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Inventor(s)	Rollins, JR.; Lee et al.

COMBUSTION CHAMBER FOR THE INCINERATION OF WASTE PRODUCTS

Abstract

A combustion chamber for use in the incineration of waste products includes an inner refractory wall which extends vertically within an outer protective wall in a spaced relationship so as to define a plenum therebetween. The inner refractory wall is constructed using a plurality of precast, refractory blocks which are stacked and arranged to define a cylindrical interior cavity. The refractory blocks include mating features on adjacent surfaces to facilitate assembly and provide structural support. For additional support, selected blocks are fixedly connected to vertical support tubes by metal tie-back anchors. To facilitate combustion, a selection of the blocks is precast with a tuyere hole in order to deliver a uniform and balanced supply of air from the plenum into the interior cavity. The precast nature of the refractory blocks enables the inner refractory wall to be constructed with great precision, thereby optimizing incineration and minimizing material degradation.

Inventors: **Rollins, JR.; Lee (Wells, ME), Souders; Russ (Flourtown, PA)**

Applicant: **Zampell Refractories, Inc.** (Newburyport, MA)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of presently-pending U.S. patent application Ser. No. 17/128,878, which was filed on Dec. 21, 2020 in the names of Lee Rollins, Jr., et al., which, in turn, claims the benefit under 35 U.S.C. 119(e) to U.S. Provisional Patent Application No. 62/954,721, which was filed on Dec. 30, 2019 in the names of Lee Rollins, Jr., et al., the disclosures of both applications being incorporated herein by reference.

FIELD OF THE INVENTION
[0002] The present invention relates generally to waste disposal and, more particularly, to combustion chambers utilized to incinerate waste products.
BACKGROUND OF THE INVENTION
[0003] A combustion chamber, or cell, is a well-known structure that is commonly used to incinerate waste products through the application of intense heat, which is typically in excess of 1000° C. For instance, wood production facilities often utilize a combustion cell to dispose of wood waste, such as sawdust and bark, created from the manufacture of wood-based products.
[0004] The heat generated by combustion chambers can, in turn, be utilized in a wide range of additional applications. For instance, in wood-based product manufacturing, the heat produced by combustion chambers is often used in the drying of finished, wood-based products. Heat produced from combustion chambers is also commonly applied to water to produce steam, which is subsequently used for, inter alia, district heating, hot water generation, and the generation of electricity by turbine generator.
[0005] Conventionally, a combustion cell is constructed as an enlarged, tower-like, chamber which includes an inner cylindrical wall that extends vertically within an outer wall, the inner wall being spaced in from the outer wall so as to define a plenum therebetween. The inner wall defines an enlarged, cylindrical interior cavity, or combustion zone, with an opening, or gas outlet, at its top end through which heat from the combustion zone escapes. A combustion grate is typically mounted at the bottom of inner wall and serves to support the waste products intended for incineration. An externally-accessible chute penetrates through both outer and inner walls at a downward angle and into communication with the combustion zone, thereby allowing for the delivery of waste product into the interior cavity.
[0006] As previously noted, a plenum is established between the outer and inner walls and allows for the delivery of air into the combustion zone to facilitate the incineration process. The primary supply of air for combustion is delivered into the interior cavity through the combustion grate. As a secondary source of air into the combustion zone, a series of small nozzles, or tuyere holes, generally circular in transverse cross-section, extend radially through the inner wall and thereby establish a fluid communication path between the plenum and the interior cavity. As can be appreciated, the number, arrangement, geometric configuration, openness, and angle of orientation of the nozzles all contribute to the effectiveness in maintaining efficient combustion of wood waste within the interior cavity.

[0007] Due to the intense heat generated within the combustion zone, it is required that the inner wall be constructed of a suitable heat-resistant material. Traditionally, the inner wall is constructed using a cylindrical, expanded metal (i.e. perforated) backbone, or support, which is welded in place. A unitary refractory liner is then applied onto the interior of the expanded metal support.

[0008] The refractory liner is typically constructed of a heat-resistant material that is initially deformable but eventually hardens through a curing process. For instance, refractory liner may be constructed of either a heat-resistant moldable refractory that is compacted with pneumatic tools onto the inner surface of the expanded metal support or a concrete-based mixture that is cast-in-place or shotcrete against the inner surface of the expanded metal support.

