March 7, 1933. E. G. BAILEY 1,900,006

FURNACE

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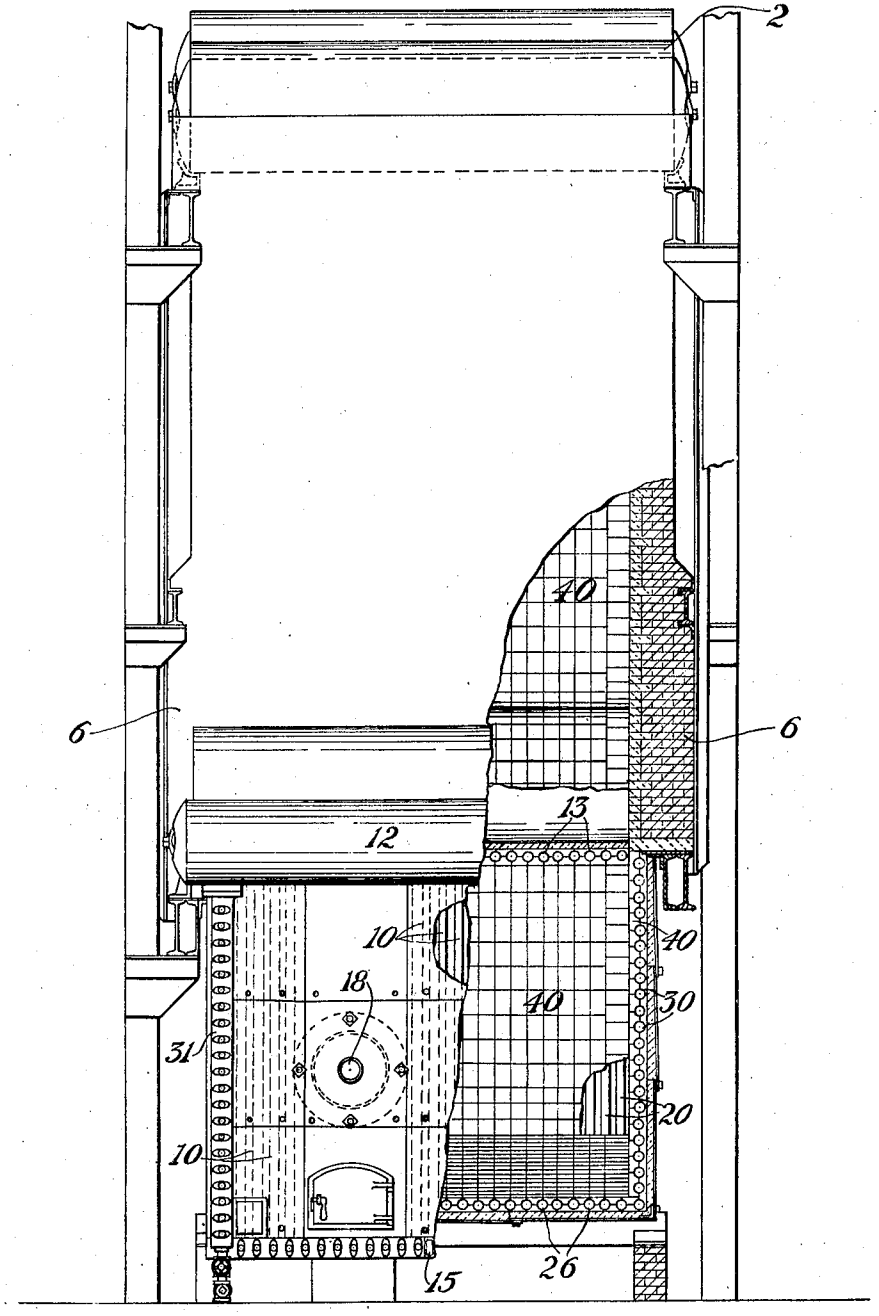


Fig. 1

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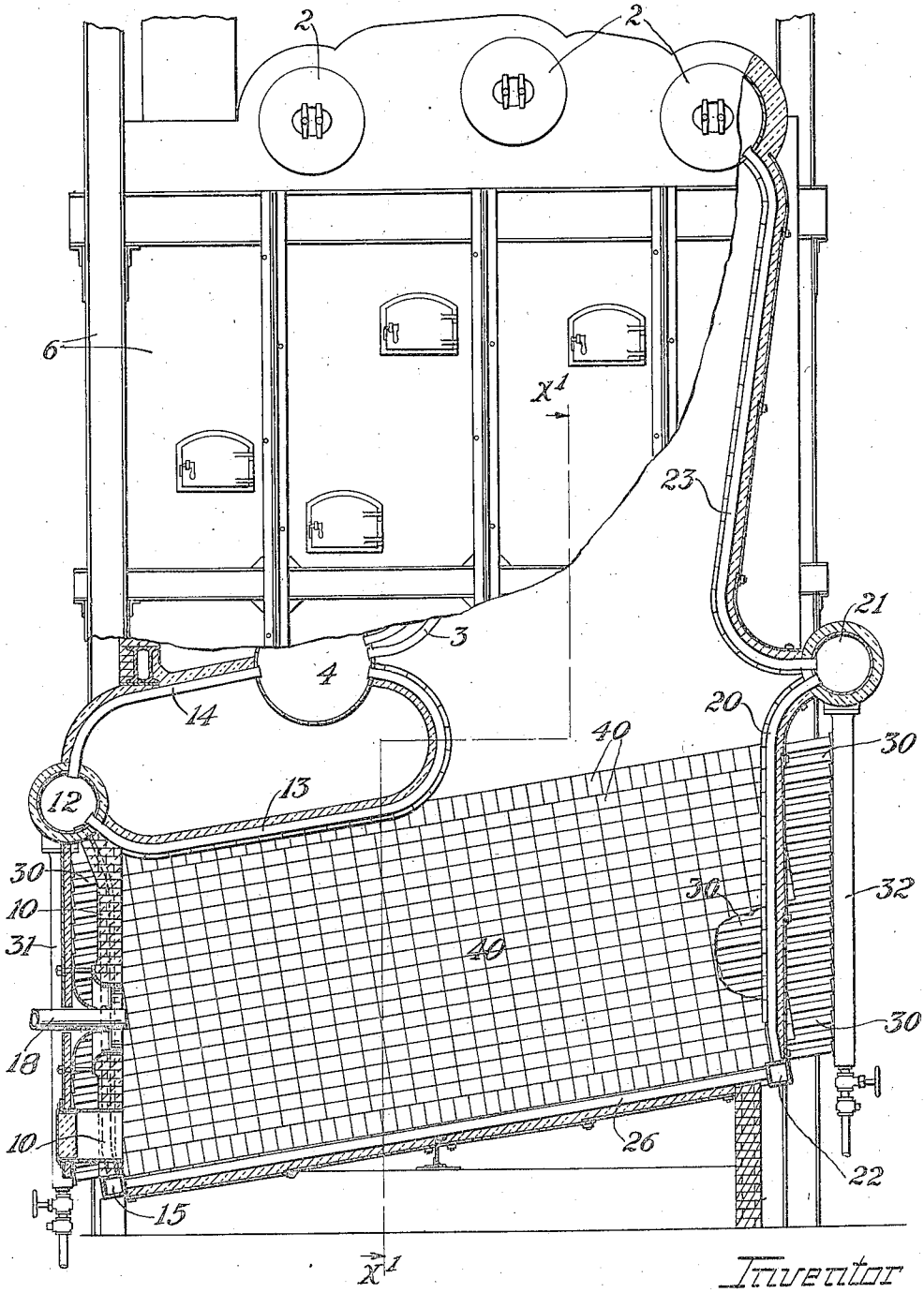


