Sept. 2, 1958 S. A. BARNES 2,850,273

ROTARY KILN TYPE METALLURGICAL FURNACE

Filed Sept. 13, 1955 3 Sheets-Sheet 1

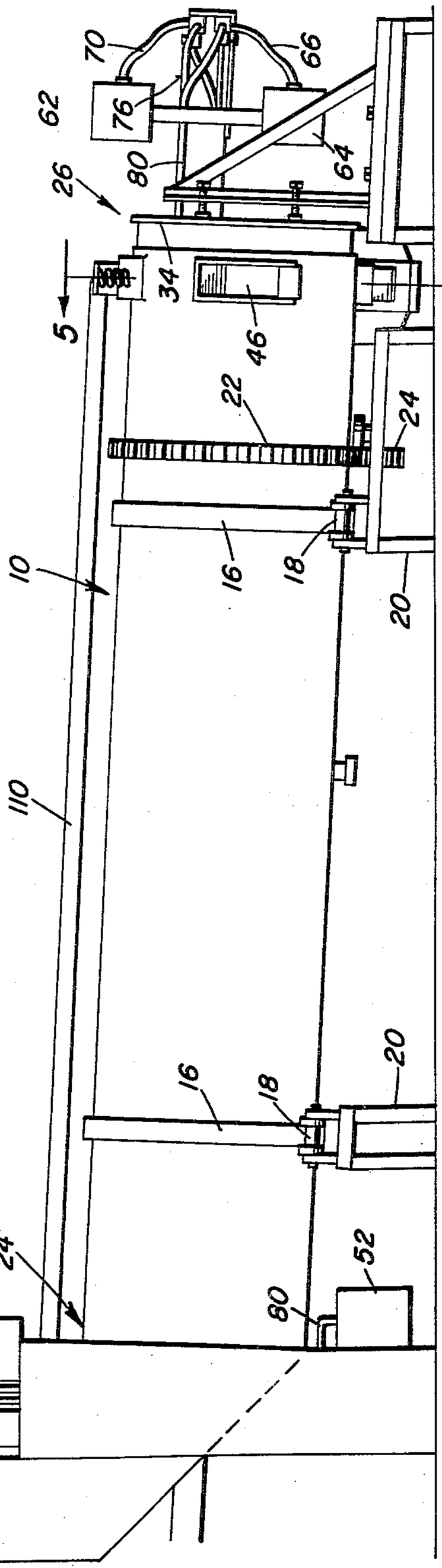

Fig. 1

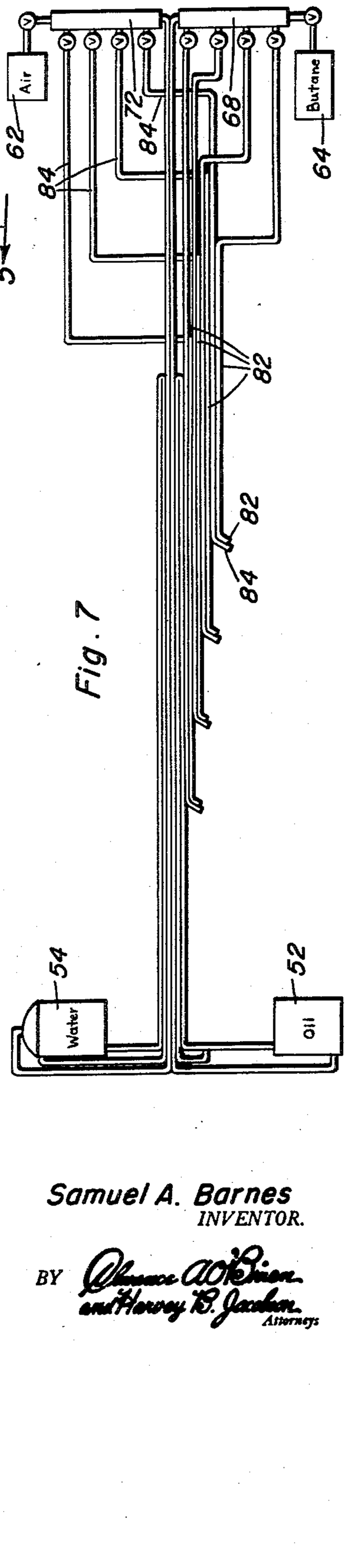

Fig. 7

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ROTARY KILN TYPE METALLURGICAL FURNACE

