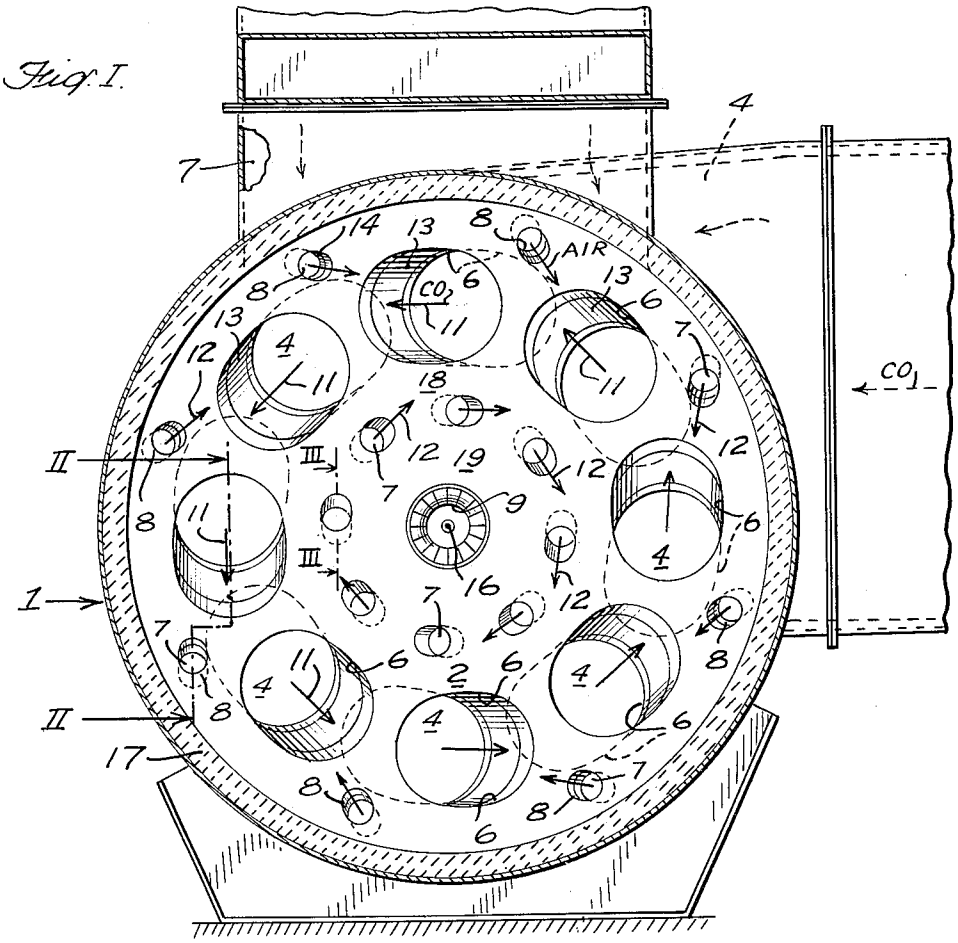
Jan. 18, 1966 K. R. WAGNER ETAL 3,229,746

HEAT RECOVERY APPARATUS AND METHOD SUITABLE FOR LEAN CONCENTRATIONS OF A BURNABLE GAS

Original Filed Nov. 13, 1961 5 Sheets-Sheet 1

Fig. I.



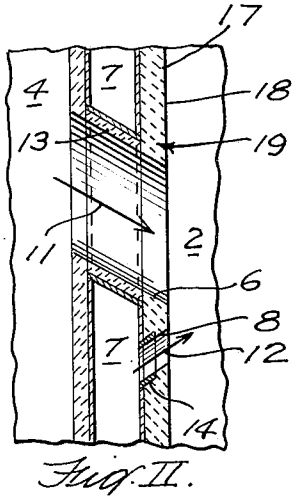


Fig. II.

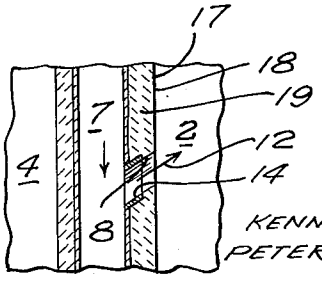


Fig. III.

