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Stark

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[54] **CLOSED REDUCTION FURNACE**

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Aug. 8, 1973 Germany 2340104

[52] **U.S. Cl.** **13/35;** 13/1; 266/17; 266/31

[51] **Int. Cl.²** **F27D 1/02;** F27B 14/12

[58] **Field of Search** 13/1, 9, 35; 266/17, 31

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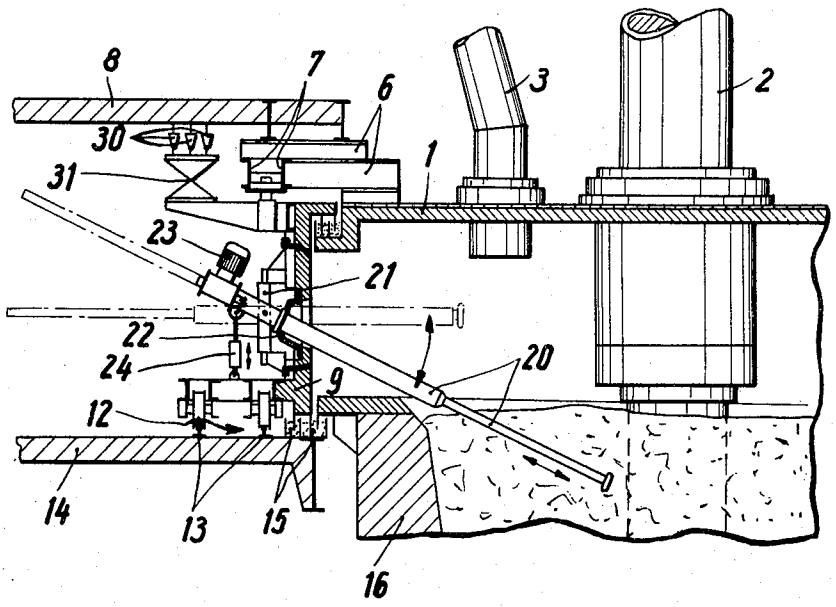
Primary Examiner—R. N. Envall, Jr.

Attorney, Agent, or Firm—Mandeville and Schweitzer

[57] **ABSTRACT**

A closed reduction furnace with a furnace shell as well as a furnace roof with gas-tight electrode conduits, gas exhaust pipes and charging devices, provided with poking devices traveling around the furnace and spatially movable in three directions is disclosed herein.