[0009] Prior to or during installation, tubular sleeves, often constructed using polyvinyl chloride (PVC) piping or wooden dowels, are placed within the boundaries of the lining to act as form blanks to create the nozzle openings. Additionally, the deformable nature of the pre-cured refractory liner allows for its penetration through the perforations in the expanded metal support and thereby form a means of interconnection. Upon curing of the refractory liner, the tubular sleeves are removed from the refractory liner to yield the plurality of airflow nozzles used to supplement the delivery of air into the combustion zone.

[0010] The refractory liner of a combustion chamber is subjected to various forms of attack which can compromise its integrity. In particular, a combustion cell utilized to incinerate wood-based products continuously subjects the refractory liner to heat, abrasion, and alkali attack. These various factors often cause the refractory liner to degrade over time, resulting in a number of harmful effects.

[0011] As a first effect, degradation of the refractory liner can change the geometry of the airflow nozzles, resulting in nozzles becoming blocked with ash and constricting, or even reversing, the designated airflow. As a consequence, combustion often becomes stifled and airflow velocity increases which, in turn, produces refractory liner abrasion and creates unbalanced combustion within the interior cavity that can accelerate degradation in the liner in certain areas.

[0012] As a second effect, degradation of the refractory liner, particularly due to alkali attack caused by the combustion of wood, can result in its destabilization, since the expanded metal backbone only affords limited structural support to the liner. Structural destabilization of the refractory liner renders it increasingly susceptible to cracking and expansion-related failure, often rendering a combustion chamber inoperable until the refractory liner is suitably repaired or completely replaced.

[0013] As a third effect, degradation of the refractory liner exposes the expanded metal support to a greater amount of heat. Because thermal expansion of the metal support occurs at a greater rate than the refractory lining, the combustion chamber is rendered more susceptible to accelerated failure.

SUMMARY OF THE INVENTION

[0014] In view thereof, it is an object of the present invention to provide a novel combustion chamber for the incineration of waste products.

[0015] It is another object of the present invention to provide a combustion chamber of the type as described above which is durable and experiences minimal material degradation.

[0016] It is yet another object of the present invention to provide a combustion chamber of the type as described above which is designed to deliver a uniform and balanced supply of air in order to combust waste products in an efficient manner.

[0017] It is still another object of the present invention to provide a combustion chamber of the type as described above which is inexpensive to manufacture, can be installed with great precision, and is easy to maintain.

[0018] Accordingly, as one feature of the present invention, there is provided a combustion chamber for the incineration of waste products, the combustion chamber comprising (a) an outer protective wall, and (b) an inner refractory wall extending within the outer protective wall, the inner refractory wall being shaped to define an interior cavity, (c) wherein the inner wall comprises a plurality of precast, refractory blocks.

[0019] Various other features and advantages will appear from the description to follow. In the description, reference is made to the accompanying drawings which form a part thereof, and in which is shown by way of illustration, an embodiment for practicing the invention. The embodiment will be described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the scope of the invention. The following detailed description is therefore, not to be taken in a limiting sense, and the scope of the present invention is best defined by the appended claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the drawings, wherein like reference numerals represent like parts:

[0021] FIGS. **1**(*a*) and **1**(*b*) are front perspective and front plan views, respectively, of a combustion chamber constructed according to the teachings of the present invention, the combustion chamber being shown in longitudinal cross-section to illustrate certain novel features relating to its construction;

[0022] FIG. **1**(*c*) is a simplified top section view of the combustion chamber shown in FIG. **1**(*b*), taken along lines **1** (c)-**1**(*c*);

[0023] FIG. **2** is a top perspective view of a precast block set utilized in the assembly of the inner refractory wall shown in FIG. **1**(*a*);

[0024] FIGS. **3**(*a*)-(*c*) are inner perspective, right end perspective, and top plan views, respectively, of the long refractory block shown in the precast block set of FIG. **2**;

[0025] FIG. **3**(*d*) is a section view of the long refractory block shown in FIG. **3**(*c*), taken along lines **3**(*d*)-**3**(*d*);

[0026] FIGS. **4**(*a*) and **4**(*b*) are inner perspective and top plan views, respectively, of the short refractory block shown in the precast block set of FIG. **2**;

[0027] FIG. **4**(*c*) is a section view of the short refractory block shown in FIG. **4**(*b*), taken along lines **4**(*c*)-**4**(*c*);