Fig. 2

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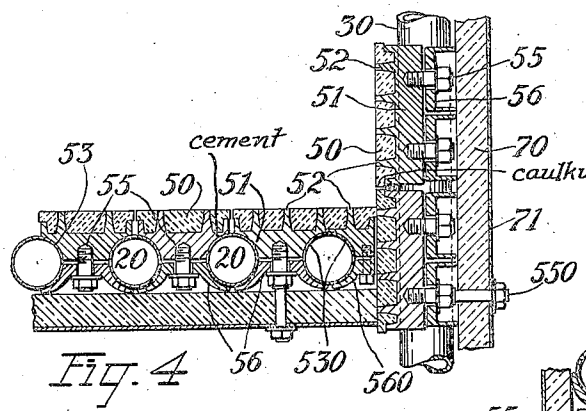


Fig. 4

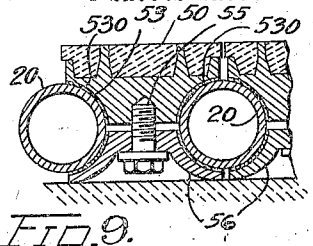


Fig. 9.

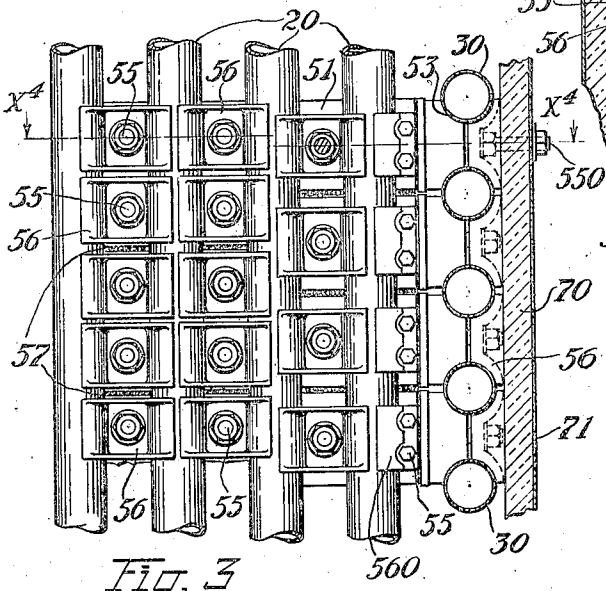


Fig. 3

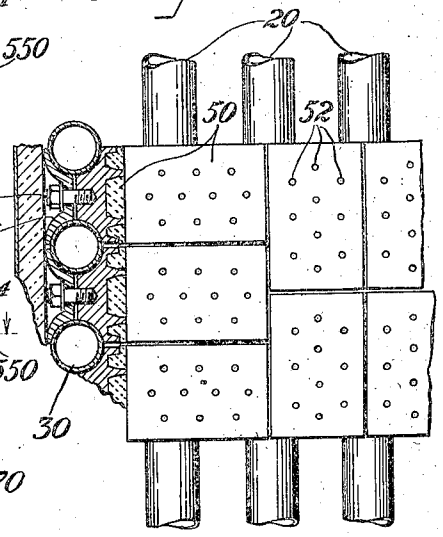


Fig. 5

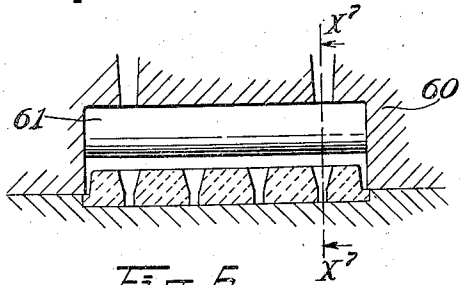


Fig. 6

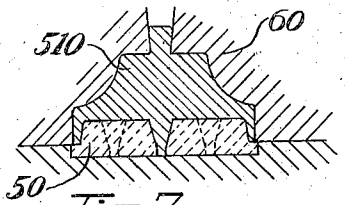


Fig. 7

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FURNACE

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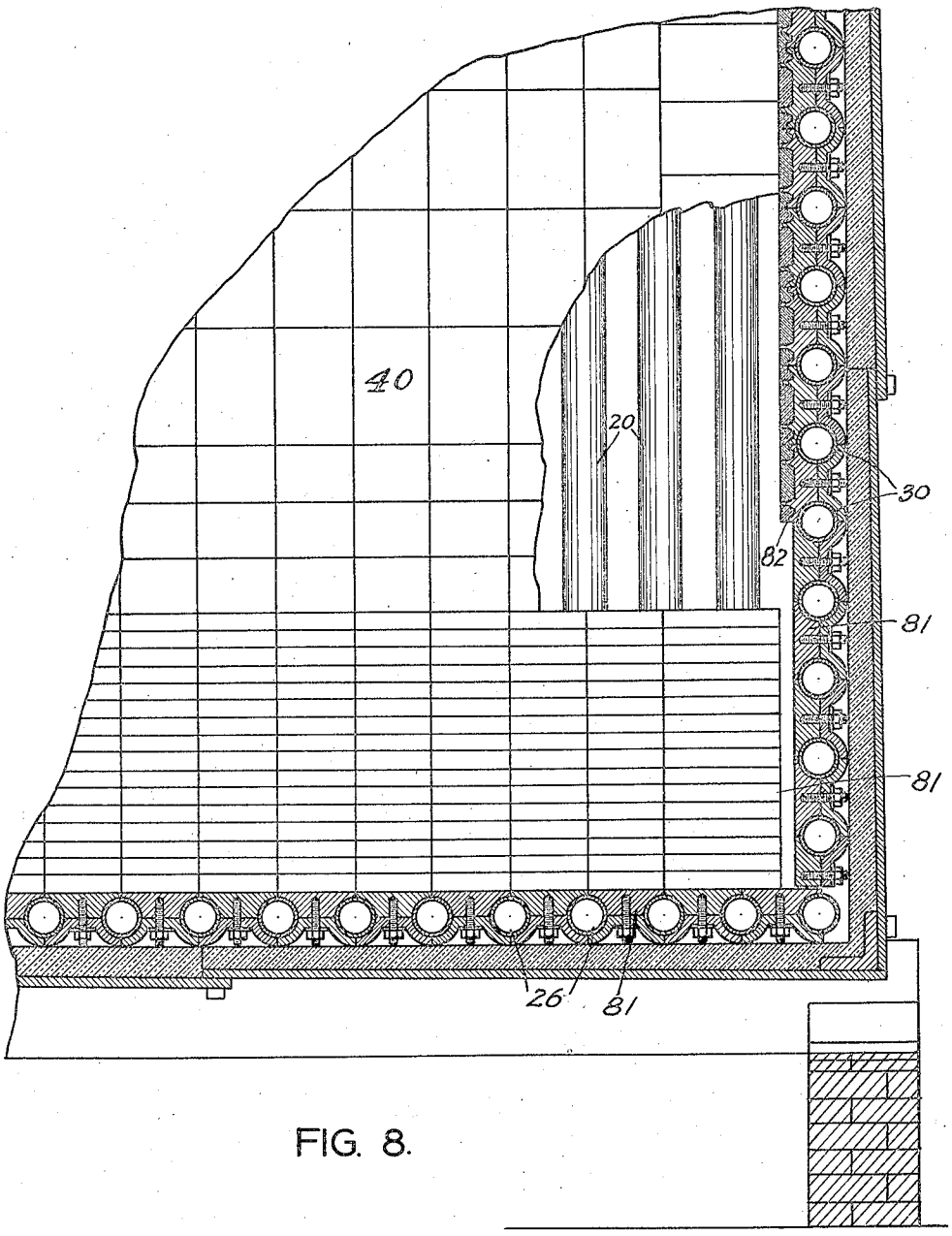


FIG. 8.

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Patented Mar. 7, 1933 1,900,006

UNITED STATES PATENT OFFICE

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FURNACE

Application filed March 20, 1925. Serial No. 17,054.

This invention is embodied in a furnace and relates especially to the construction of the furnace walls and in particular to the character of some of the components of which such walls are built. It is shown embodied in a boiler furnace.

The purpose of the invention is to secure a serviceable and durable furnace wall construction which will withstand the very high temperature found in modern practice and the destructive actions of slag from the ash from the fuel and of high velocity flame travel.

In the large furnaces which in recent years have been constructed for large steam plants, and especially those in which powdered coal is used as a fuel, the flame temperature may be as high as 3000° F. and it has been found that in spite of the best construction and the use of the best available refractory materials in the furnace walls, the walls have been very short lived because such materials become so highly heated that they rapidly waste away.

The rapid deterioration of the furnace walls and the cost of renewing them have constituted a very serious expense.

Attempts have been made to overcome this difficulty by the use of furnace walls composed wholly or in part of water tubes. But such walls, although more durable than those made only of refractory masonry, have had but little if any practical success because, if effective to prevent rapid dissolution of the refractory material, or if used without refractory material, the water tubes withdrew so much heat from the furnace as to impair the efficiency of combustion.