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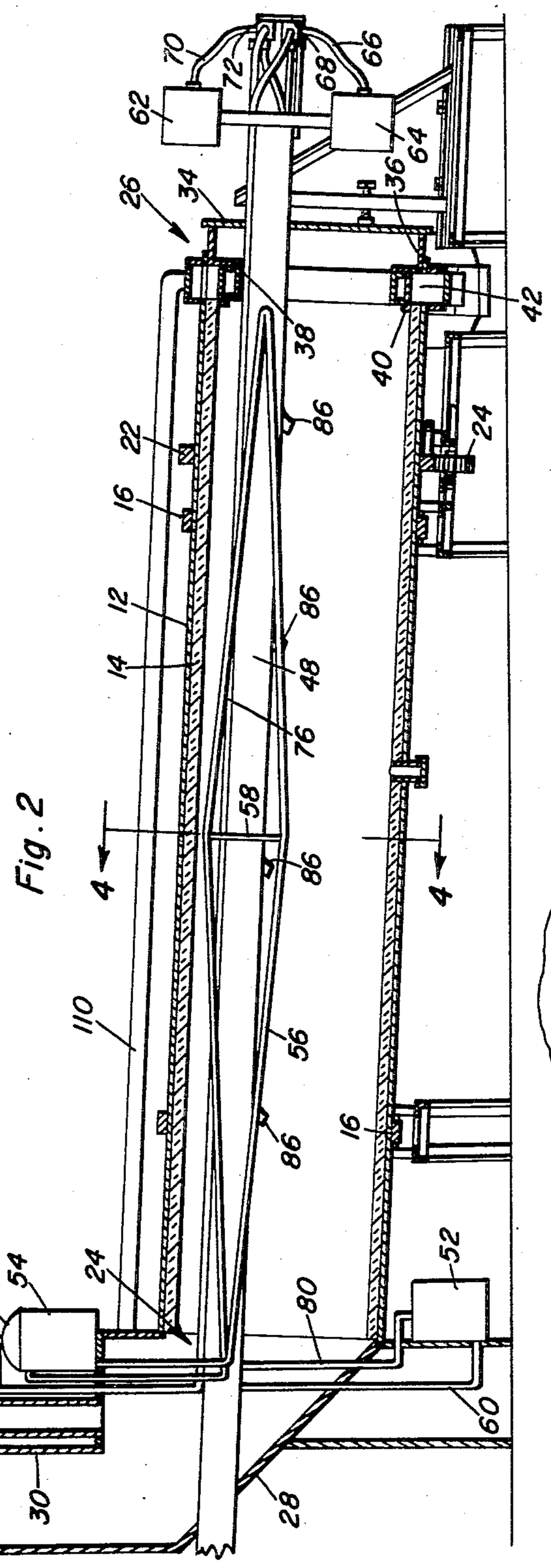

Fig. 2

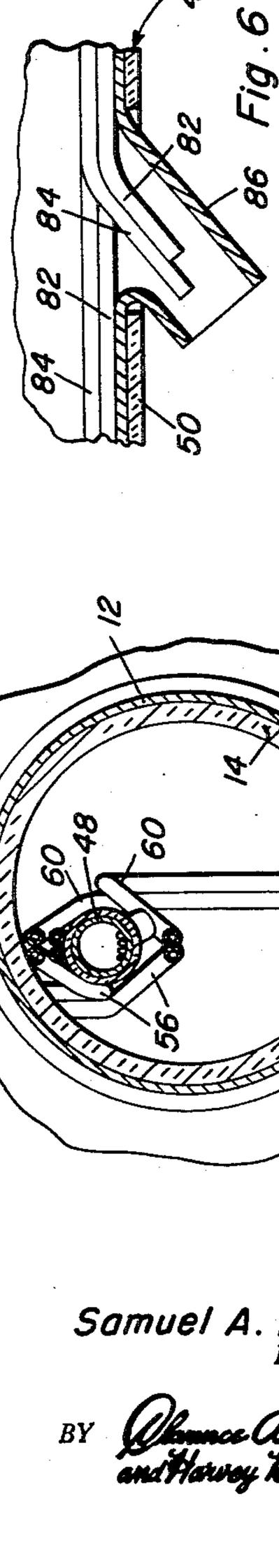

Fig. 6

Fig. 4

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ROTARY KILN TYPE METALLURGICAL FURNACE