[0028] FIGS. **5**(*a*) and **5**(*b*) are inner perspective and top plan views, respectively, of the short refractory block shown in the precast block set of FIG. **2**;

[0029] FIG. **5**(*c*) is a section view of the short refractory block shown in FIG. **5**(*b*), taken along lines **5**(*c*)-**5**(*c*);

[0030] FIGS. **6**(*a*)-**6**(*c*) are inner, right end perspective. Inner, left end perspective, and outer, right end perspective views, respectively, of the tuyere refractory block shown in the precast block set of FIG. **2**;

[0031] FIGS. **6**(*d*) and **6**(*e*) are longitudinal and lateral section views, respectively, of the tuyere refractory block shown in FIG. **6**(*a*), the figures being shown in section to illustrate the shape and orientation of the tuyere hole;

[0032] FIG. **7** is a top perspective view of the tieback refractory block shown in the precast block set of FIG. **2**, the tieback refractory block being shown exploded form with a tie-back anchor and a support tube;

[0033] FIG. **8** is a lateral section view of the tieback refractory block shown in FIG. **7**, the tieback refractory block being shown welded to the support tube by the tie-back anchor;

[0034] FIG. **9** is an enlarged, fragmentary view of the inner refractory wall shown in FIG. **1**(*c*); and

[0035] FIG. **10** is an enlarged, fragmentary, longitudinal section view of two layers of the inner refractory wall shown in FIG. **1**(*a*).

DETAILED DESCRIPTION OF THE INVENTION

Combustion Chamber **11**

[0036] Referring now to FIGS. **1**(*a*), **1**(*b*), and **1**(*c*), there is shown a combustion chamber designed for the incineration of waste products, the combustion chamber being constructed according to the teachings of the present invention and identified generally by reference numeral **11**. As will be explained further in detail below, combustion chamber **11** is constructed, in part, using a plurality of precast, modular, refractory blocks which are stacked and arranged with great precision to create an inner refractory wall which is durable, experiences minimal material degradation, and delivers a uniform and balanced supply of air for incineration.

[0037] In the description that follows, combustion chamber **11** is referenced as being primarily designed for use in the incineration of wood-based waste products. However, it should be noted that the present invention is not limited for use in the incineration of wood-based waste products. Rather, it is to be understood that the principles of the present invention could be similarly applied to combustion chambers used in the incineration of a variety of different types of waste products.

[0038] As can be seen, combustion chamber **11**, also referred to herein interchangeably as combustion cell **11** or combustion unit **11**, is constructed as an enlarged, tower-like structure which includes an inner refractory wall **13** which extends vertically within an outer protective wall, or frame, **15**. Inner wall **13** is spaced slightly in from outer wall **15** so as to define a plenum **17** therebetween. As will be explained further below, plenum **17** is provided to allow for the delivery of air used in the incineration process.

[0039] Inner refractory wall **13** is shaped to define an enlarged, generally cylindrical interior cavity, or combustion zone, **19**. Inner wall **13** is additionally shaped to define an opening, or gas outlet, **21** at the top of interior cavity **19** to allow for the escape of heat generated during incineration. Although not limited to any particular application, it is to be understood that heat exiting through opening **21** may be utilized for one or more designated purposes, such as wood drying treatments.

[0040] A combustion grate **23** is mounted on inner refractory wall **13** at the bottom of interior cavity **19**. Grate **23** is designed to support the waste products intended for incineration and is preferably constructed of a suitable material, such as a water-cooled metal. A door-enclosable access port **25**, approximately **19** inches in height, is formed in inner wall **13** proximate grate **23** to allow for the periodic cleaning, maintenance, and/or repair of the interior of combustion unit **11** when not in active operation.

[0041] Combustion chamber **11** is provided with an externally-accessible delivery chute **27** which penetrates through inner and outer walls **13** and **15** at a downward angle and into communication with combustion zone **19**. A rotatable worm drive **29** is disposed within delivery chute **27**. As can be appreciated, waste products are preferably deposited into chute **27** through enlarged exterior opening **27-1** and delivered by worm drive **29** into interior cavity **19** for subsequent incineration.