It is important that the furnace walls should be airtight, but walls composed in whole or in part of masonry besides being rapidly wasted away or dissolved by the slag when exposed to a temperature above the melting point of the slag, also become cracked and leaky which is highly objectionable because it renders it difficult to control the supply of air in proper amount for most efficient combustion, and because it cools the walls unevenly and thus interferes with the combustion and increases the stresses of expansion and contraction leading to the disintegration and destruction of the wall.

The invention resides in part in mechanical or structural features by which simplicity, strength and airtightness of the wall are attained, and in part in thermal characteristics. By its thermal characteristics the exposed face of the furnace wall is maintained at a temperature within certain well defined limits, namely at such a high temperature as not to impair the efficient combustion in the furnace, and yet at such a low temperature as to resist effectively the causes of furnace wall destruction, such as slagging of ash and high velocity of flame travel.

I have found that in the use of gases or oil as fuel, in which the ash is of small amount, the temperature of the surface of the wall may be maintained as high as 2600° F. or possibly 2700° F. without material deterioration, and that in the use of coal, in which the ash is in relatively large amounts, the temperature of the surface of the wall in most cases should not be above the fusing temperature of the ash particles that impinge against the wall, although with some kinds of refractory material it may be somewhat higher. With coal having an ash of relatively low fusing temperature it might be necessary to maintain the surface of the wall at a temperature as low as 2000° F., but in all cases it should be kept fairly close up to the limit of safety in order to maintain high combustion efficiency.

