Sept. 27, 1932. W. C. DRAKE 1,880,187

WATER WALL

Filed March 31, 1926 2 Sheets-Sheet 1

Fig. 1.

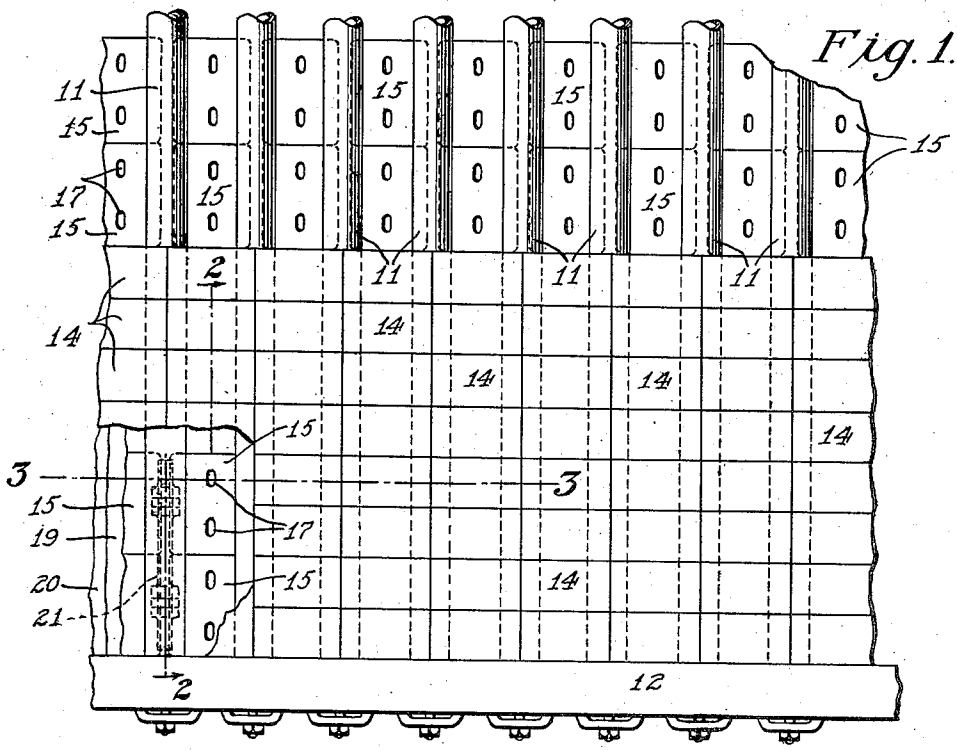


Fig. 2.

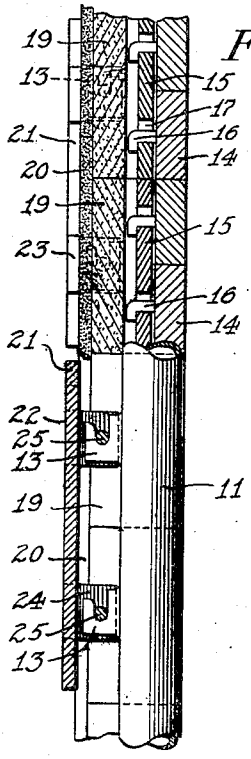
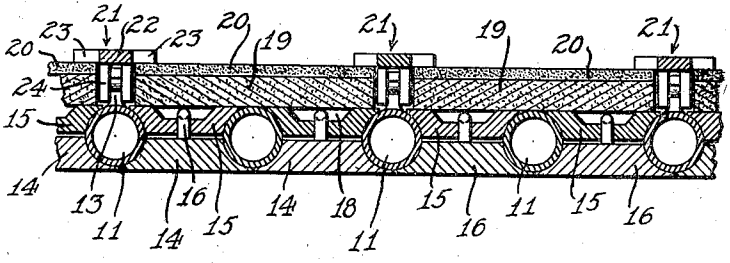


Fig. 3.



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Fig. 4.