INVENTORS
KENNETH R. WAGNER
PETER VON WIESENTHAL

BY Charles E. Bagley

ATTORNEY

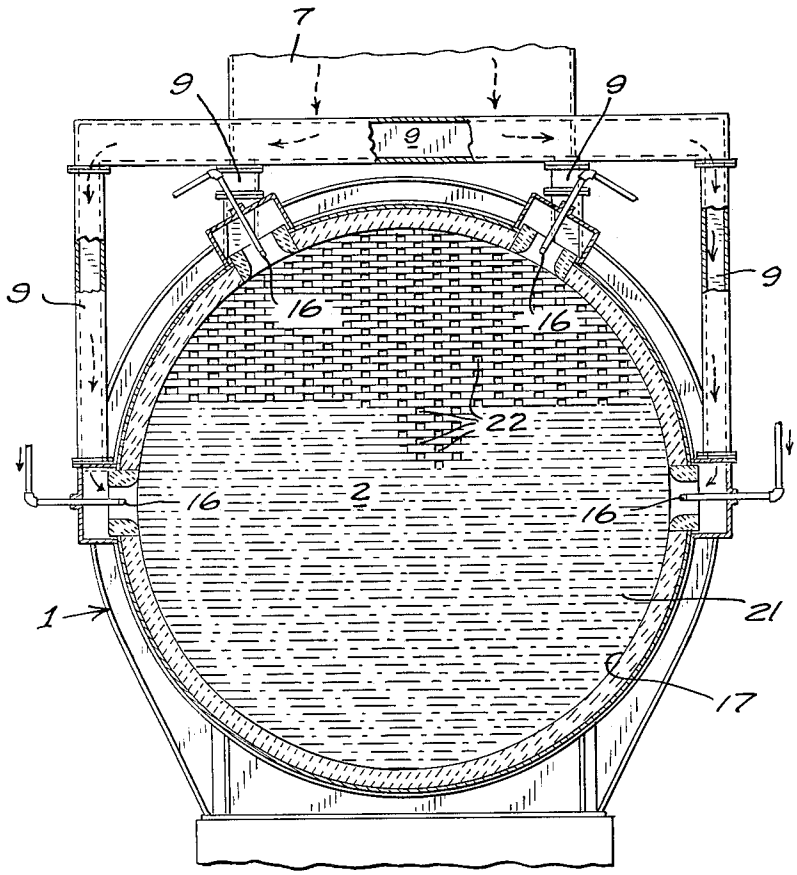


Fig. IV.