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Fig. 5

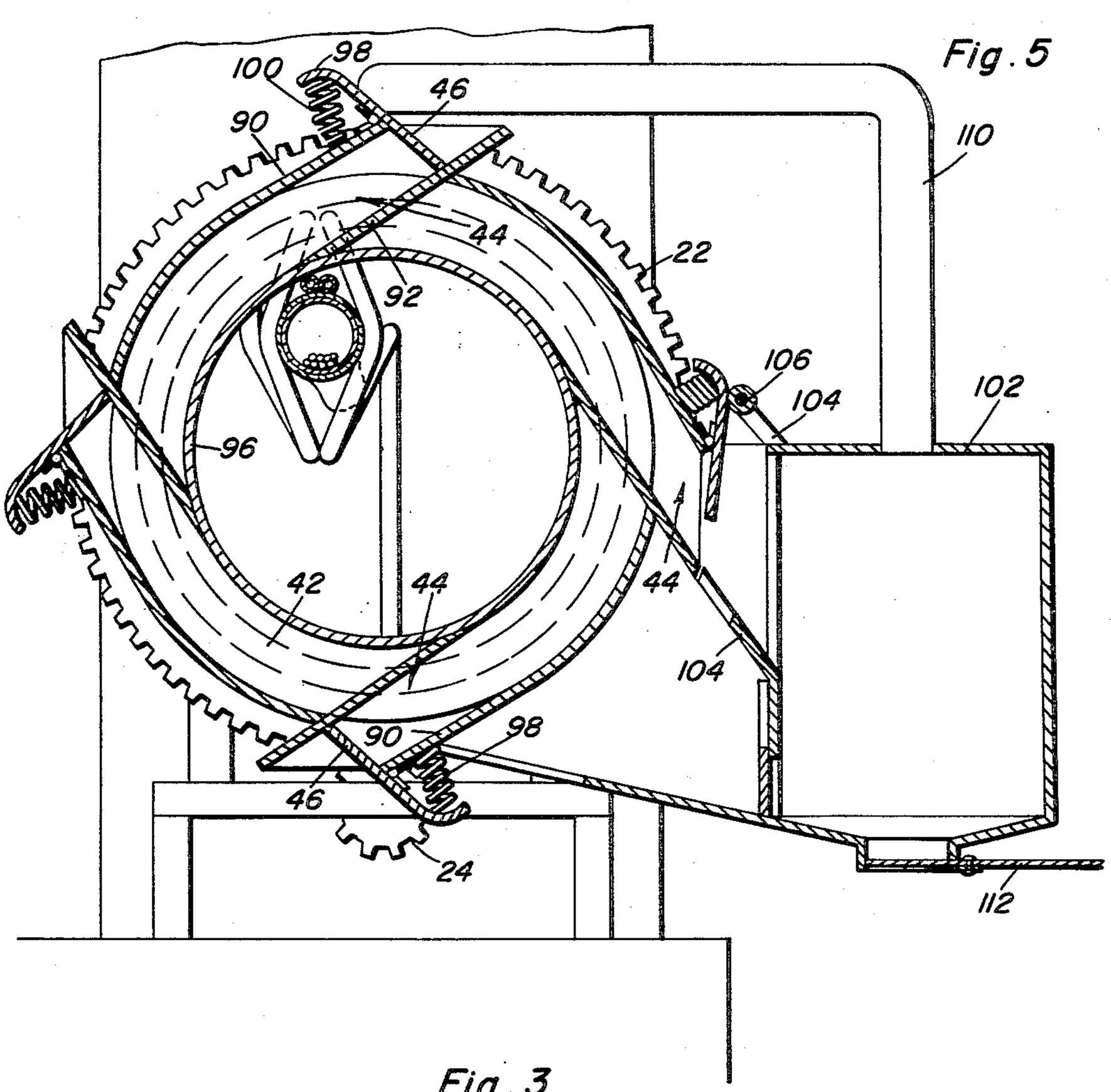
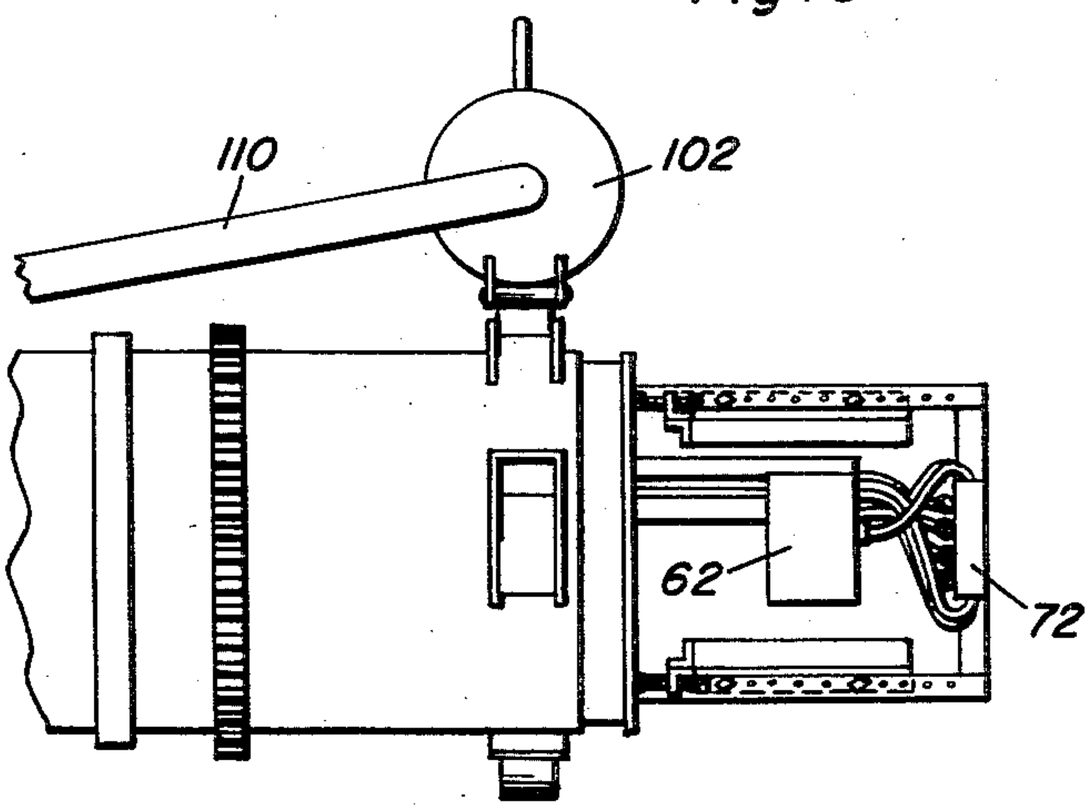