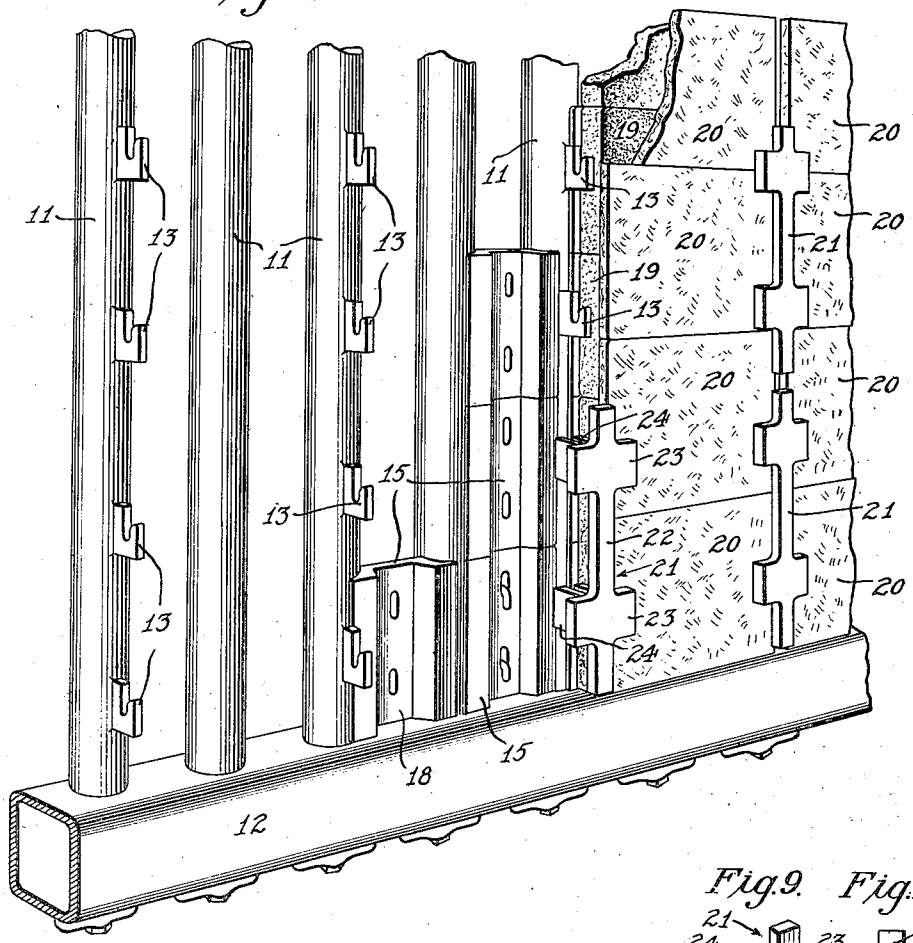


Fig. 5.

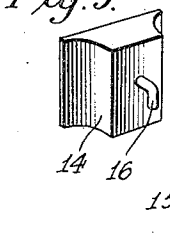


Fig. 6.

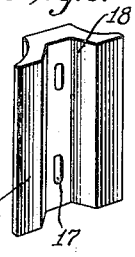


Fig. 7.

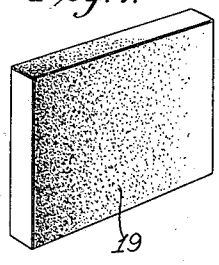


Fig. 8.

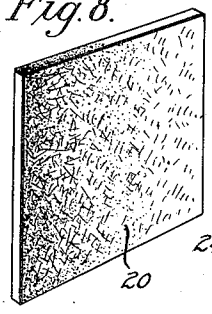


Fig. 9.

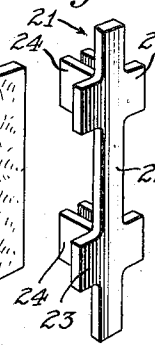
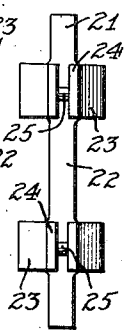


Fig. 10.



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Patented Sept. 27, 1932 1,880,187

UNITED STATES PATENT OFFICE

WARREN C. DRAKE, OF INWOOD, NEW YORK, ASSIGNOR TO ERNEST B. PRIEBE AND HARRY BUCHERT, BOTH OF NEW YORK, N. Y.