INVENTORS
KENNETH R. WAGNER
PETER VON WIESENTHAL
BY Charles E. Barclay
ATTORNEY

Jan. 18, 1966 K. R. WAGNER ETAL 3,229,746

HEAT RECOVERY APPARATUS AND METHOD SUITABLE FOR LEAN CONCENTRATIONS OF A BURNABLE GAS

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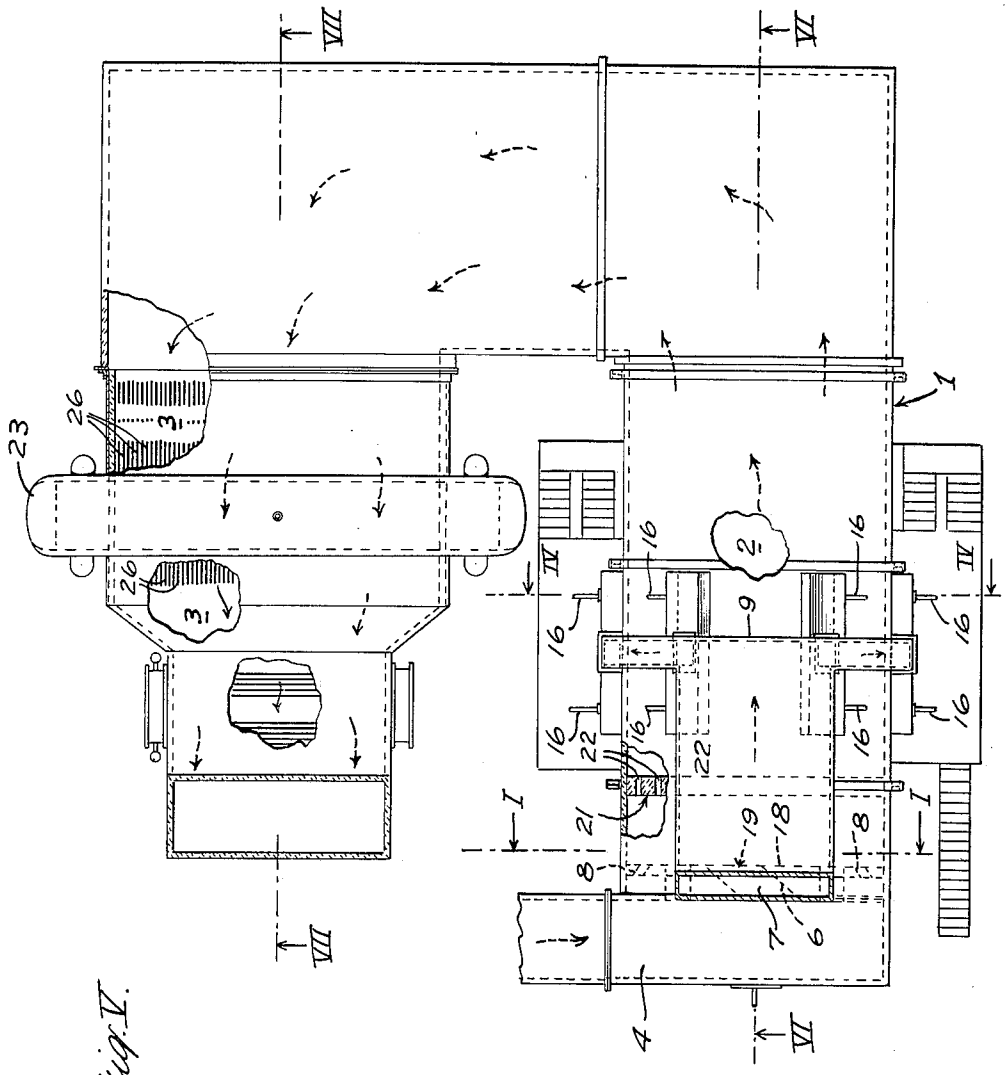


Fig. 1.