Fig. 3



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ROTARY KILN TYPE METALLURGICAL FURNACE

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Application September 13, 1955, Serial No. 534,040

7 Claims. (Cl. 263—33)

The present invention relates generally to apparatus for treating metallic ores at low temperatures, and more particularly relates to rotary kiln construction for the low temperature reduction of certain type ores, such as nickel, etc., of the oil or other liquid fuel fire type.

The primary purpose of the present invention is to provide an improved rotary kiln construction which will provide more complete heat control throughout the length of the kiln for effecting more efficient ore reduction and as a means for salvaging some non-metallic ores from the ore mass without fusing the slag.

A highly important object of the invention, ancillary to the primary object, is in the provision of a novel air pipe, fuel and water vaporizing system wherein preheating lines for fuel and water are arranged in trussed supporting relation to an air pipe extending longitudinally through the kiln in order to stiffen the air pipe throughout its length within the kiln in order to enable this pipe to withstand the temperatures within the kiln without sagging.

An exceedingly important object of the invention, ancillary to the preceding object, is in the provision of an air pipe extending longitudinally through the rotary kiln, which air pipe is provided at longitudinally spaced points therealong with apertures from which project fuel burner and fuel burner control nozzles carried by individual lines to each of the pipe openings whereby the burning temperature at each nozzle opening may be individually controlled throughout the length of the kiln.