18 Claims, 8 Drawing Figures



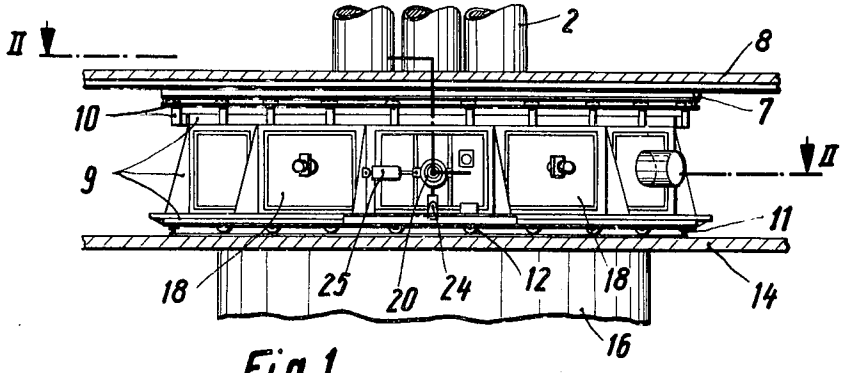

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Fig.1

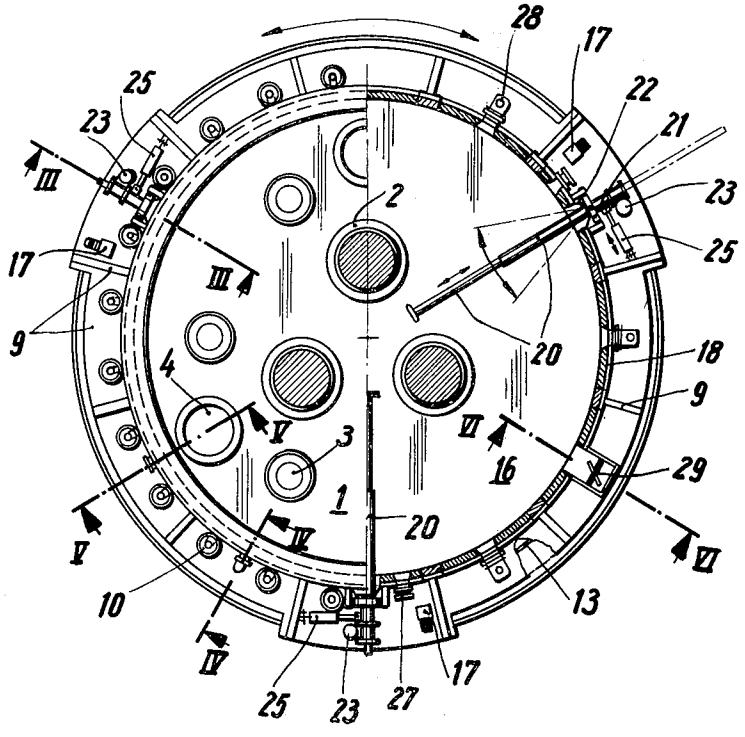

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Fig.2

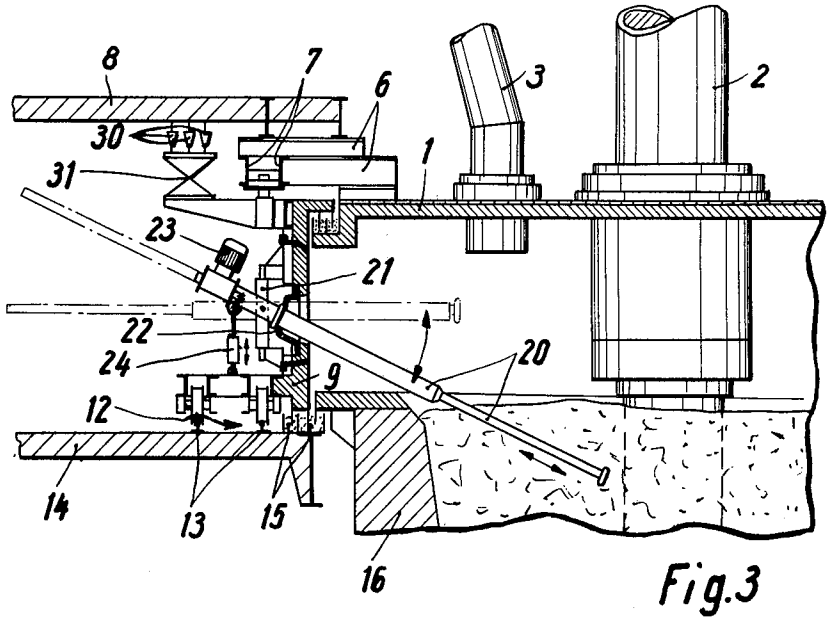

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Fig.3

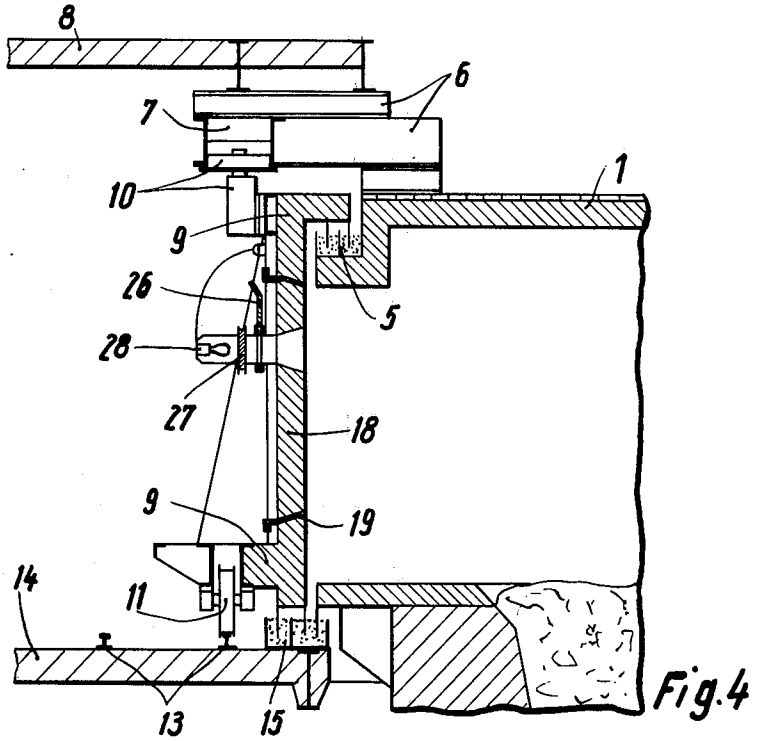

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Fig.4

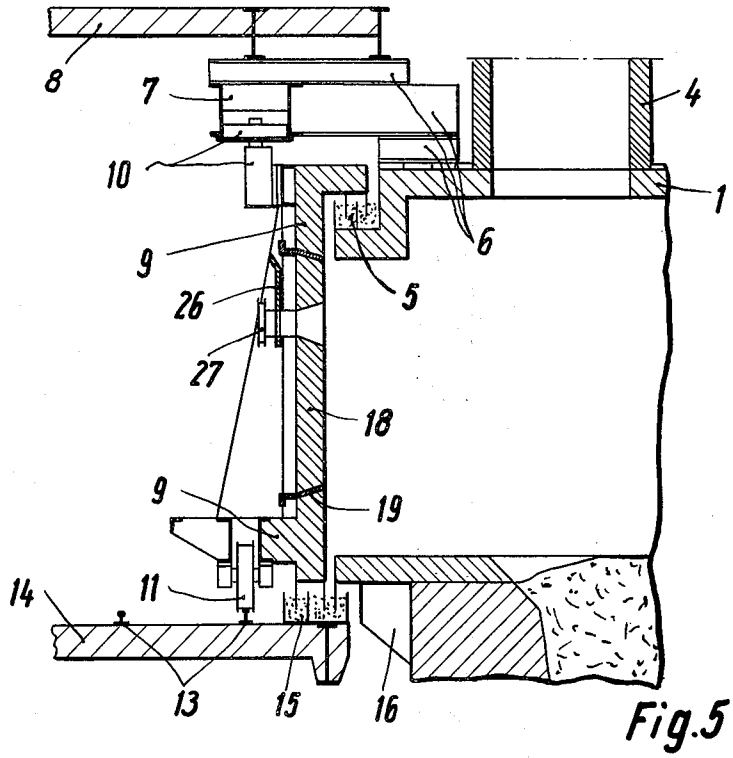

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Fig.5

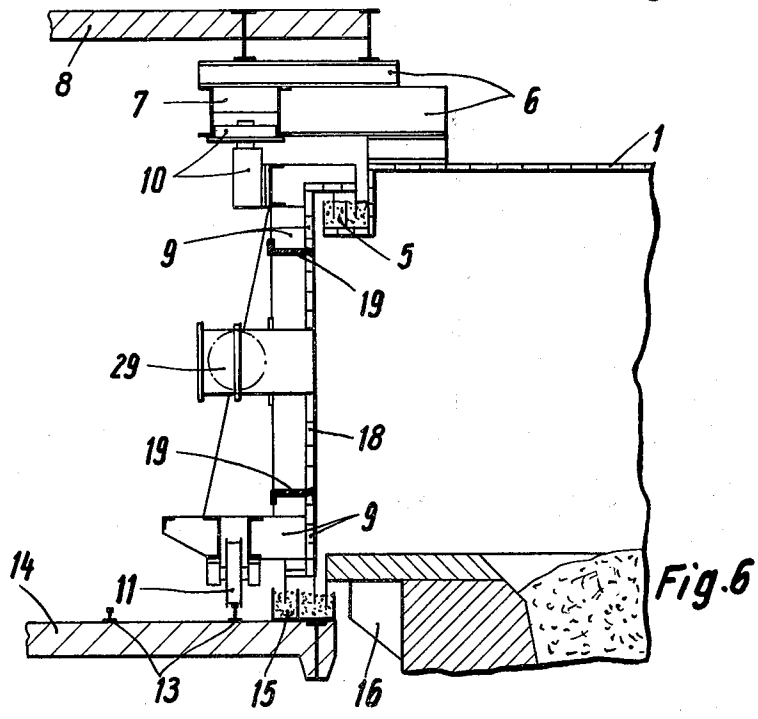

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Fig.6

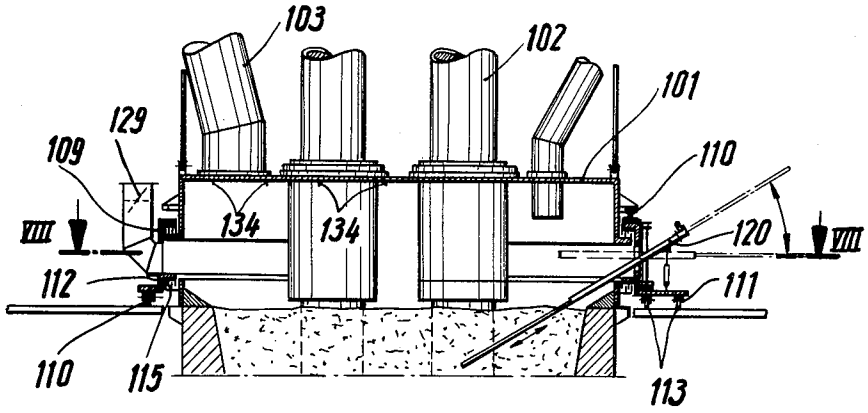

103
102
101
129
109
110
134
134
VIII
120
VIII
112
111
110
115
113

Fig.7

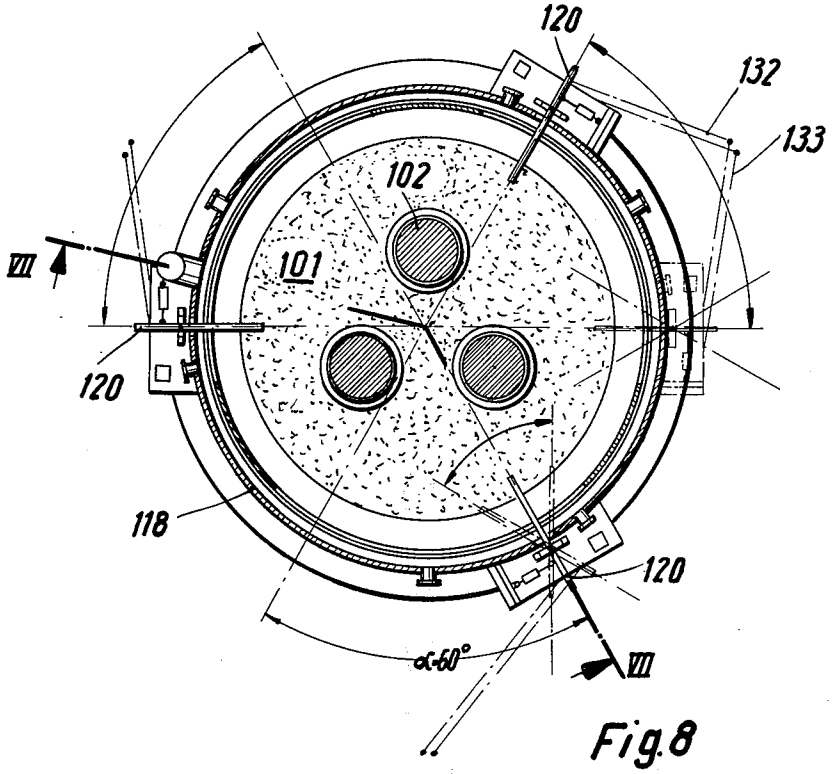

120
132
133
102
VII
101
120
118
120
α-60°
VII

Fig.8

CLOSED REDUCTION FURNACE

BACKGROUND AND SUMMARY OF THE PRESENT INVENTION

As known, the reduction gas from the reduction furnace leaves the charged surface with relatively high temperatures. This can easily result in the formation of sintered crusts on the charge surface. Such sintered crusts impair the gas permeability of the charge surface. There may be sudden hot gas eruptions with temperatures possible exceeding **2,000°** C. In order to avoid