy supports **17** for the supporting of the refractory material. Island **15** includes support assembly **20** which includes means (not shown in detail) for moving the island forwardly, upwardly, backwardly, and downwardly in cyclic fashion to progressively move a work piece.

A plenum or seal manifold **21** having a face plate **22** is provided along the length of the slot. The manifold also is used as part of the hearth support system. Manifold **21** is connected to a blower **23** by means of air pipes **24** and **25**. Face plate **22** is provided with a plurality of openings **26** along its length. For example, openings one-fourth inch in diameter spaced on three-fourths inch centers for a slot approximately 1 inch wide has provided air streams susceptible to accurate regulation.

I have found that the amount of air required to effectively seal the slot is a function of the required furnace pressure. If the pressure within the surface is not well controlled the performance of the air seal is affected.

In order to effectively seal the slot, it is necessary to achieve a balanced condition within the slot between air seal pressure and furnace pressure. An optimum balanced condition is when there is no air flow into the furnace from the seal or escape of furnace gas from the furnace. Establishment of balance conditions, either slight air flow in or slight gas flow out of the furnace is determined by measuring the oxygen content in the slot between the air jets and the furnace. A safe operating condition exists when there is a slight air flow into the furnace and the oxygen content is between 18 and 21 percent. It was found that a slight out-flow of gas was not inconsistent with safe operating parameters of the furnace. At 18% O_2, there was no thermal pollution contaminating the work area or environment and there was no air pollution that was detectable. Escaping furnace gases were not detectable above already existing background percentages.

As was to be expected, temperature nonuniformity from top to bottom of a work piece was greatest over the slots. Unexpectedly, however, it was found that this nonuniformity was greatest when no seal air was flowing and a balanced pressure condition existed. As the furnace pressure and seal flow are increased while maintaining a balanced condition, the work piece temperature over the slot became more uniform. In general the portion of the work piece over the center line of the island was more uniform in temperature than the portion resting on the hearth.

Accordingly, best results are obtained by maintaining very slight air flow into the furnace from the balanced condition. This condition would be determined as the point where approximately a 20 percent oxygen content is found within the slot. This condition provides remarkable temperature uniformity of the work piece over the slot. The temperature differential at this point was less than $\pm$ 35° F. for a 4 inches $\times$ 4 inches steel billet at furnace operating temperatures between 1400° and 2300° F.

By utilizing a support member as the air manifold, it is possible to cool the stationary hearth support simply by supplying air to the slot. The island or beam support members are cooled by the impingement of the air from the manifold. Accordingly, it is preferred that the air supplied to the manifold for impingement be fairly cool, for example, less than 100° F.

Maintenance of the balance condition is imperative wherein a pressure head is established above the air stream. This pressure head, while static, does change position within the slot due to inevitable fluctuations in the furnace pressure, movement of the island or beam, and variation in slot width. Because of the oxidizing nature of the seal air and temperatures encountered near the hearth, it is advisable to employ alloy castings in this region.

The application of my invention can be illustrated by the following example of a simple walking beam furnace of the configuration shown in FIG. 1 which has been built and operated in accordance with my teaching. In order to produce a pressure at the slot of .03 inches of water column it is necessary to supply 1500 cubic feet per hour of air per ft. of seal. Since there are two slots, each 9 feet – 0 inch long, the total amount of air required is:

$$1500\ (\text{Ft.}^3/\text{hr. ft.}) \times 9\ \text{Ft./Slot} \times 2\ \text{Slots} = 27{,}000\ \text{CFH}$$

This air must be delivered to the air seal plenum at a static pressure of 2.3 inches W.C. for the hole configuration of this example. Since each plenum receives half of the total flow or 13,500 CFH, for a velocity of 51 Ft/Sec., the supply connection should be greater than 3.68 inches; i.e., a 4 inches standard weight pipe. The main size for 51 Ft/sec should be 5.2 inches; i.e., a 6 inches standard weight pipe.

At 51 Ft/sec., the velocity pressure of the air is approximately 0.57 inches W.C. If the pressure loss in the system is held to three velocity pressures or 3 × 0.57 = 1.71 inches W.C., the static pressure required at the fan is 1.71 inches +2.30 inches or 4 inches W.C. If the fan outlet velocity is 51 Ft/Sec., the total pressure required at the fan is 4.57 inches W.C., or 5 inches. Since 0.000157 hp is required to move 1.0 CFM against a total pressure of 1 inches W.C., the air horsepower necessary is:

$$27{,}000\ \text{Ft}^3/\text{hr} \times \text{hr.}/60\ \text{min.} \times 5.0\ \text{inches} \times 1.57 \times (10^{-4}\ \text{hp})/\text{Ft}^3/\text{mininch} = 0.352\ \text{hp.}$$

If the blower is 50 percent efficient, the horsepower required would be 0.704 or approximately three-fourths hp motor.

While I have shown a presently preferred embodiment of my invention, it may otherwise be embodied within the scope of the appended claims.

I claim:

1. In a method for sealing and cooling the slot between the stationary hearth and movable beam in a walking beam furnace, the improvement comprising of:

A. injecting a plurality of air streams into the slot and impinging the streams against a side, said air streams being positioned along the slot below the furnace hearth level and

B. adjusting and directing the flow of air so that the streams are divided by their impingement, and part of the stream directed to the hearth level is in substantially balanced equilibrium with the gases within the furnace.

2. The improvement set forth in claim 1 wherein the air flow is adjusted so that the balance includes a slight inflow of air to the furnace.

3. The improvement set forth in claim 1 wherein air flow is adjusted so that the air within the slot between the streams and furnace has an oxygen content of from 18 to 21 percent.

4. The improvement set forth in claim 1 wherein the air flow is adjusted so that the air within the slot between the streams and furnace has an oxygen content of about 20 percent.

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