In attaining this end the heat conductivity of the furnace wall and its heat transferring capacity are important factors, and the invention consists in part in a construction of the wall such that the heat is conducted from its inner exposed surface at the proper rate to maintain the temperature of said exposed surface within the desired limits.

In the embodiment of the invention herein shown, for purposes of illustration, the furnace walls, including front and rear and side walls, and the floor or the bottom of the furnace, are composed of tubes, which supply the main structural strength of the furnace walls and contain a circulating cooling medium affording a heat absorbing capacity, and a closure of the intertube spaces by covering or lining elements which will hereinafter

be called tiles or blocks, which are secured, preferably detachably, to the said tubes and close the spaces between them to provide a substantially gas tight wall or enclosure for the combustion chamber of the furnace.

Another important feature of the invention consists in provision for insuring a gas tight heat conductive joint or union between the tiles or lining blocks and the supporting tubes.

There are other features contributing to the effectiveness of the construction for attaining the desired ends, which will be pointed out in connection with the description of the concrete example of an embodiment of the invention illustrated in the accompanying drawings, in which,—

Fig. 1 is a front elevation of a boiler furnace embodying a construction forming the subject of this invention, a portion of the front wall being removed to show in elevation the face of the opposite or rear wall of the furnace and in vertical section one of the side walls and a portion of the floor, and a portion of the top or arch, the section being on line X—1 of Fig. 2;

Fig. 2 is a similar side elevation with a part of the adjacent side wall broken away and showing in vertical section the front and rear walls and a portion of the interior construction;

Fig. 3 is an elevation on a larger scale of a portion of the outer or rear face of the rear wall with an adjoining portion of the side wall shown in vertical section;

Fig. 4 is a horizontal sectional detail on line X—4 of Fig. 3;

Fig. 5 a detail showing in elevation a portion of the face or front of the rear wall the rear of which is shown in Fig. 3;

Figs. 6 and 7 show sectional details illustrating one way of making some of the tiles, as will be hereinafter explained.

Fig. 8 is a view taken on the same plane as Fig. 1, but on an enlarged scale, and showing more in detail the construction of the lower part of the furnace wall.

Fig. 9 is a fragmentary view of the structure appearing in Fig. 4, but on an enlarged scale.

In the following description the surface of the wall or of the tiles or blocks of which it is composed in part, which is exposed at the interior of the furnace will be called the face or front of the wall or tile, while the direction toward the outside of the furnace will be referred to as rearward, and the outer surfaces will be called the back of the wall.

Referring to Figs. 1 and 2, the furnace forming the subject of this invention is shown as employed in connection with a boiler of well known construction comprising steam drums, 2, 2, at the top, connected by boiler tubes, 3, with a mud drum, 4, near the top of the combustion chamber, the heated gases from which flow through the spaces between the tubes, 3, and may be caused to take a sinuous path by baffles, as usual.

The fuel is introduced through the burner nozzles, 18, in the front wall, herein shown as burners for pulverized coal.

The supporting structure and walls enclosing the boiler proper above the combustion chamber of the furnace are shown at 6 and are of proper character to sustain the portions of the boiler thus far described, so that the walls of the combustion chamber, or furnace proper, in the present embodiment of the invention are not required to sustain any considerable extraneous burden.

The structural strength of the furnace walls is provided mainly by the circulating tubes of which they are in part composed, which comprise a series, 10, of vertical tubes, shown mainly in dotted lines in Fig. 1, forming the front wall of the furnace and communicating at their upper ends with a transverse drum or manifold, 12, connected by a series of circulating tubes, 13, 14, with the mud drum, 4, of the boiler, said front wall tubes, 10, being also connected at their lower ends with a horizontal header, 15, extending across the front of the furnace at approximately the level of the bottom or floor thereof. The tubes, 13, form part of a deflecting arch, which performs the usual function of such an arch.

The rear wall is composed in part of a similar series of vertical tubes, 20, connected at their upper ends with a transverse drum, 21, and at their lower ends with a horizontal manifold, 22, the drum, 21, being connected by another similar series of tubes, 23, with one of the steam drums, 2, at the top of the boiler.

The series of tubes, 20, 23, of the rear wall of the furnace are vertical, or approximately so, but are curved in portions of their length.

The floor of the combustion chamber is composed in part of the tubes, 26, which extend with an upward inclination from the transverse header, 15, at the lower end of the front wall, to the transverse header, 22, at the lower end of the rear wall.

The side walls are alike. Each is composed of a vertical row of tubes, 30, inclined upward from front to rear. The tubes of each row are connected at their front ends to a vertical header, 31, extending down from the transverse drum or manifold, 12, and at their rear ends to a similar vertical header, 32, extending down from the rear transverse drum, 21.

Water circulates from the drum, 12, to the drum, 21, and the drums, 2, 2, as follows: some water from the drum, 12, goes downward through the front wall tubes, 10, to the header, 15, thence through the floor tubes, 26, to the header, 22, and thence upward through the rear wall tubes, 20, into the drum, 21;

and some water from the drum, 12, goes downward through the front side headers, 31, thence through the side wall tubes, 30, to the rear wall headers, 32, and thence upward into the drum, 21. The water in the drum, 21, flows upward through the tubes, 23, into the rear drum 2. Also some of the water in the drum, 12, flows through the tubes, 13, into the drum, 4.

The spaces between the tubes forming in part the walls and bottom of the furnace are closed, to afford with the tubes a continuous substantially air-tight wall, by the employment in conjunction with the tubes of the tiling, 40, Figs. 1 and 2, the components or individual tiles or blocks of which (see Figs. 3 to 7) are of such nature as to afford a durable lining for the furnace and also to afford suitable heat conduction from their inner exposed faces to the tubes and cooling material therein at a proper rate to maintain their inner exposed faces at a temperature sufficiently low to resist the destructive action of the fuel in combustion but not low enough to impair materially the efficiency of the combustion.