[0042] In use, intense heat, often in excess of 1000° C., is applied in the region directly above grate **23**, this region being referenced herein as reactive fuel bed **31**. To accelerate incineration, a uniform and balanced supply of air is preferably delivered into combustion zone **19**. A primary supply of air used to fuel combustion is delivered upward through grate **23** from a cylindrical air space **33** located directly beneath grate **23**, space **33** being in direct communication with plenum **17**. A secondary supply of air used to fuel combustion is preferably delivered into interior cavity through a plurality of airflow nozzles, or tuyere holes, **35** which are formed in an optimal configuration within inner refractory wall **13** to ensure balanced airflow delivery, the particular details of tuyere holes **35** to be described in detail further below.

[0043] As can be appreciated, the unique construction of inner refractory wall **13** provides construction chamber **11** with a number of notable advantages over traditional combustion cells. Most notably, inner refractory wall **13** of combustion chamber **11** is constructed, in part, using a refractory block set **101** of the type as shown in FIG. **2**. As can be seen, refractory block set **101** is comprised of multiple varieties of modular, refractory blocks, which can be selected and stacked in a predefined arrangement to construct inner wall **13**. As can be appreciated, the precast and modular nature of the refractory blocks in set **101** serves not only to facilitate assembly and, if necessary, replacement but also to ensure construction with great accuracy and precision, particularly with respect to the location, geometric shape and angle of orientation of tuyere holes **35**, which is a principal object of the present invention.

Refractory Block Set **101**

[0044] As seen in FIG. **2**, refractory block set **101** is shown comprising a long refractory block **111**, a short refractory block **131**, a medium-length refractory block **151**, a tuyere refractory block **171** and a tieback refractory block **191**. As can be appreciated, blocks **111**, **131**, **151**, **171**, and **191** serve as the foundational pieces, or building blocks, which are selected and arranged into stacked circular levels to form uniform inner wall **13**.

[0045] It should be noted that the particular number and arrangement of each of blocks **111**, **131**, **151**, **171**, and **191** are preferably selected by an engineer based on the desired dimensions of inner wall **13** as well as the intended application. Accordingly, the particular arrangement of blocks **111**, **131**, **151**, **171**, and **191** shown in combustion chamber **11** is provided for illustrative purposes only and modifications could be readily implemented thereinto without departing from the spirit of the present invention.

[0046] Additionally, it should be noted that refractory block set **101** could include additional modular refractory blocks designs, not shown herein, without departing from the spirit of the present invention. As can be appreciated, the greater number of available refractory block shapes and styles serves to enhances the flexibility in optimizing the configuration of inner refractory wall **13**.

[0047] Referring now to FIGS. **3**(*a*)-(*c*), long refractory block **111** is shown in greater detail. As can be seen, refractory block **111** is precast as a unitary, modular component. Preferably, block **111** is precast using any suitable heat-resistant material, such a concrete mixture. As can be appreciated, the precast construction of block **111** ensures dimensional accuracy as well as material consistency (e.g., eliminating the presence of bubbles), which is not readily obtainable in traditional cast-in-place constructions.

[0048] Block **111** is solid, brick-like member with a slight, yet consistent, radial curvature and includes a flat top surface **113**, a flat bottom surface **115**, an arcuate inner surface **117**, an arcuate outer surface **119**, a flat left end surface **121**, and a flat right end surface **123**. Dimensionally, block **111** preferably has a uniform width W.sub.1 of approximately 9 inches, a uniform height H.sub.1 of approximately 6.4375 inches, and extends in length along an arc A.sub.1 of approximately 20 degrees to yield an inner arc length L.sub.I1 of approximately 11.375 inches and an outer arc length L.sub.O1 of approximately 14.5 inches. However, it is to be understood that the block **111** is not limited to the aforementioned dimensions and could be resized, as needed, without departing from the spirit of the present invention.

[0049] A projection **125**, semi-circular in transverse cross-section, protrudes upward from top surface **113** along its centerline. Additionally, a recess **126**, semi-circular in transverse cross-section, is formed in bottom surface **115** along its centerline. Both projection **125** and recess **126** have a radius of approximately 1 inch and thereby serve as complementary surface mating features, as will be described further below.

[0050] Projection **125** extends along the majority of the length of block **111**, with projection **125** extending just beyond left end surface **121** to form a tongue **127**. Tongue **127** extends vertically across left end surface **121** and is generally semi-circular in cross-section, as seen most clearly in FIG. **3**(*c*). A complementary groove **129**, generally semi-circular in cross-section extends vertically in right end surface **123**, with groove **129** having the same radius as tongue **127**.