INVENTORS
KENNETH R. WAGNER
PETER VON WIESENTHAL

BY Charles E. Baxley

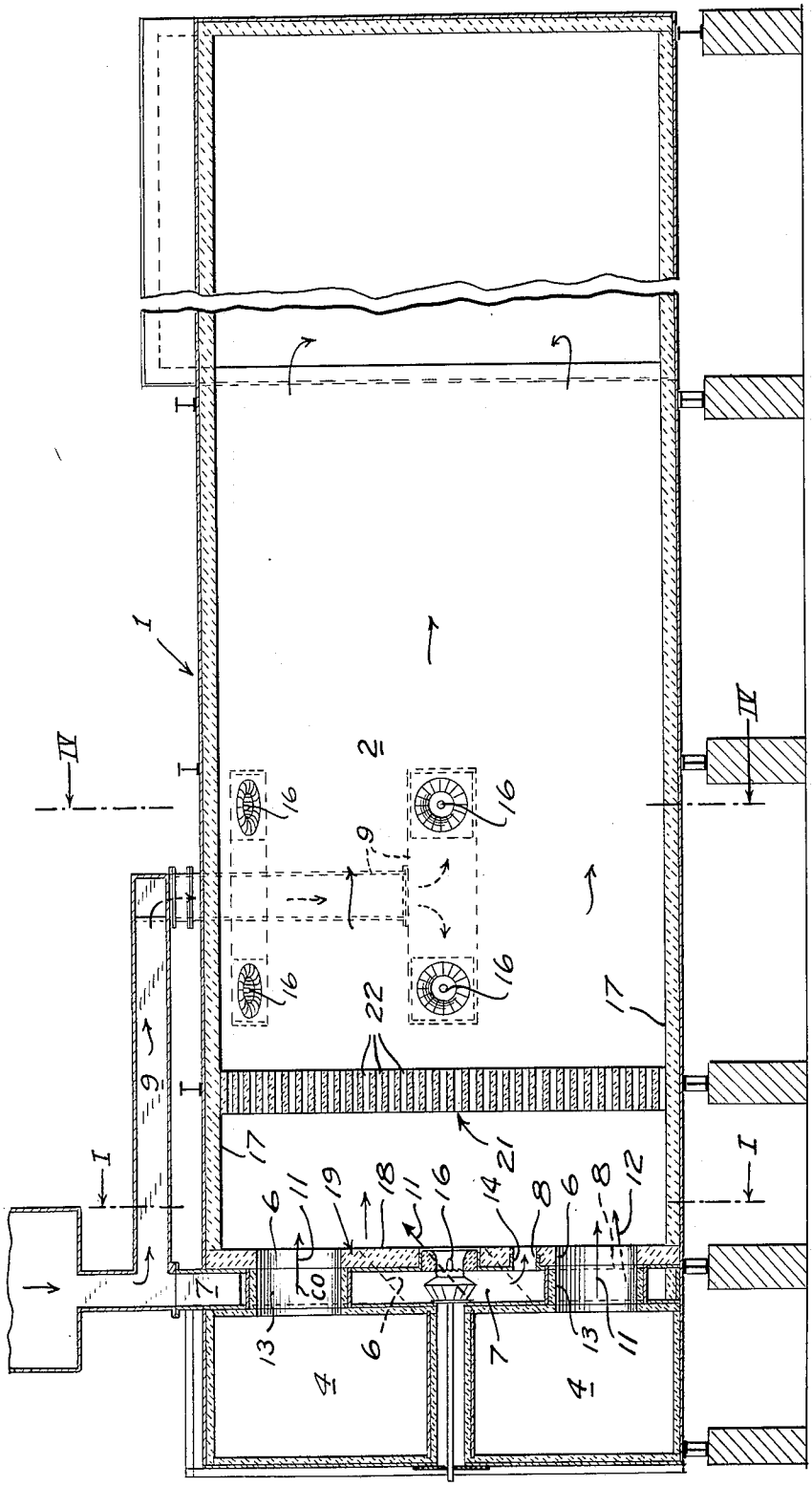
ATTORNEY

Jan. 18, 1966 K. R. WAGNER ETAL 3,229,746

HEAT RECOVERY APPARATUS AND METHOD SUITABLE FOR LEAN CONCENTRATIONS OF A BURNABLE GAS

Original Filed Nov. 13, 1961 5 Sheets-Sheet 4

Fig. III.

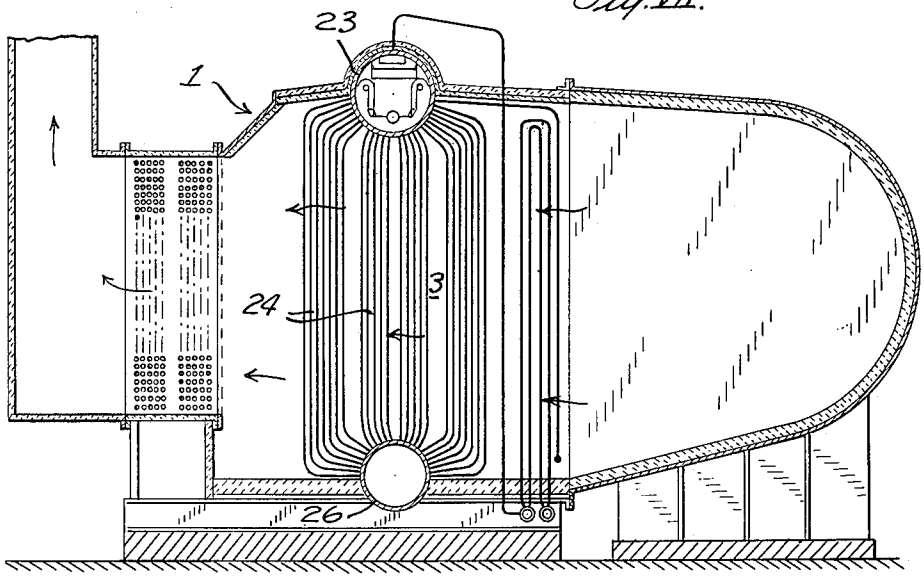


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HEAT RECOVERY APPARATUS AND METHOD SUITABLE FOR LEAN CONCENTRATIONS OF A BURNABLE GAS

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Fig. VII.