such gas eruptions, also called blasts, which cause great stress on all structural parts and which have a negative effect on the furnace process, it is necessary to disrupt the charge surface of the furnace regularly with poking or stirring devices.

In previously known closed furnaces with stationary or rotary furnace shells whose furnace roofs cannot be lifted off, the cylindrical parts of the receptable shell lateral walls are provided with several open segments distributed over the circumference, and through these open segments, the charge surface is loosened by means of a poking or stirring device traveling on the furnace platform. The openings in the cylindrical part of the lateral walls are fitted with doors which are opened for poking. Such an arrangement is only suitable for processes which do not require any intense poking, stirring, or agitation of the charge surface.

In the case of processes where the charge surface has a strong tendency to form a crust, there was no way of shutting the furnace tight, although this would be required for optimum furnace operation. Instead, a negative effect on the furnace operation had to be tolerated, and any possible recovery of furnace gases has to be relinquished. Furthermore, it had been impossible to feed only the relatively small constant quantity of combustion air required for burning the available CO into CO_2. Therefore, the size of the flue gas stacks had to be very large due to the total gas quantity which was increased by the high combustion air quantity. For the same reason, the subsequent dust removal apparatus also had to be very large. Moreover, it was extremely difficult to control and to treat effectively the entire charge surface in the furnace receptable with conventional poking devices, resulting in an unstable furnace process.

In the known furnace apparatus where the movement of a poking or stirring device travelling on the furnace platform is controlled in accordance with the temperature distribution detected by thermal sensors distributed over the surface or in accordance with the light differentiations detected by observation devices or light sensors, a satisfactory and effective solution, regarding sealing of the openings through which the poking arms are inserted, had not been developed.

Therefore, it is an important object of the present invention to improve a closed reduction furnace in such a way that the disadvantages mentioned before in connection with known reduction furnaces may be avoided, and that an effectively complete sealing of the traveling poking or stirring device inserted into the furnace may be achieved in a manner which facilitates a trouble-free furnace chamber process. The solution according to the present invention is to provide a fixed element as a furnace roof, which is provided with at least one movable part, sealed against the fixed part in all positions or operation and which comes with a gas-tight conduit or lead-through for the poking device. In this regard, it is practical to arrange the movable part to be concentric with the circular, fixed roof part. The movable part may surround the fixed part in the shape of a cylindrical jacket.

In accordance with the invention, it is desirable to seal the rotary furnace roof element against the fixed furnace roof element as well as the furnace shell by means of previously known sand packings. Furthermore, it has been found advantageous to equip the movable part with rollers which travel on rails located on the furnace platform.

According to another advantageous embodiment of the invention, the sand packing which seals the upper edges of the rotary furnace roof element may be arranged against and supported by the stationary furnace roof element, and the sand packing which seals the lower edges of the rotary furnace roof element may be arranged at the upper edge of the furnace shell at the platform.