WATER WALL

Application filed March 31, 1926. Serial No. 98,846.

This invention is a novel water wall, that is to say, a construction for the walls of the combustion chamber of a furnace, for example pertaining to a water tube boiler, in which construction the boiler water is circulated through the wall to increase the evaporation and prevent overheating of the wall; referring more especially to the lateral walls of the furnace, although in some cases certain features may be used with bottom or other walls.

Water walls as heretofore used have not proved wholly satisfactory, and the general object of the present invention is to afford a construction of water wall which will be effective in use and avoid the defects of prior known water walls. A particular object of the invention is to afford a water wall structure which is self contained, the various elements being so interconnected as to be self supporting and requiring no exterior bracing or supporting means. A further object is to afford a water wall which will be light in weight, simple and inexpensive in structure and easy to assemble, yet strong and durable in use. Further objects are to give quick heat transfer to the water tubes or wall passages without direct exposure thereof to the radiant heat, to render the wall tubes durable by suitable protection, and to present to the combustion chamber a substantially flat or uninterrupted wall surface, without substantial depressions or projections. Other objects and advantages will be pointed out in the description following or will be apparent to those skilled in the subject.

To the attainment of the objects and advantages referred to the present invention consists in the novel water wall and the novel features of construction, arrangement, combination and detail herein illustrated or described.

In the drawings Fig. 1 is an interior face view of a water wall embodying the present invention, the same partly broken away in the lower left corner to show certain interior construction.

Fig. 2 is a vertical section taken on the broken line 2—2 of Fig. 1.

Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 1.

Fig. 4 is a perspective view from the exterior showing in different parts of the figures various stages in the building up of the wall structure.

Figs. 5, 6, 7 and 8 are perspective views of the successive wall elements from the interior to the exterior.

Fig. 9 is a perspective view of one of the clamping or locking irons or members by which the assemblage is permanently secured in position.

Fig. 10 is an interior elevation view of one of the clamp members.

The water tubes 11 may be substantially vertical, or with an upward and downward trend. They are shown spaced slightly apart and all connected in a usual manner with a lower header 12 and there may be a similar upper header. Locking projections, couplings, brackets or hooks 13 are provided at the outer sides or surfaces of the tube 11, or on certain of the tubes; for example alternate tubes are shown as provided with such hooked projections, each of such tubes having a vertical series thereof to receive the locking irons or clamp members to be described; but the arrangement may be varied. Preferably the hooks 13 are welded upon the tubes so as to give strength and permanence.

The water wall as a whole consists of the water tubes 11, which are usually in circulation with the boiler, and the further elements to be described arranged to close the spaces between the tubes so as to present a solid wall facing the combustion chamber. The innermost wall members are heat conductive blocks or elements 14 shaped to give a flat face presented to the flames and with flanged or curved sides snugly engaging and enclosing the water tubes, the concave curve preferably conforming to the tube at each side. Complementary to the blocks 14 are blocks or elements 15, located directly at the outer side of the tube line, and having similar flanges and concavely shaped to fit the curvature of adjacent tubes. It will be seen that the blocks 14 and 15 are complementary and mutually enclose the tubes. The flanges of the inner

blocks 14 meet to present an unbroken inner wall while the flanges of the outer blocks 15 fall slightly short of meeting so as to give clearance for the coupling hooks 13. The complementary blocks 14 and 15 may be interlocked, for example by means of locking extensions or hooks 16 embedded in and projecting outwardly from the blocks 14 and engaging in recesses or slots 17 formed in the blocks 15. For this the illustrated downwardly bent hook is suitable.

Each of the blocks 15 it will be noticed is exteriorly vertically recessed or channelled at 18, so as to allow a space in which can be accommodated the extremities of the locking hooks 16.

Each of the inner blocks may be of half the vertical dimension of each of the outer blocks as shown so that two of the inner blocks may be engaged with each one of the outer blocks by means of two separate slots in the latter.