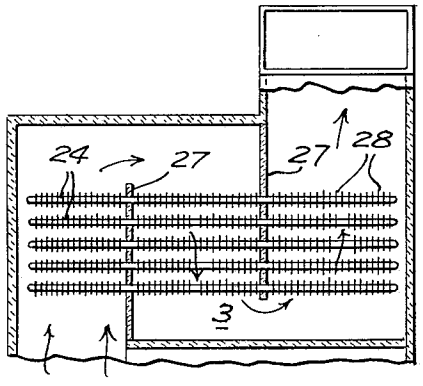


Fig. VIII.

INVENTORS
KENNETH R. WAGNER
PETER VON WIESENTHAL

BY Charles L. Bagley

ATTORNEY

United States Patent Office

3,229,746

Patented Jan. 18, 1966

3,229,746

HEAT RECOVERY APPARATUS AND METHOD SUITABLE FOR LEAN CONCENTRATIONS OF A BURNABLE GAS

Kenneth R. Wagner, Jersey City, N.J., and Peter von Wiesenthal, New York, N.Y.; said Wagner assignor to Foster Wheeler Corporation, New York, N.Y., a corporation of New York

Continuation of abandoned application Ser. No. 151,786, Nov. 13, 1961. This application June 22, 1964, Ser. No. 380,974

(Filed under Rule 47(a) and 35 U.S.C. 116)

8 Claims. (Cl. 158—7)

This application is a continuation of application Serial No. 151,786, filed November 13, 1961, now abandoned.

This invention relates to the combustion of a gas in lean concentrations. It is an apparatus and method capable of this task.

Burning lean gas mixtures has been limited to high temperature combustion zones so that stable ignition can be sustained. Toward this objective, reradiant surfaces are resorted to and heat extraction is deferred until the products of combustion are passed to a heat recovery zone.

By way of illustration, this teaching will be set forth in a waste carbon monoxide burner with a heat recovery section. But it will be understood that this invention is equally suitable for burning other burnable gases wherever they occur. Viewed in the light of its air pollution control potential, the true scope of this advance becomes apparent.

Considering in detail the burning of lean carbon monoxide in the prior art, even with reradiant surfaces it has generally been necessary to burn enough auxiliary fuel so that the temperature is maintained above 1800° F. The present advance permits the stabilizing of CO ignition at a temperature in the range from 1200° to 1500° F. After startup, this lower temperature is maintained in most cases by the combustion of CO alone. In the remaining cases the auxiliary fuel requirement is minimal.

The apparatus here contemplated includes a refractory lined adiabatic combustion zone with means for intimately commingling burnable gas and oxygen.

Basically, this advance offers self sustained combustion of the lean burnable mixture with a consequent saving of auxiliary fuel. Total air requirements are reduced because auxiliary fuel requirements are lessened. Further, canalizing means can also be included to improve the commingling of burnable gas and oxygen from the air. This additional aspect improves design versatility.

Heat extraction employs convective transfer. The heat recovery zone is arranged substantially at grade level where all components are readily accessible for inspection and maintenance.

These and other advantages will appear more fully from the accompanying drawings wherein:

FIGURE I is an elevation view in section taken along line I—I of FIGURES V and VI showing a preferred organization of gas and air inlet ports in an end wall of a CO boiler embodying the present invention.

FIGURE II is a fragmentary detail section taken along line II—II of FIGURE I and showing a gas mixture conduit passing through the air chamber for access to the combustion zone.

FIGURE III is a similar fragmentary detail section taken along line III—III of FIGURE I and showing an air port with its associated deflector.

FIGURE IV is a transverse section taken along line IV—IV of FIGURE V and showing canalizing means as an open checker brick wall.

FIGURE V is a partly fragmented plan view of the heat recovery apparatus with parts broken away.

FIGURE VI is a longitudinal vertical section taken along line VI—VI of FIGURE V.