To accomplish these results, and especially that of affording proper heat conduction, the construction of the tiles may vary, and as herein shown, is varied according to the location in the walls and consequent exposure to the sweep of the flame and heat of combustion. The tiles, except in some locations which will be referred to later, are composed in part of a strong and effective heat conducting material, such as cast iron, and in combination therewith a more refractory material, such as any of the various refractory materials employed for refractory masonry, and the proportions of the refractory face portion and metallic body portion may be varied according to the requirements of heat conduction which are dependent on the conditions to which the tiles are to be exposed, which may vary in different parts of the same furnace.

In some cases the tiles may be composed entirely of metal, such construction being shown in the present case at the floor and at portions of the side and end walls adjacent to the floor as shown at 81 in Fig. 8, where for reasons which will be explained more fully hereinafter it is desirable to maintain a somewhat lower temperature than in the main portions of the furnace walls surrounding the combustion chamber. In some cases the tiles may be wholly of refractory composition.

The tiles for the most part are of the composite construction, such as is best shown in Figs. 3 to 5 inclusive.

Each tile is composed of a face portion, 50, of refractory material and a back portion, 51, of metal preferably of cast iron secured to or interlocked with said face portion, 50. The back portion is shown as having projecting portions, 52, which extend into the face portion, 50, and may extend wholly through into the face surface thereof. Such projections serve both to assist in securing the face portion, 50, to the back portion, 51, and to facilitate the conduction of heat from the front to the back of the tile.

The proper union of the refractory face portion and metallic back portion may be attained in any suitable way. One way is to manufacture the face portion with suitable recesses and rabbets as shown, and then place the same in a mold such as used for casting metals, a portion of which is indicated at 60 in Figs. 6 and 7, having a cavity, 61, (Fig. 6) adjacent to the refractory portion, of proper shape for the metallic portion of the tile. The molten metal is then run into the mold, as indicated at 510 in Fig. 7, and entering the cavities and rabbets of the refractory portion becomes completely interlocked therewith and forms intimate union with the refractory portion throughout the entire contacting surface thereof.

The tile or block is provided with concave seats, 53, at the ends of one of its longitudinal dimensions to fit and make close contact with the pair of tubes against which the tile is to be secured, said seats in the construction shown being substantially quarter-cylindrical grooves extending for the entire length of the corresponding edge of the block, the other dimension of which is a trifle less than the distance between the centers of the tubes.

The specific construction of the provision for securing the tiles to the tubes of the furnace walls may be varied, but the construction illustrated has been found to be serviceable and as shown comprises bolts, 55, herein shown as two to each tile, securely anchored in the body portion, 51, of the tile, herein shown as by screw threads, said bolts cooperating with the clamping members or saddles, 56, herein shown as two to each tile, having seats similar to those formed in the tile bodies for engaging with the tubes, which are thus, as it were, clamped between the tile at one side of each pair of tubes and a corresponding pair of clamp members at the other side, each individual tile thus being securely clamped or held with frictional pressure against a pair of tubes.

It is desirable to have as intimate a heat conducting connection or contact between the tiles and tubes as possible, and to seal hermetically the contact between the tubes and tiles, thus making a heat conducting gas tight joint or union. These results may be measurably attained by the employment of comparatively soft and highly conductive metal shims such as sheets of copper or aluminum interposed between the tiles and tubes, but in practice the most effective con-

nection or union between the tiles and the tubes, both as a matter of gas tight sealing and of heat conduction, has been secured by the employment of a filling material, indicated at 530 in Fig. 4, in the nature of a plastic cement between the two, which forms a more conductive union and a tighter joint between the tubes and blocks than is attainable by a strip or sheet of metal interposed between them.

A cement or conductive filling the body portion of which is of metal powder, may be used, but I have found some other materials to be preferable as being less liable to chemical change, and a very effective specific compound for effecting the sealed conductive union between the tubes and the tiles, is composed of finely pulverized carborundum with water glass as a vehicle, and with glycerine to render the material more plastic, or more readily flowing, and thus more easily handled in applying the same when securing the tiles to the tubes. While the compound described is one which has been found satisfactory, it is, of course, to be understood that other compounds may be employed. For example, the glycerine mentioned above may be replaced in whole or in part by castor oil, and the water glass may be replaced in whole or in part by linseed oil. It has been found that the above substances, when used as indicated, will render the carborundum or other pulverized material mobile so that it will flow readily under pressure.

The said conductive plastic material is applied between the outer surface of the tubes and inner surfaces of both the tiles and clamp members which, as will be seen in Fig. 4, nearly completely surround and enclose the tubes, and, being pressed forcibly against the tubes, affords maximum conduction of heat to the walls of the tubes and to the cooling medium therein. Preferably, the forcible pressing together of the tiles, tubes, and clamp members is sufficient to squeeze the plastic material into a thin layer, as indicated in the drawings, this layer being of a minimum thickness. That is to say, all that is necessary is to have sufficient plastic material to replace the air gap, which would otherwise be present, with a relatively high heat-conductive material which will fill the unevennesses in the surfaces of the tubes, tiles, and clamp members. The compacting of the material by pressure will, of course, make the material itself into a better heat conductor as well as causing the material to flow into the unevennesses of the various surfaces. By inserting the plastic material not only between the tubes and the tiles, but also between the tubes and the clamp members, any heat which flows from the tiles to the clamp members, either through the bolts 55 or across any space which may exist between the tubes and clamp members, may pass from these clamp members to the walls of the tubes with which they are engaged.

By having the tube seats, 53, at the ends of the tile, and each tile of approximately the length of the space between tube centers, each tile when united or sealed to the tubes as has been described, makes a complete closure of the space between the tubes for the width of the tile. A small space may be left between the adjacent ends of the tiles meeting on a tube which provides for contraction and expansion without stressing the tiles or the walls, and may be left open when the wall is installed.

Each course of tiles transverse to the tubes thus makes an airtight section of wall, and the successive courses should be secured to the tubes with a small space left between the courses which space may be sealed by a continuous line of suitable packing material, such for example as asbestos rope, or the space between courses may be caulked from tube to tube, by suitable refractory packing material, as indicated at 57 in Fig. 3.