The wall structure thus far described has advantages in itself irrespective of the members yet to be described. Gravity holds the several blocks down upon the lower header and the blocks are properly alined and interlocked so as to surround and protect the tubes. The blocks 14 and preferably also the blocks 15 are constructed of good heat conducting material which is also refractory to resist destruction. A suitable material is silicon carbide, although cast iron or other conductive refractory will sometimes do equally well. By this feature the heat received at the wall is quickly transmitted to the tubes and serves to heat and evaporate the water circulating in the tubes, thus increasing the evaporation of the boiler, while the circulation carries off the heat and prevents overheating of the wall. It may sometimes be sufficient to provide the inner blocks 14 surrounding only the lower part of the combustion chamber, and in Fig. 1 an arrangement is shown whereby the upper part of the combustion chamber is surrounded directly by a wall structure comprising the water tubes 11 and the heat conducting exterior blocks 15 between the tubes, held in place by the welded coupling 13, these outer blocks 15 in this case preferably being formed without the holes or slots 17 referred to.

Next outside the described elements are shown rectangular slabs or tiles 19 composed preferably of ordinary refractory material. These are of such lateral dimension as to extend substantially from one vertical series of hooks to the next series, and thus, as shown each tile 19 will exteriorly cover two of the blocks 15. Directly outside the tiles 19 are preferably a series of insulating plates or sheets 20, which may be composed of any suitable heat insulating material, such as asbestos, or silocel.

The structure is completed by the clamping or locking means consisting of a series of clamp irons or members 21, which are rigid structures arranged and shaped to overlie and hold the wall elements 19 and 20, and to engage and lock with the couplings or hooks 13 which are welded at the outer sides of the water tubes. Each clamp member 21 is shown as having a generally vertical body portion 22, and this covers the vertical space existing between the several series of wall elements 15, 19 and 20. Lateral lugs or wings 23 stand out at both sides from the body of the clamp member, and these overlie the outer wall elements so as to hold them snugly and firmly in place. Each clamp member is also provided with one or more pairs of inwardly extending lugs 24, spaced slightly apart so as to straddle the tube hooks 13. A cross piece or coupling pin 25 is shown extending between the lugs 24 and arranged to engage or drop into the recess of the tube hook 13, which has a slanted wall, acting to wedge the parts in place. It will be understood that the clamp members are thrust into place slightly above their normal level, and drawn downwardly until the cross pins 25 firmly engage the hooks 13. When all the wall elements have been assembled in the manner indicated and described, and the several locking or clamping members have been positioned the wall is completed and ready for use. It will be observed that any desired part of the wall can quickly be disassembled for access, repair or other purpose, from the face side without dismantling the outer wall portion, an additional advantage of the described structure; and the elements most exposed to deterioration are in smaller units, so as to be replaceable at minimum expense.

The hooks 13 on the tubes and the parts 24 and 25 on the clamp plates may be considered as complementary couplings, extending between the refractory wall elements. The coupling 13 in effect is a hook opening upwardly, while the pin 25 is a hook engageable therewith, the side lugs 24 acting as guards, straddling the tube hook, and preventing lateral disengagement. The term coupling is intended to include any form of engaging device welded or projecting from the rear or outer sides of the tubes and adapted to receive or engage a complementary coupling or engaging member which holds, confines or presses the wall elements in place. For example the iron blocks 15 are held pressed inwardly against the exterior of the tubes by the coupling or engaging members 13 and 22 the former welded on the tubes and the latter engaging them and giving inward pressure on the blocks for intimate contact with the tubes.

The illustrated water cooled wall may be considered as any structure bounding a furnace chamber, and it is not intended in the use of the word wall to restrict the invention

to a side wall as it may be applied to a bottom wall or floor, or any other surface of the chamber. Such wall or bounding structure herein comprises the spaced apart water circulation tubes having the hooks 13 or any other couplings upon their outer sides, and with high heat conductive inner wall portions, namely the blocks 14, facing the chamber and substantially closing the spaces between the tubes and adapted to absorb and transfer heat rapidly to the tubes and water therein; together with outer wall elements exterior to such inner wall portions, and exterior securing means, represented by the members 22, adapted to hold the outer wall elements in place and comprising couplings engaging the couplings on the tubes. The outer wall elements preferably comprise insulating material, represented by the layer 20, and rigid wall elements, represented by the layer 19, these, or the outer one of them, constituting a furnace shell or outer casing and being secured and locked in place by the securing means 22.