FIGURE VII is a longitudinal vertical section of the heat recovery zone and taken along line VII—VII of FIGURE V.

FIGURE VIII is a horizontal sectional view of the heat recovery apparatus.

In FIGURE V, a setting generally designated **1** defines combustion zone **2** and heat recovery zone **3** horizontally disposed at grade level. Gas is communicated to the combustion zone via gas chamber **4** and gas ports **6**. Air is introduced via air chamber **7**. The air enters the combustion chamber through air ports **8**. Secondary air to support the combustion of auxiliary fuel is admitted to the combustion chamber through conduits **9**.

As shown in FIGURE I, gas mixture and air are intimately commingled by opposing vortices indicated by directing arrows **11** and **12** created by aiming means shown as inclined conduits **13** which conduct the gas mixture from gas chamber **4** to gas port **6** and short air pipes **14**.

Start-up means shown in FIGURES I, IV and VI as auxiliary burners **16** are provided to initially heat the gases in the combustion zone to a suitable kindling temperature.

Refractory material **17** lines the combustion zone to reradiate heat to the gases therein. By this arrangement, CO in concentrations of less than 8% such as catalytic cracking off gas can be burned. Of course, higher concentrations are less difficult to accommodate. An outstanding feature of this design is that it requires less than 1% of excess oxygen as measured in the products of combustion. In chamber **2**, a temperature in the range of from 1200° to 1500° F. can conveniently be maintained so that after light off CO will usually be able to burn without the need for auxiliary fuel. Heat is liberated by the burning of CO in zone **2**. Intrinsically there is a heat liberating system operating in chamber **2**. In an extrinsic sense, combustion zone **2** has been designed so that there is practically no net heat input or heat removal to zone **2** vis-a-vis its surroundings. In particular there are on cooling devices (such as heat exchange tubes) associated with zone **2**. Throughout this specification, the term "Adiabatic combustion zone" is to be taken in its extrinsic sense.

End wall **18** is defined by partition **19**. Air ports **8** and gas ports **6** penetrate partition **19** to define substantially concentric annular groups in end wall **18**.

Canalizing means shown in FIGURES IV and VI as open checker brick wall **21** cause the combustion gases to flow through restricted canals **22** to thereby increase commingling. As best seen in FIGURES V and VII, heat recovery zone **3** is defined by setting **1** downstream of combustion zone **2**. Header **23**, tubes **24** and drum **26** are provided to pass fluid in non-contact heat exchange relationship with the combustion gases. An economizer **27** and a superheater **28** are also included.

FIGURE VI shows further details of the combustion zone **2**. The setting defines an enclosure for the combustion zone having end walls and side walls extending between the end walls. All of the walls are arranged to reradiate heat to the combustion zone via the refractory **17**. The exhaust port by which the hot gases are transmitted to the heat recovery zone **3** is at an end of the setting removed from the gas ports **6** and air ports **8**, and constitutes a sufficiently small portion of one of the side walls to maintain reradiation of heat from all walls of the enclosure at the highest level possible. At the same time, the combustion zone is sufficiently large to accommodate liberation of a major portion of the combustion heat to the refractory walls.

In addition, as shown in FIGURE VI, the heat recovery zone, the only heat sink structure of the apparatus, is completely removed from exposure to the zone. This is in comparison to conventional CO boiler installations where a heat sink in the form of water tubes either is in the combustion zone or exposed to radiant heat of the burning gases. Such a heat sink increases the requirement for auxiliary fuel and reduces to a marked extent flame stability and reliability of CO gas conversion.

It should now be apparent that this structure results in the highest temperature possible in the combustion zone for maximum efficiency in burning low B.t.u. gas with optimum combustion stability. Once the setting is hot, and as a consequence of careful introduction and mixture of combustion air and CO gas, it is possible to maintain bulk temperature above ignition temperature with little or no auxiliary fuel; i.e., the temperature of the entire body of gases is raised to a level where combustion or conversion of CO is certain to take place.

The invention has been described with respect to general principles. The applicability of these principles may vary with process specifications, for instance, the temperature level of or heat availability in the CO gas fed to the heater. However, it should be apparent that even with low heat availability, the above general principles are applicable in the conversion of CO to CO_2 towards maintaining combustion temperature.