Each block is individually secured to the wall tubes, being wholly independent of the others as to the attaching means and the conductive sealing joint with the tubes, so that one or any number of blocks, whether or not contiguous to one another, may be removed and replaced by others should occasion arise for doing so, without disturbing the remaining blocks and with very small expenditure of time and labor.

The refractory face portion, 50, may be made of any suitable refractory material and the back metallic portion is preferably made of iron. The heat is conducted from the surface of the face portion, through that portion and through the iron back portion, which acts as a funnel for the conduction of the heat to the tubes to which they are united by the clamping devices and interposed conductive cement. The cast iron or other metal forming the back of each tile or block gives that part of the block a high heat transferring capacity, much higher than that given by the usual refractory material known to the prior art and formed of clay and the like. The material selected for the joints between the tubes on the one hand and the tiles and clamp members on the other hand is preferably one which has as high a heat transferring capacity as it is possible to get in a material which will fulfill the other conditions necessary for forming the joints.

In practice the temperature of the tubes, which are the heat absorbing element in the wall, may vary from as low as 212° F., in the case of water tubes, to as high as 700° F., in the case of superheated steam tubes, and the temperature of the face of the tiles may be maintained without danger of deterioration at as high a temperature as possible, for example 2700° F., in the case of the use of

gaseous or oil fuel, while in the case of coal fuel having ash of a low melting temperature the temperature of the face of the tiles can not be permitted to be over 2000° F. These possible variations in condition make it best to explain my invention by giving the details of the example of its application to a water tube steam boiler furnace such as herein shown when run under heat conditions such as are normal and usual in present-day practice.

Suppose that the water tubes in such a furnace are normally at a temperature approximately 400° F. and that the fuel is of such character that the refractory facing of the tile would be destroyed if the temperature of its surface were over 2200° F. In such cases it is necessary that the temperature of the face of the tile should be less than 2200° F. and it is desirable that it should be at least as much as 2000° F. in order to obtain conditions of best efficiency of combustion.

I therefore select such quality of refractory material and make the facing, 50, composed of it of such thickness, and I make the metal backing of such thickness, that the temperature drop from the face of the tile to the water tubes will amount to from 1600° F. to 1800° F., that is to say the flow of heat through the composite tile will be such that its surface, exposed to the flame in the furnace, will be at a temperature between 2200° F. and 2000° F. and its rear surface, in metallic contact with the water tubes, will be at about 400° F.

I have found that very good results are obtained when the flow of heat in the face portion, 50, and the rear portion, 51, is so distributed that the temperature drop from the front to the rear of the face portion amounts to something between 1200° F. and 1400° F., and the temperature drop from the front to the rear of the metal backing amounts to something between 300° F. and 500° F.

By this construction the heat is conducted from the refractory material to the water sufficiently rapidly to preserve the refractory material in spite of the high temperature in the furnace, and the wall is extremely durable as compared with the usual refractory wall construction, and yet as contrasted with a water tube wall it protects the tubes from possibility of burning and also maintains a sufficiently high surface temperature to keep the combustion of the fuel and gas in a state of good efficiency.

The heat which is taken from the furnace is conducted to the water in the tubes and serves the purpose of generating steam so that there is no substantial waste of heat.

In the practical operation of a steam boiler furnace fired with powdered coal in which the temperature of the flame is in the neighborhood of 2800° F., I have found that the desired results were obtained with a composite tile having a facing of refractory material of good heat conductivity and resistance to slag formation about 1 to 1½ inches thick, and with an iron back portion, shaped substantially as herein shown, of a minimum thickness between the refractory facing and the water tube of ¼ of an inch and sufficient additional thickness at the middle to extend rearward approximately to the plane through the axes of the tubes upon which the tile is secured. If the facing material is of higher conductivity it may be made thicker.

The quality of the refractory facing, and its thickness, and the shape and thickness of the metal body or backing may be varied within reasonable limits without departing from my invention.

A tile or block composed mainly of carborundum with a suitable binder has a high coefficient of heat conductivity, and one having alumina as its main ingredient with a suitable binder has the slag resistant property in high degree, and tile material may be made from mixtures of these materials in various proportions to secure the properties needed to meet the various conditions encountered in furnace practice.

It has been found in practice that in some cases there is what may be regarded as an automatic correction of the heat transferring capacity of the blocks. In case the face portion of the block is somewhat too thick for the conditions which it meets in the furnace, the higher temperature which it acquires will cause it to begin to waste away, but this in itself will increase the heat transferring capacity and thus check the wasting until finally a condition of substantial equilibrium is reached, and the block will then stand without any material further wasting or loss of thickness, performing its functions as has been described.

I prefer the construction of independent blocks or composite tiles as herein shown, but the invention in its broadest aspect is not limited to that specific construction as other forms of construction of the furnace wall having a front facing of refractory material and the backing of metal in intimate contact with the tubes may be employed.

While the tubes and tiling are sufficient for the wall structure, the wall is shown in Figs. 3 and 4 as completed by a layer, 70, of non-conducting material applied on the outside of the tubes, as shown in Figs. 3 and 4, and covered by plates, 71, of sheet metal which are secured together and also secured to the furnace wall by some of the block fastening bolts, 55, which are extended through to the outside of the furnace, as shown at 550 in Fig. 4.

The specific form of the tiles may be varied to meet various requirements and as shown in Figs. 4 and 5 the tiles near the ver-

ticle ends of the front and rear walls are of somewhat different size and construction from those employed throughout the remainder of the walls, being provided with a substantially half-round seat near one end to extend practically half way around the endmost pipe of the front or rear wall, said tiles being applied with their greater length horizontal instead of vertical, as is the case with other tiles of the front and rear walls as appears in Fig. 5. Corresponding half clamps may be employed in connection with these end tiles, as shown at 560 in Fig. 4.

This construction affords a good joint with the side walls, the tiling of which extends entirely across the vertical edges of the front and rear walls which abut and may be caulked against the inner faces of the side walls, as shown.

The floor is preferably provided with tiles or blocks similar to those upon the side walls, except that in this case the refractory component may be omitted and the greater heat transferring capacity thus provided will maintain the floor wall at a somewhat lower temperature than the side walls and lower than would be desirable in the side walls where it would impair the efficiency of the combustion.