It will thus be seen that there has been described a water wall, or wall construction for a furnace combustion chamber embodying the principles and attaining the objects of the present invention. Since many matters of combination, arrangement, design, operation and detail may be variously modified without departing from the principles of the invention, it is not intended to limit the invention to such matters except so far as set forth in the appended claims.

What is claimed is:

1. A water wall comprising a series of water tubes having a series of couplings projecting from their outer sides, refractory wall elements closing the spaces between tubes, and exterior clamping members engaging such couplings and confining said wall elements in place, each consisting of a longitudinal body with side wings overlapping the wall elements and an inwardly projecting coupling extending between the wall elements and coupled with a tube coupling.

2. A water wall comprising a series of water tubes having a series of couplings projecting from their outer sides, refractory wall elements closing the spaces between tubes, and exterior clamping members engaging and supported by such couplings and confining said wall elements in place; the tube coupling consisting of a hook opening upwardly, and the clamp having a pin or hook engageable in said tube hook.

3. A water wall comprising a series of water tubes having a series of couplings projecting from their outer sides, refractory wall elements closing the spaces between tubes, and exterior clamping members engaging and supported by such couplings and confining said wall elements in place; the tube coupling consisting of a hook opening upwardly, and the clamp having a pin or hook engageable in said tube hook and side guards straddling the tube hook.

4. A water wall comprising a series of water tubes having a series of couplings projecting from their outer sides, refractory wall elements closing the spaces between tubes, and exterior clamping members engaging and supported by such couplings and confining said wall elements in place; each tube coupling consisting of a hook opening upwardly, and each clamp having a pin or hook engageable in such tube hook, the tube hook having a slanted engaging face acting to wedge the clamp member inwardly.

5. A water cooled bounding structure or wall for a furnace chamber comprising spaced apart water circulation tubes, with high heat conductive inner wall portions facing the chamber and substantially closing the spaces between the tubes and adapted to transfer heat rapidly to the tubes and water therein, said tubes having couplings upon their outer sides, outer wall elements exterior to said inner wall portions, and exterior securing means for the outer wall elements comprising couplings engaging the couplings on the tubes.

6. A structure as in claim 5 and wherein the outer wall elements comprise insulating elements and rigid elements secured in place by said exterior securing means.

7. A closed water cooled bounding structure or wall for a furnace chamber comprising a series of water tubes spaced apart, and a system of flanged, heat-conductive blocks held in contacting relation to the inner sides of said tubes and closing the spaces between the same, such blocks being concavely shaped to fit and intimately contact the tubes for maximum transmission of heat thereto, couplings on the outer sides of tubes, outer wall-closing elements, and means for confining such outer elements comprising couplings engaging with said tube couplings.

8. A closed water-cooled bounding structure or wall for a furnace chamber comprising spaced apart water tubes exposed to the fire and having coupling extensions welded upon their outer sides and projecting outwardly for engagement with wall securing means, outer wall closing elements, including high heat conductive blocks contacting with thermal fit the outer sides of the tubes, and wall securing means having couplings engaging with the welded coupling extensions on the tubes for holding said outer wall-closing elements in place.

9. A closed water-cooled bounding structure or wall for a furnace chamber comprising spaced apart water tubes exposed to the fire and having coupling extensions projecting at their outer sides, wall closing elements including highly refractory blocks shaped for effective heat transferring contact with the

outer sides of the tubes and exposed to the fire between the tubes, and wall securing means including couplings engaging with the coupling extensions on the tubes for holding said outer wall-closing elements and confining them under pressure against the tubes.

10. A water cooled wall for a furnace chamber comprising spaced apart water circulation tubes, forming substantially upright spaces between each two tubes, and with a base member or header below, and in each such tube space a superposed system of complementary blocks composed of high heat conductive material and supported by the base member and formed with projections and recesses for mutually interlocking them, the complementary blocks spanning the tube space and contacting the tube circumferences at the face sides substantially to the tube center lines, and at the rear sides sufficiently to lock them to the tubes when in position, but constructed for renewal at the face side, by lifting out of interlocking relation and removal and replacement of damaged blocks.