It will be understood by those skilled in furnace construction that changes may be made in the details of this design without departing from the scope of invention defined by the claims:

What is claimed is:

1. Apparatus for the combustion of carbon monoxide from a predominately inert gas mixture having a lean concentration of the carbon monoxide, the apparatus comprising

a setting which defines an adiabatic combustion zone therein, the setting defining an enclosure having end walls and side walls between the end walls;

gas inlet means for introducing the gas mixture into one end of the combustion zone;

gas directing means at said one end for flowing the gas mixture in a vortical path in the zone;

air inlet means at said one end for introducing air into the zone so that oxygen from the air will oxidize the carbon monoxide;

air directing means at said one end for circulating the air in a vortical path in close proximity with and in an opposite rotation sense from the vortical path of the gas mixture;

means in the zone adjacent said one end for causing the commingled gas mixture and air to flow together whereby the carbon monoxide and oxygen are further commingled;

start-up means adjacent said one end for initially heating the gases in the zone to a temperature in the range of 1200° F. to 1500° F.;

the zone having a volume sufficiently large to accommodate liberation of a major portion of the combustion heat;

a low thermal conductivity refractory substantially continuously lining the end and side walls, the walls being free of heat absorbing means, by which said combustion zone is substantially adiabatic;

the refractory and walls arranged so that hot combustion gases pass in sweeping relationship thereover to heat the refractory to incandescence whereby heat is reradiated from the end walls and side walls to the zone;

exhaust means in a wall at an end of the combustion zone removed from said one end for removing the products of combustion from the zone.

2. Apparatus for the combustion of a burnable gas from a predominately inert gas mixture having a lean concentration of the burnable gas, the apparatus comprising

a setting which defines an adiabatic combustion zone therein, the setting defining an enclosure having end walls and side walls between the end walls,

the setting defining gas inlet ports for introducing the gas mixture into the zone at one end thereof,

gas directing means operatively associated with the gas inlet ports flowing the gas mixture in a vortical path in the zone,

the setting defining air inlet ports at said one end for introducing air into the zone at the end to oxidize the burnable gas,

air directing means operatively associated with the air inlet ports for flowing the air in a vortical path in close proximity with and in an opposite rotation sense from the gas mixture whereby the burnable gas and oxygen will be intimately commingled,

means in the zone adjacent said one end for causing the commingled gas mixture and air to flow together whereby the burnable gas and oxygen are further commingled,

start-up means adjacent said one end for initially heating the gases in the zone to a temperature in the range of 1200° F. to 1500° F.,

the zone having a volume sufficiently large to accommodate liberation of a major portion of the combustion heat,

a low thermal conductivity refractory substantially completely lining and defining an enclosure having end walls and side walls between the end walls,

the setting defining gas inlet ports for introducing the gas mixture into the zone at one end thereof,

gas directing means operatively associated with the gas inlet ports flowing the gas mixture in a vortical path in the zone,

the setting defining air inlet ports at said one end for introducing air into the zone at the end to oxidize the burnable gas,

air directing means operatively associated with the air inlet ports for flowing the air in a vortical path in close proximity with and in an opposite rotation sense from the gas mixture whereby the burnable gas and oxygen will be intimately commingled,

the zone having a volume sufficiently large to accommodate liberation of a major portion of the combustion heat,

a low thermal conductivity refractory substantially completely lining the end and side walls, the walls being free of heat absorbing means, by which said combustion zone is substantially adiabatic,

the refractory and walls arranged so that hot combustion gases pass in sweeping relationship thereover to heat the refractory to incandesence whereby heat is reradiated from the end walls and side walls to the zone,

exhaust means in a wall at an end removed from said one end for removing the products of combustion from the zone.