It is also desirable, as herein shown, to make the side and end walls for one or two courses adjacent to the floor of tiling without the refractory face portion and thus of greater heat transferring capacity, and with their faces somewhat to the rear of the face of the wall above them, which thus overhangs the lower courses at the inside of the furnace as indicated at 82 in Fig. 8. As shown, the face dimensions of the blocks are preferably equal to or multiples of each other, so that the blocks may be readily interchanged if desired. By "multiple", I mean that the dimensions of blocks in the different zones have such relation to each other that one or more blocks in one zone may be interchanged with one or more from another zone. This is of particular advantage in case it is desired to vary the relative extents of the zones formed by the above construction. That is to say, one zone has been described as formed of blocks or tiles entirely of metal, whereas an adjacent zone has been described as formed of the composite blocks having a refractory facing. By making the tiles so that they may be independently secured in position, and by suitably selecting their face dimensions, it is possible to adjust the relative areas of the different zones as may be found expedient.

The function of this overhanging construction and of the maintenance of the lower portion of the furnace walls at a slightly lower temperature than that of the remainder of the walls is as follows: the temperature in the same furnace will vary according to conditions of use, the temperature being higher than average or normal when the fire is increased for higher boiler rating, or demand for power above the normal or average, and the temperature becoming somewhat lower when the consumption of fuel is diminished for a lower boiler rating. At the lower ratings, when the furnace walls are relatively cooler than the normal temperature for which they are constructed, the ash will sometimes be in condition to adhere to the walls and will accumulate thereon forming a coating of greater or less thickness of ash of more or less cohesive nature. Then when the boiler rating is increased and an abnormally high temperature is produced the coating of ash will melt and run down the wall as slag, but upon arriving at the lower edge of the overhanging portion above the cooler courses it will congeal and will assume a formation similar to icicles hanging down from the lower edge of the overhanging part of the wall at the front of the cooler portion of the wall below. The slag in this form can be readily broken away from time to time and can then be raked out from the furnace in the usual way.

The floor being somewhat cooler than the side walls will not receive the ash in molten condition or have the ash melt in contact with it and consequently such ash as falls through the furnace accumulates on the floor with but little if any cohesiveness and may be readily removed from time to time.

The tiling on the tubes, 13, constituting therewith the deflecting arch or top wall of the combustion chamber is of the same construction and is jointed to the pipes in the same way as the tiling on the side walls, and in most cases should be of about the same heat transferring capacity as the tiling in the adjacent portions of the side walls.

Where the wall tubes are curved to produce a corresponding curvature of the walls, as is the case in some portions of the arch and of the front and rear walls herein shown, the construction is substantially the same as in the flat or plane parts, but the concave seats at the ends of the tile blocks should be made with a longitudinal curvature to fit the bend or curvature of the tubes as well as the transverse curvature to fit around the tubes. It may also be necessary or desirable to bevel or incline the longitudinal side surfaces of the blocks to accommodate or correspond to the inclination of one course to the next along the series of curved tubes.

Where the radius of curvature is great the same tiling as used for flat walls may serve, the conductive cement used being sufficient to neutralize the slight lack of fit of the tiling seats to the tubes.

I claim

1. A furnace wall composed of parallel tubes combined with tiles or blocks, each block having at the ends of its rear portion

concave seats adapted to fit the outer surfaces of a pair of tubes, and each having conductive cement material between the tubes and tile affording a gas-tight heat-conducting union between the tubes and tile, and means for securing the tiles to the tubes under pressure.

2. A furnace the vertical walls of which are composed of cooling tubes and tiles secured thereto closing the spaces between adjacent pairs of tubes, said tiles at the lower margins of said vertical walls being of greater heat transferring capacity than those above, thereby providing a portion at the foot of the walls which is cooler than the portion above.

3. The combination in a furnace wall of cooling tubes, tiling fitted to said tubes, heat conducting cement between said tiling and said tubes comprising powdered carborundum and a suitable vehicle, and means to clamp said tiling to the tubes and to thereby exert pressure on said cement.

4. In a furnace, means for feeding powdered fuel thereto, means for maintaining the floor of said furnace at a lower temperature than the melting point of refuse particles from said fuel, and means forming part of the side walls for removing heat more rapidly from the lower than the upper parts of the side walls of said furnace and maintaining the upper portions of said walls at a temperature above the melting point of said particles.

5. A furnace the vertical walls of which are composed of tubes and tiles secured thereto closing the spaces between each adjacent pair of tubes, said tiles at the lower margins of said vertical walls being of greater heat transferring capacity than those above, thereby providing a portion at the foot of the walls which is cooler than the portion above, and with the upper portion of the wall overhanging the lower portion.

6. A furnace wall comprising a row of spaced cooling tubes and a plurality of tile positioned edge to edge to form a substantially continuous wall area, said tile formed entirely of metal to conduct heat rapidly from the furnace to the tubes, means forming an intimate thermal contact between the tile and the tubes, and means detachably holding each tile in position with respect to the tubes.

7. A fuel-burning furnace having a vertically extending wall comprising a row of cooling tubes and a plurality of tile, means forming an intimate thermal contact between said tubes and tile, said tile being arranged in a plurality of horizontally extending zones, the tile in one zone being of relatively high heat transferring capacity and those in an adjacent zone being of relatively low heat transferring capacity.

8. In combination, a furnace having means for burning slag-forming fuel therein and having a vertically extending wall with a drip ledge intermediate its height, the edge of the ledge being spaced inwardly from the portion of the wall beneath the ledge, whereby molten slag or ash running down the wall may drip freely from the ledge without contacting with the wall beneath it, a cooling tube disposed in position to cool said ledge, the portion of the wall beneath said ledge being formed of metal, and the portion above the ledge being formed with its inner face of refractory material, and cooling tubes disposed in the metal portion of the wall to cool the same.