A favorable design for the rotary furnace roof element is in the nature of a skeleton frame construction, which frame may be entirely brick-lined, or, as in another layout, bricklined segments may be inserted. Moreover, the rotary furnace roof element may be movable in both directions, either continuously or in a reciprocating motion. The rotary furnace roof element may be provided with hollow walls and connected to a cooling water circulation by means of flexible piping.

In order to contact as large an area as possible, the poking or stirring devices are attached to the rotary furnace roof element in a manner providing for two-dimensional (vertical) movement relative to the cylindrical roof element which, of course, travels in a horizontal plane (giving the poking device three-dimensional movement). Advantageously, the poking device is movable by pressure-operated cylinders hinged at a circular track about which the cylindrical furnace roof element travels. More specifically, in order to decrease the mass of the rotary furnace roof element and to contribute to the efficacy of the sand packing sealing of the furnace roof and furnace shell, it is designed as a relatively narrow ring. Furthermore, it is practical to provide the rotary furnace roof with observation devices as well as air supply pipes with control devices.

For a more complete understanding of the present invention and a greater appreciation of its attendant advantages, reference should be made to the following detailed description thereof, taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of the upper portions of a totally closed reduction furnace embodying the inventive concepts;

FIG. **2** is a partially sectional plan view of the furnace roof of FIG. **1**, the cross-sectional portion being taken along line II—II in FIG. **1**;

FIG. **3** is an enlarged, fragmentary, cross-sectional view taken along line III—III of FIG. **2** showing details of the roof and poker construction of the invention;

FIG. **4** is an enlarged, cross-sectional view taken along line IV—IV of FIG. **2** and showing an illuminating device;

FIG. **5** is an enlarged, fragmentary, cross-sectional view taken along line V—V of FIG. **2**, showing an observation device;

FIG. 6 is an enlarged, fragmentary, cross-sectional view taken along line VI—VI of FIG. 2, showing an air supply pipe with a control device;

FIG. 7 is an axial, cross-sectional view of the upper portions of alternate embodiments of the invention; and

FIG. 8 is a horizontal, cross-sectional view taken along line VII—VII of FIG. 8.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGS. 1 and 2, a stationary, brick-lined furnace roof element 1 for a cylindrical furnace is provided with gas-tight lead-throughs or openings for electrodes 2, charging and correction on pipes 3, as well as gas exhaust pipe 4. The furnace roof element 1 is fastened to a platform construction 8 of the furnace housing by means of girders 6 and 7, respectively (FIGS. 3 and 4). Like reference numerals are used to indicate like elements throughout the drawings and the following description.

In accordance with the invention, a rotary, essentially cylindrical furnace roof element 9 surrounds the fixed, circular roof element 1 and cooperates therewith to form the furnace roof. The upper part of rotary roof element 9 is provided with supporting rollers 10 journaled for rotation about vertical axes; the supporting rollers 10 transmit radial forces exerted on cylindrical roof element 9 to the stationary element 1 of the roof structure during poking operations to be described hereinafter. Near the lower edge of rotary element 9 a circular guide track 12 is established, and this track is provided with rollers 11 evenly distributed over the circumference. The rollers 11 are journaled for rotation about horizontal axes and run on spaced guide rails 13, which are fixed to a furnace platform 14 and define the guide rail track 12 upon which the rotary roof element 9 travels.

The rotary furnace roof element 9 is sealed against the stationary roof element 1 as well as against furnace shell 16, in accordance with the invention, by means of upper and lower sand packings 5, 15, respectively. The upper sand packing 5, as shown in FIGS. 3–7, is arranged at the stationary roof element 1; the lower sand packing 15 is arranged either on the furnace platform 14 (FIGS. 3–6) or at the lower part of stationary roof element 109 (FIG. 7). The rotary roof element 9 is driven by one or more motor drives 17 (FIG. 2), depending on furnace size, as will be understood.