[0051] In this manner, it is to be understood that multiple blocks **111** are adapted to be stacked directly upon one another, with projection **125** of a lower block **111** protruding into recess **126** in an upper, or stacked, block **111**. In this manner, this interlocking arrangement between projection **125** and recess **126** serves not only to facilitate proper registration between a stacked pair of blocks **111** but also to provide structural support and thereby minimize the risk of inner wall destabilization over time.

[0052] Similarly, it is to be understood that multiple blocks **111** are adapted to be configured in an end-to-end relationship, with tongue **127** of one block **111** protruding into groove **129** in an adjacent, or neighboring, block **111**. This interlocking arrangement between tongue **127** and groove **129** also serves to facilitate proper registration between an adjacent pair of blocks **111** and provide structural support to inner refractory wall **13**, which is highly desirable.

[0053] As referenced above, the dimensions of block **111** could be readily modified without departing from the spirit of the present invention. Most notably, arc A.sub.1 of block could be adjusted to provide the designer of inner refractory wall **13** with greater flexibility in its structural configuration.

[0054] As an example, in FIGS. **4**(*a*)-(*c*), short refractory block **131** is shown in greater detail. As can be seen, short refractory block **131** is identical to refractory block **111** in that short refractory block **131** is precast as a unitary, modular component using any suitable heat-resistant material, such a concrete mixture.

[0055] Refractory block **131** is also identical to refractory block **111** in that refractory block **131** is constructed as solid, brick-like member with a slight, yet consistent, radial curvature and includes a flat top surface **133**, a flat bottom surface **135**, an arcuate inner surface **137**, an arcuate outer surface **139**, a flat left end surface **141**, and a flat right end surface **143**.

[0056] As further similarities, a projection **145**, semi-circular in transverse cross-section, protrudes upward from top surface **133** along its centerline and mates with a semi-circular recess **146** formed in bottom surface **135** along its centerline. Additionally, a tongue **147**, semi-circular in transverse cross-section, extends vertically across left end surface **141** and mates with a complementary groove **149** extending vertically in right end surface **143**.

[0057] Refractory block **131** only differs from refractory block **111** in its dimensions. Although refractory block **131** has a uniform width W.sub.2 of approximately 9 inches, which is identical to refractory block **111**, and a uniform height H.sub.2 of approximately 6.4375 inches, which is identical to refractory block **111**, refractory block **131** is considerably shorter in length than refractory block **111**.

[0058] Notably, refractory block **131** extends in length along an arc A.sub.2 of approximately 10 degrees to yield an inner arc length L.sub.I2 of approximately 5.6875 inches and an outer arc length L.sub.O2 of approximately 7.25 inches. As such, refractory block **131** is one-half the length of refractory block **111**.

[0059] As another example, in FIGS. **5**(*a*)-(*c*), medium-length refractory block **151** is shown in greater detail. As can be seen, medium refractory block **151** is identical to refractory block **111** in that medium refractory block **151** is precast as a unitary, modular component using any suitable heat-resistant material, such a concrete mixture.

[0060] Refractory block **151** is also identical to refractory block **111** in that refractory block **151** is constructed as solid, brick-like member with a slight, yet consistent, radial curvature and includes a flat top surface **153**, a flat bottom surface **155**, an arcuate inner surface **157**, an arcuate outer surface **159**, a flat left end surface **161**, and a flat right end surface **163**.

[0061] As further similarities, a projection **165**, semi-circular in transverse cross-section, protrudes upward from top surface **153** along its centerline and mates with a semi-circular recess **166** formed in bottom surface **155** along its centerline. Additionally, a tongue **167**, semi-circular in transverse cross-section, extends vertically across left end surface **141** and mates with a complementary groove **169** extending vertically in right end surface **163**.

[0062] Refractory block **151** only differs from refractory block **131** in its dimensions. Although refractory block **151** has a uniform width W.sub.3 of approximately 9 inches, which is identical to refractory block **111**, and a uniform height H.sub.3 of approximately 6.4375 inches, which is identical to refractory block **111**, refractory block **151** is considerably shorter in length than refractory block **111** but greater in length than refractory block **131**.

[0063] Notably, refractory block **151** extends in length along an arc A.sub.3 of approximately 16 degrees to yield an inner arc length L.sub.I3 of approximately 9.125 inches and an outer arc length Los of approximately 11.625 inches. As such, the length of refractory block **151** lies between the lengths of refractory blocks **111** and **131**.