3. Apparatus for the combustion of a burnable gas from a predominately inert gas mixture having a lean concentration of the burnable gas, the apparatus comprising

a setting which defines an adiabatic combustion zone therein, the setting defining an enclosure having end walls and side walls between the end walls,

one end wall defining a plurality of ports arranged in at least two groups including a first group and a second group annularly disposed relative each other,

gas input means for communicating the first group of ports with a source of the gas mixture for introducing the gas mixture into zone.

gas directing means operatively associated with the first ports for flowing the gas mixture in a vortical path in the zone,

air input means for communicating the second group of ports with a source of air therefor for introducing the air into the zone for oxidizing the burnable gas,

air directing means operatively associated with the second ports for flowing the air in a vortical path in close proximity with and in an opposite rotation sense from the gas vortical path,

means in the zone adjacent said one end for causing the commingled gas mixture and air to flow together whereby the burnable gas and oxygen are further commingled,

start-up means adjacent said one end for initially heating the gases in the zone to a temperature in the range of 1200° F. to 1500° F.,

the zone having a volume sufficiently large to accommodate liberation of a major portion of the combustion heat therein,

a low heat conductivity refractory material continuously lining the side walls and end walls to line the zone, the walls being free of heat absorbing means by which said combustion zone is substantially adiabatic,

the refractory and walls arranged so that hot combustion gases pass in sweeping relationship thereover to heat the refractory to incandescence whereby heat is reradiated to the zone,

exhaust means in a wall at an end of the combustion zone removed from said one end for removing the products of combustion from the zone.

4. Apparatus for the combustion of a burnable gas from a gas mixture having a lean concentration of the burnable gas, the apparatus comprising

a setting which defines an adiabatic combustion zone therein, the setting including an enclosure having opposed end walls and side walls between the end walls,

one end wall at one end of the combustion zone comprising a partition defining a plurality of gas ports, gas input means communicating with the gas ports with a supply of gas mixture for introducing the gas mixture into the zone, the gas ports arranged in the partition to define a circular configuration,

a gas deflector means associated with each gas port to direct the gas mixture issuing into the zone in a vortical path,

the partition defining a plurality of air ports, air input means communicating the air ports with a supply of air, the air ports arranged in the partition in an inner and outer circular configuration each concentric relative the gas port configuration, the inner circular configuration inward of the circular configuration described by the gas ports,

the outer circular configuration outward of the circular configuration described by the gas ports, an air deflector means associated with the air inlet ports arranged to direct the air in inner and outer vortical paths in close priximity and in an opposite rotation sense from the path of the gas mixture whereby the combustible gas and oxygen from the air will be intimately commingled,

canalizing means in the zone adjacent said one end causing the commingled gas mixture and air to flow together whereby the burnable gas and oxygen are further commingled,

start-up means at said one end for initially heating the gases in the zone to a temperature in the range of 1200° F. to 1500° F.,

the zone having a volume sufficiently large to accommodate liberation of a major portion of the combustion heat,

a low thermal conductivity refractory substantially continuously lining the end and side walls to line the zone, the walls being free of heat absorbing means, by which said combustion zone is substantially adiabatic, arranged so that hot combustion gases pass in sweeping relationship thereover to heat the refractory to incandesence whereby heat is reradiated from the end walls and side walls to the zone,

exhaust means comprising at least one aperture in a wall of the combustion zone adjacent an end removed from said one end for removing the products of combustion from the zone, the aperture being sized to maintain reradiation to the zone at the highest level possible.

5. The apparatus of claim **4** wherein the setting forms a gas chamber and an air chamber, the air chamber positioned between the combustion zone and the gas chamber, a plurality of conduits connected between the gas chamber and the combustion zone, each gas port communicating in flow series with the source of the gas mixture via the gas chamber and the gas conduits, the inlet ports communicating in flow series with the source of air via the air chamber.

6. The apparatus of claim **5** with the gas conduits inclined to serve as the gas deflecting means, inclined pipes extending from the partition and terminating at the end wall to serve as the air deflecting means.

7. The apparatus of claim **6** wherein said canalizing means comprises an open checker brick wall disposed in the zone and spaced from the end wall; the open checker brick wall defining restricted canals therethrough whereby the burnable gas and oxygen are caused to flow through the restricted canals.

8. The apparatus of claim **7** the start-up means comprising at least one auxiliary burner penetrating the setting, the auxiliary burner communicating with a source of auxiliary fuel.

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PERCY L. PATRICK, *Primary Examiner.*

KENNETH W. SPRAGUE, *Examiner.*