11. A water cooled furnace wall comprising a series of spaced apart water tubes having their inner sides directly exposed to the furnace heat, and at the outer sides of the tubes a system of high heat conducting wall blocks spanning and closing the spaces between the tubes and shaped and mounted for intimate contact with the tubes, whereby to absorb radiant heat passing between the tubes and transmit it to the tubes and the medium circulating therein; and means for confining the blocks against the outer sides of the tubes comprising couplings projecting upon the outer sides of the tubes, with means for applying pressure upon the blocks comprising couplings engaging said tube couplings.

12. A water cooled furnace wall comprising spaced circulation tubes having their inner sides exposed to the fire, a system of iron wall blocks at the outer sides of the tubes shaped for heat conducting contact with the tubes and closing the spaces between the tubes and exposed to the fire between the tubes, couplings projecting upon the outer sides of the tubes, and means for effecting inward pressure upon the wall closing blocks to confine them intimately to the tubes, comprising couplings engaging said first named couplings.

13. A water cooled wall for a furnace chamber comprising spaced apart water circulation tubes, forming substantially upright spaces between each two tubes, and with a base member or header below, and in each such tube space a superposed series of complementary blocks composed of high heat conductive refractory material and supported by the base member and such blocks formed with mutually interlocking portions, the complementary blocks spanning each tube space and contacting the tube circumferences at the face sides to a protective extent, and at the outer sides sufficiently to lock them to the tubes when in position, and an independently supported wall closing portion outwards of such blocks; whereby the series of blocks exposed to the furnace heat rest by gravity in interlocked relation to the tubes but may be extracted for replacement by lifting out of such relation by access from the face side only without disturbing the outer wall portion.

14. A water cooled furnace wall structure comprising spaced upright water tubes, an inner wall face portion protecting the tubes and an outer wall portion; the outer wall portion closing the wall and having means holding it to the tubes; the face portion built up of series of superposed high heat conductive blocks closing the spaces between the tubes and having means locking them to the tubes accessible from the face of the wall, whereby damaged face blocks may be removed and replaced from the wall face without dismantling the outer wall portion.

15. A water cooled furnace wall structure comprising spaced upright water tubes having outward coupling extensions, an inner wall face portion protecting the tubes, and an outer wall portion; the outer wall portion closing the wall and having means holding it to the coupling extensions of the tubes; the face portion built up of series of superposed high heat conductive blocks closing the spaces between the tubes and having means locking them by gravity to the tubes accessible from the face of the wall, whereby damaged face blocks may be lifted out and replaced from the wall face without dismantling the outer wall portion.

16. A closed water cooled furnace bounding structure or wall comprising a system of spaced apart water tubes having their inner sides directly exposed to the furnace heat, and at the outer sides of the tubes a system of highly refractory heat conducting wall blocks spanning and closing the spaces between the tubes and shaped and mounted for intimate contact with the tubes, whereby to absorb radiant heat passing between the tubes and transmit it to the tubes and the medium circulating therein; and means carried by the system of tubes for applying pressure to confine the blocks against the outer sides of the tubes.

17. A water cooled wall bounding a furnace combustion chamber, and comprising the combination of differentially operating upper and lower wall areas, with a system of parallel water tubes traversing both the upper and lower areas of the wall, and a system of high heat conductive wall blocks covering and protecting the face sides of the tubes at the lower area of the wall and exposed to the hotter heat of the fire in the lower part of the chamber, to absorb such

heat and conduct it to the tubes and the medium circulating therein, and the upper wall area having the tubes exposed directly to the less hot heat of the fire at the upper part of the chamber, with a system of high heat conductive wall blocks carried by the tube system and contacting the outer sides of the exposed tubes in the upper wall area and closing the spaces between the tubes, to absorb heat passing between the tubes and conduct it to the tubes and the medium circulating therein.

18. A water cooled wall bounding a furnace combustion chamber, and comprising the combination of differential upper and lower wall areas, with a system of spaced water tubes traversing both the upper and lower areas of the wall, a high heat conductive covering protecting the face sides of the tubes at the lower area of the wall and exposed to the hotter heat of the fire in the lower part of the chamber, to absorb such heat and transmit it to the tubes and water therein, and the upper wall area having the tubes exposed directly to the less hot heat of the fire at the upper part of the chamber, with a system of high heat conductive wall blocks having thermal contact with the outer sides of the tubes in the upper wall area and closing the spaces between the tubes, to absorb heat passing between tubes and transmit it to the tubes, and means upon the outer sides of the tubes for giving support to said outer blocks, and holding them to the tubes.