[0064] Referring now to FIGS. **6**(*a*)-(*e*), tuyere refractory block **171** is shown in greater detail. As will be explained further in detail below, each block **171** is precast to define a single tuyere hole, or airflow nozzle, **31**. Due to the precast nature of block **171**, the exact position, dimensions, and angle of orientation of airflow nozzle **31** can be ensured with great precision. As a result, combustion cell **11** is more effective in sustaining efficient and balanced combustion of waste products.

[0065] By contrast, the conventional practice of creating tuyere holes by ramming and subsequently removing cylindrical sleeves into a one-piece, curable, refractory lining has been found to be difficult to implement with great precision. As a result, airflow nozzles are often arranged and formed in conventional refractory linings with widespread variances and inconsistencies, which is highly undesirable.

[0066] As can be seen, tuyere refractory block **171** is identical to refractory block **111** in that refractory block **171** is precast as a unitary, modular component using any suitable heat-resistant material, such a concrete mixture.

[0067] Refractory block **171** is also identical to refractory block **111** in that refractory block **171** is constructed as solid, brick-like member with a slight, yet consistent, radial curvature and includes a flat top surface **173**, a flat bottom surface **175**, an arcuate inner surface **177**, an arcuate outer surface **179**, a flat left end surface **181**, and a flat right end surface **183**.

[0068] As further similarities, a projection **185**, semi-circular in transverse cross-section, protrudes upward from top surface **173** along its centerline and mates with a semi-circular recess **186** formed in bottom surface **175** along its centerline. Additionally, a tongue **187**, semi-circular in transverse cross-section, extends vertically across left end surface **181** and mates with a complementary groove **189** extending vertically in right end surface **183**.

[0069] The exterior dimensions of refractory block **171** are also identical to refractory block **111**. In fact, block **171** only differs from refractory block **111** in its inclusion of tuyere hole **31**. As can be seen, tuyere hole **171** is in the form of a tubular bore with a circular cross-section of uniform diameter D along its length, diameter D preferably being approximately 1.375 inches.

[0070] Tuyere hole **31** is designed to extend in a downward and right-to-left direction from outer surface **179** to inner surface **177**, with one end **31-1** located in the corner of outer surface **179** proximate top surface **173** and right end surface **183** and the other end **31-2** located in the corner of inner surface **177** proximate bottom surface **175** and left end surface **181**. Preferably, tuyere hole **31** is pitched so as to extend at a downward angle θ.sub.1 of approximately 15 degrees and a right-to-left, or horizontal, angle θ.sub.2 of approximately 45 degrees. As can be appreciated, the dimension and orientation of tuyere hole **31** is optimized to deliver an efficient and balanced airflow supply into combustion zone **19**.

[0071] Referring now to FIGS. **7** and **8**, tieback refractory block **191** is shown in greater detail. As will be explained further in detail below, each tieback block **191** is uniquely designed to facilitate its securement to a fixed support structure. As a result, the inclusion and fixed securement of tieback blocks **191** provides anchored structural support to inner wall **13** so as to minimize the risk of destabilization over time.

[0072] As can be seen, tieback refractory block **191** is identical to refractory block **111** in that tieback refractory block **191** is precast as a unitary, modular component using any suitable heat-resistant material, such a concrete mixture.

[0073] Tieback refractory block **191** is also identical to refractory block **111** in that refractory block

191 is constructed as solid, brick-like member with a slight, yet consistent, radial curvature and includes a flat top surface **193**, a flat bottom surface **195**, an arcuate inner surface **197**, an arcuate outer surface **199**, a flat left end surface **201**, and a flat right end surface **203**.

[0074] As further similarities, a projection **205**, semi-circular in transverse cross-section, protrudes upward from top surface **193** along its centerline and mates with a semi-circular recess **206** formed in bottom surface **195** along its centerline. Additionally, a tongue **207**, semi-circular in transverse cross-section, extends vertically across left end surface **201** and mates with a complementary groove **209** extending vertically in right end surface **203**.

[0075] The exterior dimensions of refractory block **191** are also largely identical to refractory block **111**. However, block **191** differs from refractory block **111** in that block **191** is shaped to include an external groove, or recess, **211** which is suitably dimensioned to receive an L-shaped tie-back **213**. As will be explained further below, tie-back **213** is designed for fixed securement to a support structure in order to stabilize inner wall **13**.