9. In combination, a furnace having means for burning slag-forming fuel therein and having a vertically extending wall with a drip ledge intermediate its height, the edge of the ledge being spaced inwardly from the portion of the wall beneath the ledge, whereby molten slag or ash running down the wall may drip freely from the ledge without contacting with the wall beneath it, a cooling tube disposed in position to cool said ledge, and cooling tubes disposed in the wall beneath said ledge.

10. In combination, a furnace having means for burning slag-forming fuel therein and having a vertically extending wall with a drip ledge intermediate its height, the edge of the ledge being spaced inwardly from the portion of the wall beneath the ledge, whereby molten slag or ash running down the wall may drip freely from the ledge without contacting with the wall beneath it, a cooling tube disposed in position to cool said ledge, and cooling tubes disposed in the wall beneath said ledge and above it.

11. In combination, a furnace having means for burning slag-forming fuel therein and having a vertically extending wall with a drip ledge intermediate its height, the edge of the ledge being spaced inwardly from the portion of the wall beneath the ledge, whereby molten slag or ash running down the wall may drip freely from the ledge without contacting with the wall beneath it, a cooling tube disposed in position to cool said ledge, the portion of the wall beneath the ledge being formed of a row of cooling tubes, and metallic tile secured thereto and in intimate thermal contact therewith and presenting a substantially continuous metallic face to the inside of the furnace.

12. The method of forming a furnace wall of metallic cooling tubes and tiles of high heat transferring capacity, which comprises placing between the tubes and the tiles a fluid plastic material of ultimate high heat-conductive quality, and forcing the tiles and tubes together to cause said material to flow and thus to form an intimate thermal union between the tubes and the tiles.

13. A furnace wall comprising a cooling tube of high heat-conductive material, a tile of high heat-conductive material closely fit-

ting the outer wall of said tube, and a plastic material disposed between said tube and tile and having substantially uniform high heat-conductive properties throughout, said material intimately thermally connecting said tube and tile.

14. A furnace wall comprising a cooling tube of high heat-conductive material, a tile of high heat-conductive material closely fitting the outer wall of said tube, and a plastic material disposed between said tube and tile, said material comprising finely divided particles having high heat-conductive property mixed with a fluid, and means exerting pressure on said material to cause it to form an intimate thermal union between the tube and the tile.

15. A furnace chamber having two walls meeting at a corner, each of said walls being formed of spaced cooling tubes and heat-conducting means closing the spaces therebetween and forming the inner facing of the walls, said means adjacent said corner on both of said walls having high heat transferring capacity and at least one of said walls having a portion remote from the corner in which said space closing means is of less heat transferring capacity than the space closing means adjacent said corner.

16. A furnace wall comprising a row of spaced cooling tubes and a plurality of tile positioned edge to edge to form a substantially continuous wall area, said tile formed entirely of metal to conduct heat rapidly from the furnace to the tubes, a plastic material disposed between said tubes and tile and having substantially uniform high heat-conductive properties throughout, said material intimately thermally connecting said tube and tile, and means detachably holding each tile in position with respect to the tubes and said plastic material.

17. In combination, a furnace having means for burning slag-forming fuel therein and having a vertically extending wall with a drip ledge intermediate its height, the edge of the ledge being spaced inwardly from the portion of the wall beneath the ledge, whereby molten slag or ash running down the wall may drip freely from the ledge, and cooling-medium circulating means in the wall in thermal heat-conductive relationship to said ledge to conduct heat therefrom.

18. A furnace wall comprising a cooling tube of high heat-conductive material, a tile comprising high heat-conductive material closely fitting the outer wall of said tube, a plastic material disposed between said tube and tile and having substantially uniform high heat-conductive properties throughout, and means to clamp said tile to said tube to reduce said plastic material to a minimum thickness and thereby establish connection of high heat transferring capacity between the tube and tile.

19. The combination in a furnace wall of cooling tubes, tile fitted to said tubes, heat conducting plastic material disposed between said tile and tubes, and means to clamp said tile to said tubes and to thereby exert pressure on said material and to cause contact of high heat transferring capacity between the tubes and tile.

20. In combination, a tube of high heat-conductive material subjected to the action of a source of heat, a member of high heat-conductive material between the tube and the source of heat and closely fitting the outer wall of said tube, a plastic material disposed between said tube and member and having substantially uniform high heat-conductive properties throughout, and means to clamp said member tightly to said tube and thereby cause said material to intimately thermally connect said tube and member.

21. A fuel-burning furnace having a vertically extending wall comprising a row of cooling tubes and a plurality of tile, means forming an intimate thermal contact between said tubes and tile, said tile being arranged in a plurality of horizontally extending zones, the tile in one zone being of relatively high heat transferring capacity and those in another zone being of relatively low heat transferring capacity, and means independently securing said tile to said tubes, whereby said tile may be changed from one zone to another to vary the zoning of the wall.

22. A fuel-burning furnace having a vertically extending wall comprising a row of cooling tubes and a plurality of tile, means forming an intimate thermal contact between said tubes and tile, said tile being arranged in a plurality of horizontally extending zones, the tile in one zone being of relatively high heat transferring capacity and those in another zone being of relatively low heat transferring capacity, the tile in one zone having face dimensions which are multiples of corresponding face dimensions of the tile in the other zone, and means independently securing said tile to said tubes, whereby said tile may be changed from one zone to another to vary the zoning of the wall.

23. In combination with a furnace, a cooling tube of high heat-conductive material, a tile of high heat-conductive material closely fitting the outer wall of said tube, a clamp member cooperating with said tile and tube to hold the tile in position on the tube, a plastic heat conducting material disposed between both the tile and the clamp member, and means to compress said plastic material between said tube and said tile and clamp member.

24. A furnace wall comprising a row of cooling tubes, a facing formed of tile disposed along the inner side of said row and closely adjacent thereto, means holding said tile in position with relation to said tubes,

heat conducting means on the outer side of said tubes and arranged to receive heat from said tile, means holding said heat conducting means in position with relation to said tubes, and plastic material of high heat-conductive properties disposed between said tubes and both said tile and said heat conducting means, whereby heat received by said heat conducting means and by said tile may be readily conducted to the contents of said tubes.

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