19. A water cooled wall consisting of upper and lower wall areas bounding a furnace combustion chamber, and comprising the spaced water tubes traversing both the upper and lower areas of the wall, a system of metallic members covering and protecting the face sides of the tubes at the lower area of the wall in the lower part of the chamber, to receive the hottest heat of the fire and conduct it to the tubes, the upper wall area having the tubes exposed directly to the reduced heat at the upper part of the chamber, and with a system of metallic members in the upper wall area carried by the tube system and closing the spaces between the tubes and arranged to receive heat and conduct it to the water.

20. A water cooled wall consisting of upper and lower wall areas bounding a furnace combustion chamber, and comprising spaced water tubes traversing both the upper and lower areas of the wall, a system of high heat conductive members covering and protecting the face sides of the tubes at the lower area of the wall in the lower part of the chamber, to receive the hottest heat of the fire and conduct it to the tubes, the upper wall area having the tubes exposed directly to the reduced heat at the upper part of the chamber, and with a system of high heat conductive members in the upper wall area carried by the tube system and closing the spaces between the tubes and arranged to receive heat and conduct it to the water in the tubes; the system of high heat conductive wall members in the lower wall area comprising separate blocks exposed to the heat of the fire, such blocks being shaped to assume gravity locking relation to the tubes and combined with means for supporting them in such locking relation, whereby such blocks may be extracted by lifting and removal at the face side of the wall, and replaced by insertion and dropping in place, so that renewals may be effected from the wall face side.

21. A closed water cooled bounding structure or wall for a furnace chamber consisting of the combination of differentially operating upper and lower wall areas, with a system of spaced water tubes traversing the upper and lower areas of the wall, a system of highly refractory and high heat conductive wall blocks covering and protecting the face sides of the tubes at the lower area of the wall and exposed to the hotter heat in the lower part of the chamber, and the upper wall area having the tubes exposed directly to the lesser heat at the upper part of the chamber, and with a system of high heat conductive wall members in the upper wall area carried by and contacting the tube system and closing the spaces between the tubes and arranged to receive heat and conduct it to the tubes and the water circulating therein.

22. A furnace wall construction comprising a system of spaced circulation tubes, and a system of high heat conductive wall blocks arranged in side-by-side as well as superposed relation forming longitudinal and transverse rows and closing the spaces between such tubes, the tubes and blocks presenting a continuous all-metal surface to the furnace chamber, the blocks being recessed so as to embrace at least a portion of the circumference of the tubes whereby to conduct to the tubes and medium circulatnig therein the heat absorbed by such blocks, together with a system of outer backing or holding members for the system of blocks, each thereof being of extended dimension so as to function to hold a plurality of such blocks, and clamp means carried by the tube system for drawing the backing members toward the tubes and holding them in place and thereby holding the blocks in position against the tubes.

23. In a fluid cooled furnace wall, the combination of a series of spaced-apart circulation tubes near the face side of the wall, a renewable inner wall face portion comprising highly refractory and heat conductive wall face blocks protectively covering said series of tubes, and shaped for effective heat transferring contact with the tubes whereby to effect cooling of the blocks and heating of

the circulating fluid, and an outer wall portion including supporting elements by which said face blocks are engaged and supported in alined relationship, the engagement between the supporting elements and the face blocks being such that the face blocks are removable at the face side of the wall without dismantling the outer wall portion.

24. In a fluid cooled furnace wall, the combination of a series of spaced-apart circulation tubes near the inner face of the wall, a renewable inner wall portion comprising refractory wall face blocks protectively covering said series of tubes, and an outer wall portion contacting the tubes and comprising at the inner side thereof holding members by which said face blocks are held in alined relationship in contact with the tubes, the said inner wall portion having coupling means extending outwardly through the spaces between the tubes and in engagement with such holding members of the outer wall portion, the engagement between said holding members of the outer wall portion and said coupling means being such that said face blocks may be disconnected and removed and replaced at the inner side of the wall without dismantling the outer wall portion.