[0076] As can be seen, external groove **211** is generally circular in transverse cross-section and has a uniform diameter of approximately 0.5 inches. External groove **211** is generally L-shaped and includes (i) a horizontal portion **211-1** formed in top surface **193** which extends radially inward from outer surface **199** at its approximate midpoint, and (ii) a vertical portion **211-2** which extends orthogonally downward from the inner end of horizontal portion **211-1**, vertical portion **211-2** extending down from top surface **193** towards bottom surface **195** for a depth of approximately 3 inches.

[0077] External groove **211** in block **191** is designed to retain a corresponding tie-back anchor, or tie-back, **213**. Tie-back **213** is constructed as a unitary, L-shaped rod constructed of a rigid and durable material, such as stainless steel. In the present embodiment, tie-back **213** has a uniform diameter of 0.5 inches and includes a horizontal segment **213-1** and a vertical segment **213-2** extending at a right angle.

[0078] As shown in FIG. **8**, tie-back **213** is designed for fitted insertion in external groove **211**, with horizontal segment **213-1** of tie-back **213** lying within horizontal portion **211-1** in block **191** and vertical segment **213-2** of tie-back **213** projecting within vertical portion **211-2** in block **191**. Mounted into engagement as such, the distal end of horizontal segment **213-1** of tie-back **213** protrudes beyond outer surface **199** of block **191**.

[0079] A vertical support tube **221** extending in abutment against outer surface **199** of block **191**. In the present embodiment, tube **221** is represented as an elongated tubular member, constructed of a rigid and durable material, with a 2-inch square shape in transverse cross-section. As a feature of the invention, the distal end of tie-back **213** preferably aligns flush against a side surface of tube **211**. Therefore, by directly welding tie-back **213** to side surface of tube **211**, block **191** (and effectively all other blocks connected thereto) is provided rigid anchored support from tube **221**.

Design and Assembly of Inner Wall **13**

[0080] Referring back to FIGS. **1**(*a*)-(*c*), inner wall **13** of combustion chamber **11** is preferably constructed, at least in part, in the following manner. First, prior to assembly, a plurality of support tubes **221** are arranged in a circular configuration so as to define the outer diameter of inner wall **13**. Tubes **221** extend vertically and are preferably welded, or otherwise fixedly secured to, outer wall **15**.

[0081] As seen most clearly in FIG. **1**(*c*), tubes **221** are preferably spaced evenly apart from one another so as to provide uniform support for inner wall **13**. In the present embodiment, eighteen tubes **221** are spaced apart at 20-degree intervals. As such, the requisite number of evenly-spaced tieback blocks **191** in each layer (e.g. nine tieback blocks **191**) is able to anchor onto a corresponding set of tubes **221**.

[0082] With support tubes **221** installed, the design of inner wall **13** is formulated using refractory block set **101**. The particular selection and arrangement of blocks **111**, **131**, **151**, **171**, and **191** utilized to construct inner wall **13** as a complete sealed ring are determined based on, inter alia, the desired dimensions, structural needs, and airflow requirements of combustion unit **11**.

[0083] Once design of inner wall **13** is formulated, the selection of refractory blocks from set **101** are stacked, layer by layer, in the predetermined arrangement, with the interlocking mating faces of adjacent refractory blocks not only facilitating proper registration but also providing enhanced structural support, as shown in FIGS. **9** and **10**. The four-sided interlocking of each refractory block with its neighboring blocks also enables the interior surface of inner wall **13** to wear away by nearly half of its thickness without disruption to the intermating feature established between adjacent surfaces. As part of the assembly process, all other essential components of combustion unit **11** (e.g., outlet **21**, grate **23** access port **25**, chute **27**) are properly integrated into inner wall **13** during the stacking of the selection of refractory blocks **111**, **131**, **151**, **171** and/or **191**.

[0084] Preferably, a refractory mortar (not shown) is preferably applied in the joint, or spacing, between adjacent blocks for bonding purposes in order to create a uniform interior surface and ensure structural integrity. Preferably, a thin, uniform layer of the mortar (e.g., approximately 0.0625 inches in thickness) is applied to effectuate bonding without distorting proper positioning.

[0085] Ideally, a predefined number of tieback blocks **191** are utilized in each layer, with variability in the location and/or number of tieback blocks **191** created through selection amongst the different lengthened blocks **111**, **131** and **151**. Tieback blocks **191** are therefore preferably arranged for welding to corresponding tubes **221** by tie-backs **213**. As a feature of the invention, the welding of tieback blocks **191** to support tubes **221** eliminates the need for the expanded metal support utilized in traditional combustion units and thereby remedies the various shortcomings associated therewith.