The rotary furnace roof element 9 comprises a skeletal frame which is entirely brick-lined in the embodiment shown in FIGS. 1–5. The righthand side of FIG. 2 illustrates the manner in which linear segments 18 are inserted into the skeleton construction of the rotary roof element 9. Selected segments 18 are equipped with a plurality of poking devices 20 and accordingly have gas-tight ports through which the respective poking devices reach into the furnace. Each poking device consists essentially of a spatially movable poking rod and a poking rod guide which is two-dimensionally movable in a hinge 21 fixed to the segment 18. The port in segment 18 is large enough to guarantee sufficient freedom of movement for the poking rod. In accordance with the invention the poking device 20 is sealed in a gas-tight manner against segments 18 by means of a fireproof elastic packing 22, in the illustrated embodiment, a bellows made of an asbestos-containing material. The poking rod may be extended into and retracted from the furnace shell 16 by means of a drive 23 arranged on the rod guide, as shown. The up and down movement of the poking device 20 is executed by an essentially vertical built-in cylinder 24 (FIG. 3). Lateral movements of the poking rod are executed by means of an essentially horizontal cylinder 25 (FIG. 2). Both ends of the cylinders are movable in all directions so that the poking rod may be brought into any desired position.

As shown in FIGS. 4 and 5, the segments 18 are provided with observation and illumination devices 28, including protective glass 27 and sliding shutter 26 to close the opening in which the glass is installed. The illumination device is laterally movable. When cleaning the protective glass 27, the shutter 26 is, of course, closed before removing the glass.

The rotary furnace element 9 is provided with air supply pipes 29 with dampers (FIGS. 2 and 6). The pipes 29 serve to control the volume of combustion air admitted for the combustion of the furnace gases within the furnace area and also for the exhaust of reduction gas during gas recovery or gas combustion without the furnace shell. The damper is closed for gas recovery or gas combustion outside the housing. However, should the gas be burned within the furnace beneath the roof with small amounts of combustion air, the damper is opened to the required extent.

Electric energy is supplied to the individual devices by means of a current supply line, feasibly a slide line 30 (FIG. 3) located below the platform 8. Current is supplied to rotary furnace element 9 through a separate current pick-up device 31.

The furnace roof is brick-lined only if roof element 9 is continuously rotating in both directions. If the rotary roof element 9 is not rotating continuously but only through a certain angle, e.g., 60°, the entire construction of the roof, i.e., the stationary element 1 as well as the rotary element 9, may be designed with hollow walls, as shown in FIG. 6. The individual elements 1, 9 and/or the segments 18 are then connected to a circulating cooling water supply (not shown) by means of a flexible tubing.

In FIGS. 7 and 8, the rotary element 9 is shown as a relatively narrow annular ring 109 connected to the jacket of stationary furnace roof element 101, in an arrangement analogous to the furnace designs shown in FIGS. 1–6. Thus, the ring 109 is mounted on circular guide track 112 by rollers 111, which run on guide rail 113. The upper part of ring 109 carries supporting rollers 110. Rotary ring 109 comprises segments 118, poking devices 120 and air supply pipes 129 having suitable control devices or dampers. The stationary roof element 101 is equipped with bushing supported electrodes 102 as well as charging pipes 103. Upper and lower sand packings 105, 115 are attached respectively to the stationary roof element 101 and the stationary furnace shell. FIG. 8 shows the 60° reciprocatory motion of the roof element 109. The flexible lines 132 for current and lines 133 for cooling water are schematically illustrated in FIGS. 1–6.

The operation of the reduction furnaces shown in FIGS. 1–8 is as follows: Temperature sensors 134, which continuously measure and indicate temperatures and their distribution over the entire furnace area, are arrayed over the surface of furnace roof elements (1 or 101). The poking device (20 or 120) is then activated in accordance with the highest temperature gradient of

the temperature distribution as measured. As will be understood, the start of the poking process is triggered for a certain section of the furnace, either by hand or automatically, by integration of the temperature gradients.