25. In a fluid cooled furnace wall, the combination of a series of spaced-apart circulation tubes near the face side of the wall, a renewable inner wall face portion comprising highly refractory wall face blocks protectively covering said series of tubes, and an outer wall portion, the said inner wall portion having coupling extensions between the tubes, and the outer wall portion having complementary elements receiving said coupling extensions, in such manner that the face blocks are secured to and may be uncoupled from the outer wall portion and removed and replaced at the face side without dismantling the outer wall portion.

26. In a fluid cooled furnace wall, the combination of a series of spaced-apart circulation tubes near the face side of the wall, a renewable inner wall face portion comprising highly refractory wall face blocks protectively covering said series of tubes, and with coupling extensions between the tubes, and an outer wall portion including elements with which the coupling extensions of said face blocks are removably engaged, each such face block being confined against lifting and uncoupling by the face block above it but releasable by displacement of such block above it to permit disengagement from the outer wall portion and removal and replacement at the face side without disturbing the outer wall portion.

27. A furnace wall comprising a series of substantially parallel cooling tubes forming substantially upright spaces between them, a system of refractory face blocks associated with said tubes contacting and covering the face sides of the tubes and shaped for heat conducting contact with the tubes, and closing the spaces between the tubes, said system of face blocks having extensions projecting outwardly between adjacent tubes and each of such extensions being provided with a coupling, and wall blocks at the outer sides of the tubes having complementary couplings extending inwardly and engaging with said face block couplings and contacting against the tubes, thereby securing the face blocks to the tubes, and the face block couplings and outer block couplings being respectively constructed for mutual engagement in a manner permitting the face block couplings to be moved out of such engagement, thereby permitting the face blocks to be uncoupled by access from the face side of the wall for face removal and replacement of said face blocks.

28. A closed water cooled bounding structure or wall for a furnace combustion chamber, the same comprising a series of water tubes spaced apart with a system of iron members in protecting relation at the inner sides of the tubes, outer wall closing elements and means for confining such outer wall closing elements comprising couplings projecting from the outer sides of the tubes and complementary couplings engaging with said tube couplings and in confining relation to the outer wall closing elements.

29. A closed water cooled bounding structure or wall for a furnace combustion chamber consisting of the combination of differentially operating upper and lower wall areas, with a system of spaced water tubes traversing both the upper and lower areas of the wall; the lower wall area exposed to the hotter heat of the fire and comprising a high heat conductive facing covering and protecting the face sides of the tubes and operating to absorb the radiant heat and transmit it to the tubes and water therein; and the upper wall area having the tubes directly exposed to the less hot heat of the fire in the upper part of the combustion chamber and comprising a high heat conductive wall portion closing the spaces between the tubes and arranged to absorb radiant heat from the combustion chamber and conduct it to the tubes; said lower facing and upper wall portion being supported by the tube system.

30. A closed water cooled bounding structure or wall for a furnace combustion chamber consisting of the combination of differentially operating upper and lower wall areas, with a system of spaced water tubes traversing the upper and lower areas of the wall, the lower wall area comprising a highly refractory facing covering and protecting the face sides of the tubes, and the upper wall area having the tubes directly exposed to the fire in the combustion chamber and comprising metallic portions substantially

closing the spaces between the tubes and arranged to absorb heat and rapidly conduct it to the tubes; said facing and said metallic portions both being wholly supported by the tube system.

31. A closed water cooled bounding structure or wall for a furnace combustion chamber consisting of the combination of differentially operating upper and lower wall areas, with a system of spaced water tubes traversing the upper and lower areas of the wall, the lower wall area comprising a highly refractory facing closing the spaces between the tubes and protecting the face sides of the tubes, and the upper wall area having the tubes directly exposed to the fire in the combustion chamber and comprising a highly refractory backing closing the spaces between the tubes, and means welded upon the outer sides of the tubes for holding the highly refractory backing in contact with the tubes.

In testimony whereof, I have affixed my signature hereto.

WARREN C. DRAKE.