A further object of the invention is in the provision of a novel ore discharge arrangement for the kiln whereby the ores are not subjected to any reoxidation as they leave the kiln.

A still further object of the invention is in the provision of a rotary kiln construction which will maintain a positive pressure of gas within the kiln and eliminate undesirable air leaks into the kiln or any parts thereof while at the same time preventing gas stratifications in the kiln which would otherwise tend to incompletely reduce the ores.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

Figure 1 is a side elevational view of a rotary kiln constructed in accordance with the present invention;

Figure 2 is a side elevational view of the kiln of Figure 1 in cross-section to disclose the interior construction thereof;

Figure 3 is a top view of the discharge end portion of the rotary kiln;

Figure 4 is a cross-sectional view through the kiln taken substantially along the plane of section line 4—4 of Figure 2;

Figure 5 is a cross-sectional view through the kiln taken substantially along the plane of section line 5—5 of Figure 1 disclosing the ore discharge means from the kiln;

Figure 6 is an enlarged detail view of the burner and burner control nozzles for the kiln; and

Figure 7 is a top plan view of the burner and steam piping per se.

In the drawings, the rotary kiln is designated in its entirety by the numeral **10** and consists essentially of a cylindrical outer shell **12** having a suitable refractory or other type insulating liner **14**.

At longitudinally spaced intervals thereon, the kiln is provided with circumferentially extending rings **16** which rotatably support the kiln on rollers **18**, which rollers are in turn mounted on supports **20**.

To positively rotate the kiln **10**, the rollers **18** may be actuated or as shown in the drawings, the kiln shell may be provided with a bull gear **22** driven by means of a pinion **24** from a suitable driving mechanism or prime mover, not shown.

The kiln **10** is inclined downwardly from its ore inlet end **24** to its ore discharge end **26**.

In order to introduce ore into the kiln **10**, the inlet end **24** thereof opens into a feed chute **28** which in turn opens at its upper end into a ground ore bin **30**. Also adjacent this end from the feed chute **28**, gas discharge stack **32** is disposed opening into the feed chute **28**.

The discharge end **26** of the kiln **10** is closed by means of a fixed plate **34** having a collar **36** telescopically received within the extreme end of the cylindrical tube **12**. At this end and spaced closely adjacent thereto is an internal annular ring **38** of considerable depth forming a partial wall to dam up or hold back ore as it moves from the inlet end **24** toward the discharge end **26** of the kiln.

Spaced along the kiln from the ring **38** is a second shallower ring **40** so that an ore receiving channel **42** is formed therebetween.

The ore receiving channel is provided with a series of ore scoops **44** therearound which form ore outlet spouts normally closed by gates **46** to be more specifically described presently.

Extending longitudinally through the kiln **10** and being open at the opposite ends thereof with the openings controlled by dampers (not shown) is a large internal diameter air pipe **48**, having a suitable insulating jacket **50** therearound.

Conveniently disposed at the inlet end of the kiln **10**, although not necessarily so, is an oil tank **52** and a water tank **54**.

Extending from the water tank **54** is a preheating water line or vaporizing steam line **56** which extends generally longitudinally along the air pipe **48** and returns back therealong into the top portion of the water tank **54**. Through its passage into and out of the kiln, the water line **56** is arranged in the form of a truss with intermediate truss brace **58** and the return portions of the line at opposite sides of the truss brace **58** being attached to the air pipe **48** to serve as a truss brace therefor.

Likewise, a preheating line **60** extends from the oil tank **52** along the opposite side of the air pipe **48** and is trussed in the same manner as the water preheating line **56**.

Quite clearly, the rigidity of the trussed effect for the air pipe **48** may be increased by increasing the number of convolutes of the preheating lines for the water and fuel oil. In any event, the structure provides a stiffening truss for the large diameter air pipe through the kiln, whereby the air pipe is enabled to withstand relatively high temperatures without sagging and in addition per-

form a further valuable function in the function of the apparatus to be immediately described.