Furnace observation devices, which are not illustrated as they are not the subject of the invention, may also be used in lieu of thermal sensors. Such devices react to heat radiation and show the temperature distribution across the charge surface on a TV screen. Based on the observations, the poking process may then be triggered by hand or automatically. Infrared cameras or similar devices may be used as observation devices.

In accordance with the principles of the invention, the entire receptacle surface may be exposed to the stirring or agitation action of poking devices, while the furnace area proper is completely sealed against the exterior atmosphere. This guarantees uniform operational process. The entire charge surface may be controlled constantly through suitable observation devices arranged about the rotary roof element.

As the reduction process progresses within the tightly closed area, sealed against the exterior atmosphere, gas recovery is possible. The crude gas, however, may also be removed and burned inside or outside the furnace shell. In the former case, the damper at the air supply pipe may be opened sufficiently to burn the available CO and CO_2 within the gas area under the roof. The combustion air quantity is four to five times that of the available CO quantity.

The closed reduction furnace herein illustrated and and described is intended to be representative only, as certain changes may be made therein without departing from the teachings of the disclosure. For example, it is also possible to separate the cylindrical elements **9** or **109** (FIGS. **1–8**) into several end-overlapping or otherwise telescoping cylinder segments, each of which may be moved independently by an amount not in excess of the overlap. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

I claim:

1. A closed reduction furnace having a furnace shell and a furnace roof equipped with gas-tight electrode conduits, exhaust pipes and charging devices and poking devices traveling around the furnace, characterized in that

a. said furnace roof includes a stationary element and at least one rotary element;

b. means sealing the fixed element with respect to the rotary element; and

c. gas-tight means mounting said poking device upon said rotary element.

2. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said stationary element is circular;

b. said rotary element is arranged concentrically with said stationary element.

3. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said rotary element is in the form of a cylinder;

b. said cylinder surrounds said stationary element.

4. A closed reduction furnace in accordance with claim **2**, further characterized in that

a. said rotary element is sealed against said stationary element and against said furnace shell by sand packing means.

5. A closed reduction furnace in accordance with claim **4**, further including

a. roller means which travel on rail means;

b. platform means supporting said rail means;

c. said rotary element is supported by said roller means.

6. A closed reduction furnace in accordance with claim **5**, further characterized in that

a. said sand packing means sealing the rotary element against the stationary element is supported at the stationary element.

7. A closed reduction furnace in accordance with claim **5**, further characterized in that

a. the sand packing sealing the rotary element against the furnace shell is supported at the platform means.

8. A closed reduction furnace in accordance with claim **7**, further characterized in that

a. said rotary element includes a cylindrical skeleton frame.

9. A closed reduction furnace in accordance with claim **8**, further characterized in that

a. brick lining means complete the cylindrical form of said rotary element.

10. A closed reduction furnace in accordance with claim **8**, further characterized in that

a. said brick lining means includes individual brick-lined segment means inserted into said skeleton frame.

11. A closed reduction furnace in accordance with claim **3**, further including

a. drive means continuously rotating said rotary element;

b. said drive means is bi-directional.

12. A closed reduction furnace in accordance with claim **3**, further characterized in that

a. drive means radially reciprocate said rotary element with respect to said fixed element.

13. A closed reduction furnace in accordance with claim **3**, further characterized in that

a. said rotary element is comprised of hollow wall means;

b. flexible piping means connect said wall means with a cooling liquid supply.

14. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said poking means is supported in said rotary element for vertical, two-dimensional movement with respect thereto.

15. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said poking means includes pressure-operated cylinders hingedly mounted to a circular guide track.

16. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said rotary element is in the form of a narrow ring.

17. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said rotary element is equipped with observation devices.

18. A closed reduction furnace in accordance with claim **1**, further characterized in that

a. said rotary element is equipped with air supply pipes having dampers.

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