[0086] As seen in FIG. **1**(*c*), each layer of inner wall **13** preferably secures a tieback block **191** to a first set of alternating (i.e. every other) support tubes **221**, with adjacent layers of wall **13** preferably securing a tieback block **19** to the remaining (i.e. second set) of alternating support tubes **221**. In this fashion, support to inner wall **13** is uniformly distributed.

[0087] Additionally, a predefined number of tuyere blocks **171** is preferably utilized and equidistantly arranged in each layer to provide the necessary secondary airflow required to optimize combustion within interior cavity **19**. By ensuring balanced and efficient combustion within unit **11**, any degradation of inner wall **13** is greatly minimized. Furthermore, because blocks **171** are precast, the shape and dimension of each tuyere hole **31** is formed with considerable precision.

[0088] As can be appreciated, the construction of inner wall **13** using a plurality of precast refractory blocks improves its overall structural integrity and manufacturing precision. As an additional benefit, the modular nature of inner wall **13** allows for sections thereof to be simply and easily restored using replacement refractory blocks, as needed.

[0089] The invention described in detail above is intended to be merely exemplary and those skilled in the art shall be able to make numerous variations and modifications to it without departing from the spirit of the present invention. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.

Claims

1. A method for constructing a combustion chamber for the incineration of waste products, the method comprising the steps of: (a) installing an outer protective wall; (b) providing a plurality of precast, refractory blocks, each of the plurality of precast, refractory blocks comprising a top surface, a bottom surface, an inner surface, an outer surface, a left end surface, and a right end surface, all of the plurality of precast, refractory blocks having a common width in the horizontal direction between the inner surface and the outer surface, wherein a selection of the plurality of precast, refractory blocks is precast to define a tuyere hole extending therethrough; (*c*) selecting and assembling the plurality of refractory blocks in a predefined, side-by-side, and stacked arrangement to create an inner refractory wall that extends within the outer protective wall, the inner refractory wall being shaped to define an interior cavity, wherein the selection of refractory blocks precast with a tuyere hole is optimally arranged within the inner refractory wall to ensure balanced airflow delivery into the interior cavity.

2. The method as claimed in claim 1 wherein the tuyere hole is circular in transverse cross-section.

3. The method as claimed in claim 2 wherein the tuyere hole extends downward and horizontally from the outer surface to the inner surface.

4. The method as claimed in claim 1 wherein the plurality of refractory blocks includes a variety of refractory blocks of different lengths.

5. The method as claimed in claim 4 wherein the variety of refractory blocks is arranged to create the inner refractory wall with a desired dimension.

6. The method as claimed in claim 5 wherein a joint is formed between adjacent refractory blocks in the inner refractory wall.

7. The method as claimed in claim 6 further comprising the step of applying refractory mortar in the joint between adjacent refractory blocks in the inner refractory wall.

8. The method as claimed in claim 7 wherein the inner refractory wall is spaced in from the outer protective wall so as to define a plenum therebetween.

9. The method as claimed in claim 8 wherein the plurality of precast, refractory blocks matingly engages one another when stacked in layers.

10. The method as claimed in claim 9 wherein the inner surface for each of the plurality of precast, refractory blocks has a fixed radial curvature.

11. The method as claimed in claim 10 wherein a projection is formed on the top surface of each of the plurality of precast, refractory blocks.

12. The method as claimed in claim 11 wherein a recess is formed on the bottom surface of each of the plurality of precast, refractory blocks.

13. The method as claimed in claim 12 wherein the recess on one of the plurality, of precast, refractory blocks is dimensioned to fittingly receive the projection on another of the plurality of precast, refractory blocks when arranged in a stacked relationship.

14. The method as claimed in claim 13 wherein a tongue extends out from one of the left end surface and the right end surface of each of the plurality of precast, refractory blocks.

15. The method as claimed in claim 14 wherein a groove is formed in the other of the left end surface and the right end surface of each of the plurality of precast, refractory blocks.

16. The method as claimed in claim 15 wherein the groove on one of the plurality, of precast, refractory blocks is dimensioned to fittingly receive the tongue on another of the plurality of precast, refractory blocks when arranged in an end-to-end relationship.