Referring now to Figures 2 and 7 particularly, it will be noted that exteriorly of the kiln **10** at the discharge end thereof are an air supply tank **62** and a butane or LPG tank **64**. Lines **66** from the butane tank **64** open into an elongated valve casing **68**, and lines **70** from the air tank **62** open into an elongated valve casing **72**. Additionally, steam line **76** from the steam dome **78** of the water tank **54** extends longitudinally along the top of the air pipe **48** through the kiln and also opens into the valve casing **72**, whereas oil line **80** extending from the oil tank **52** opens into the valve casing **68**.

From the respective valve casings **68** and **72**, a plurality of oil or fuel lines **82** extend.

From the valve casing **72**, a plurality of steam or steam and air lines **84** extend.

At longitudinally spaced intervals throughout its length, the air pipe **48** is provided with nozzle openings **86**. The terminal ends of the fuel and air or air and steam pipes **82** and **84**, respectively, open into these nozzles **86**. Into each nozzle **86** one fuel pipe **82** and one steam or steam and air pipe **84** open. Individual valves are provided at the casings **68** and **72** for controlling the amount of steam and fuel through each of the individual lines **82** and **84** to the individual burner nozzles **86** opening from the air pipe **48**.

Thus, the air pipe serves as a housing for the fuel mixing and burning lines through the kiln whereby the temperature of the kiln may be positively controlled throughout the length thereof in a simple and expedient manner. Conversely, the air pipe would be within the mixing and burning lines if it is desired to further preheat the fuel under some circumstances.

By properly controlling the valves, obviously, the steam and oil fuel mixture may be varied, the steam serving to assist in vaporizing the oil at the burner nozzles while at the same time serving as a control for the flame and maintaining pressure within the kiln with a minimum chance of air leakage into the kiln.

The butane or LPG tank **64** which is alternatively in communication with the fuel lines **82** is utilized primarily to start the operation of the kiln and preheat the same so that the oil may be partially vaporized or at least considerably preheated within the truss **60** therefor while the water may be converted to steam or a large portion thereof converted to steam prior to switching over to the oil and water or steam mixture at the burner nozzles **86**.

Referring now to Figure 5, the ore discharge means will be readily observed wherein it is seen that the ore spouts **44** project spirally beyond the cylindrical wall of the kiln at circumferentially spaced points therearound to form discharge spouts.

As noted previously, the mouths of the spouts are closed by gates **46**.

Consequently, as the kiln **10** rotates, the ore is scooped up by each of the scoops **44** and carried around until it is automatically dumped in a manner to be now descrbied.

As will be noted from Figure 5, one wall of each of the scoops **44** extends tangentially from the cylindrical surface of the kiln **10**, this wall being designated by the numeral **90**. The other wall **92** of each scoop **44** extends tangentially from an inner cylindrical sleeve **96** spaced concentrically within the kiln and utilizing the space formed therebetween as the previously mentioned ore discharge channel **42**.

Each discharge gate **46** bridges the mouth of the associated spout formed by each set of walls **90** and **92**. One portion of the gate **46** projects above the exterior wall **90** of the spout and has a lip **98** overlying the wall **90**. A resilient spring **100** reacts at its ends on the wall **90** and on the lip **98** of its associated gate **46** to continuously bias the gate to closed position with respect to its spout **44**.

To one side of the kiln adjacent the discharge end **26** is an ore receiving bin or box **102** which has an upwardly extending lip **104** identifying the mouth thereof. Further, from the upper edge thereof adjacent the kiln extends a supporting bracket **104** mounting a roller **106**. The roller **106** engages each gate **46** as it comes past and presses the same against the action of its biasing spring **100** to open the discharge spout **44** to discharge the ore contents thereof into the bin **102** in a manner so that very little air leakage can possibly occur.

Additionally, exhaust gases from the kiln which ordinarily leave from the stack **32** at the entrance end of the kiln may be piped by virtue of pipe **110** into the ore receiving bin **102** to prevent any reoxidation of the ore as it passes thereinto.

Slide valve **112** at the bottom of the ore receiving bin **102** may serve to release the ore therefrom for further processing.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, said shell being downwardly inclined from its ore charging to its ore discharging ends, means for controlling the temperature throughout the length of the kiln comprising an oxygen conducting pipe extending longitudinally through said kiln, said oxygen conducting pipe having openings into said kiln at longitudinally spaced intervals therealong, fuel mixing lines extending through said pipe and having nozzles opening through said openings into said kiln, means for individually controlling the fuel mix at each pipe opening, said fuel mixing lines having portions supporting said oxygen conducting pipe within said kiln.

2. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, said shell being downwardly inclined from its ore charging to its ore discharging ends, means for controlling the temperature throughout the length of the kiln comprising an oxygen conducting pipe extending longitudinally through said kiln, said oxygen conducting pipe having openings into said kiln at longitudinally spaced intervals therealong, fuel mixing lines extending through said pipe and having nozzles opening through said openings into said kiln, means for individually controlling the fuel mix at each pipe opening, said fuel mixing lines having portions supporting said oxygen conducting pipe within said kiln, said shell having an annular metal receiving channel adjacent the discharge end thereof, gates arranged at circumferential intervals around said channel, means causing each of said gates to open at a predetermined point as the kiln is rotated to release the metal therefrom.

3. In a rotary kiln for treating ore comprising a rotatable shell having an ore charging entrance opening at one end and ore discharging means at the other end with the kiln being inclined downwardly from its charging to its discharging end, means for controlling the heat throughout the length of the kiln comprising an insulated air pipe extending longitudinally through said kiln, said air pipe having a plurality of openings therein at longitudinally spaced points therealong, fuel and water preheating lines arranged exteriorly of and attached and supporting said pipe, fuel and steam lines communicating with said preheating lines and extending through said air pipe, one of said fuel and one of said steam lines terminating at each opening in said air pipe, and means ex-

teriorly of said kiln for individually controlling the amount of fuel and steam to each line.

4. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, said shell being downwardly inclined from its ore charging to its ore discharging means, means closing the ends of said kiln, an air pipe extending longitudinally through said kiln, fuel and water lines having preheating portions thereof extending longitudinally through said kiln, said preheating portions supporting said pipe, said water lines communicating with a casing having a plurality of steam lines leading therefrom through said air pipe, fuel lines extending into said air pipe, said air pipe having openngs into said kiln at longitudinally spaced points therealong, one of said fuel lines and one of said steam lines terminating in each of said openings, and means for individually controlling the fuel and steam through each line.

5. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, said shell being downwardly inclined from its ore charging to its ore discharging ends, means for controlling the temperature throughout the length of the kiln comprising an oxygen conducting pipe extending longitudinally through said kiln, said oxygen conducting pipe having openings into said kiln at longitudinally spaced intervals therealong, fuel mixing lines extending through said pipe and having nozzles opening through said openings into said kiln, means for individually controlling the fuel mix at each pipe opening, said fuel mixing lines supporting said air pipe within said kiln, said ore discharging means comprising an annular ore receiving channel in said kiln, ore scoops at circumferential intervals around said channel forming protuberances exteriorly of said kiln shell, ore discharge gates closing said protuberances.

6. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, said shell being downwardly inclined from its ore charging to its ore discharging ends, means for controlling the temperature throughout the length of the kiln comprising an

oxygen conducting pipe extending longitudinally through said kiln, said oxygen conducting pipe having openings into said kiln at longitudinally spaced intervals therealong, fuel mixing lines extending through said pipe and having nozzles opening through said openings into said kiln, means for individually controlling the fuel mix at each pipe opening, means connected to said fuel mixing lines for supporting said air pipe within said kiln, said ore discharging means comprising an annular ore receiving channel in said kiln, ore scoops at circumferential intervals around said channel forming protuberances exteriorly of said kiln shell, ore discharge gates closing said protuberances, and means for automatically opening each of said gates at a predetermined position for releasing ore from the scoops.

7. A rotary kiln for treating ore comprising a rotatable kiln shell having an ore charging port at one end and ore discharging means at the other end thereof, means for controlling the temperature throughout the length of the kiln including an enlarged oxygen conducting pipe extending longitudinally through said kiln, said oxygen conducting pipe having openings into said kiln at longitudinally spaced intervals therealong, fuel mixing lines located substantially longitudinally and internally of the kiln, a truss brace located near the longitudinal central portion of said oxygen conducting pipe and connected about a substantially semi-circumferential portion of said oxygen conducting pipe, said truss brace supported by said fuel mixing lines, said fuel mixing lines further supporting said oxygen conducting pipe near the charging port and dischargng means, said fuel mixing lines having nozzles opening through said openings into said kiln.

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