

Oct. 25, 1932.

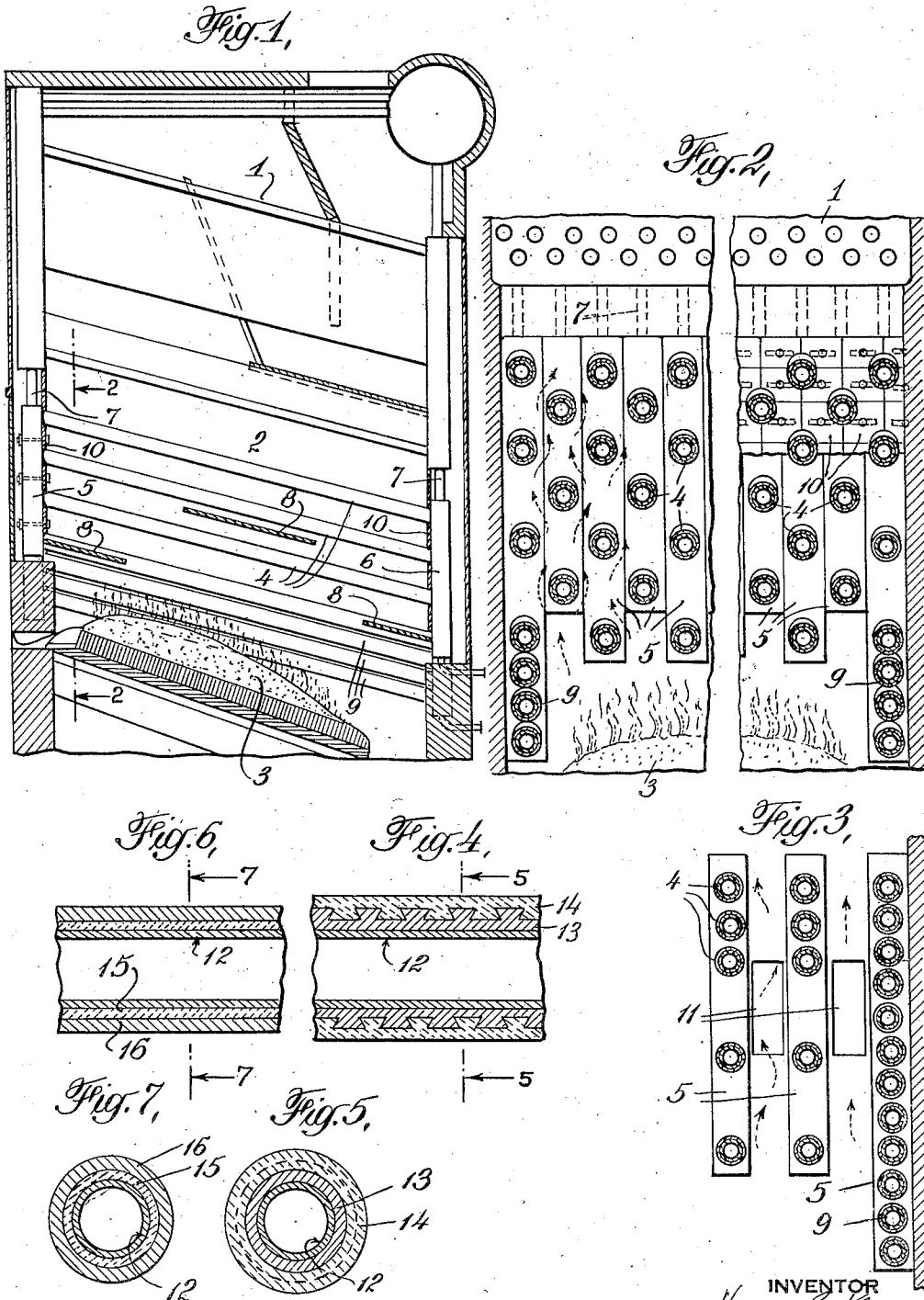
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1,884,741

RADIANT HEAT BOILER

Filed March 27, 1930

3 Sheets-Sheet 1



INVENTOR

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3 Sheets-Sheet 2

Fig. 8,

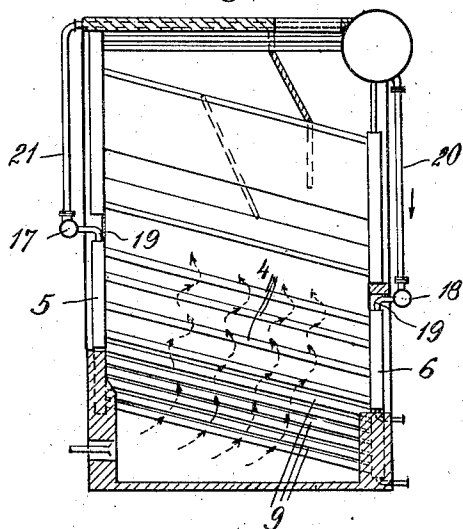


Fig. 9,

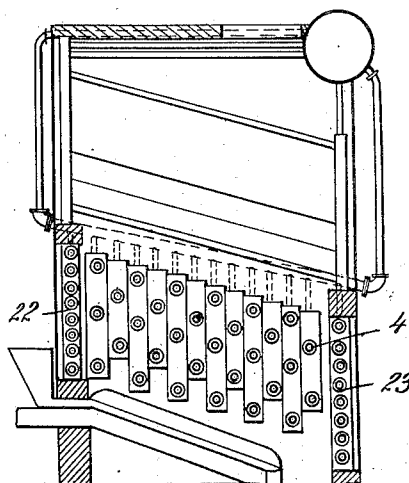


Fig. 10,

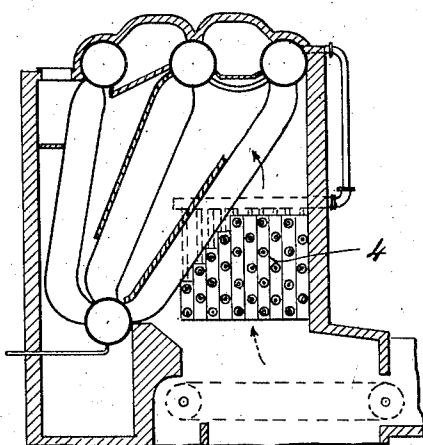


Fig. 11,

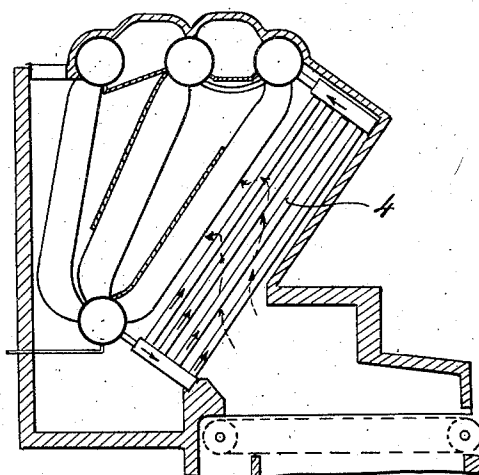
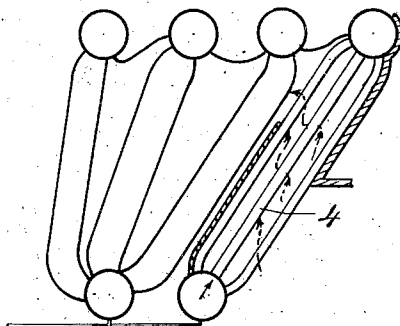


Fig. 12,

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3 Sheets-Sheet 3

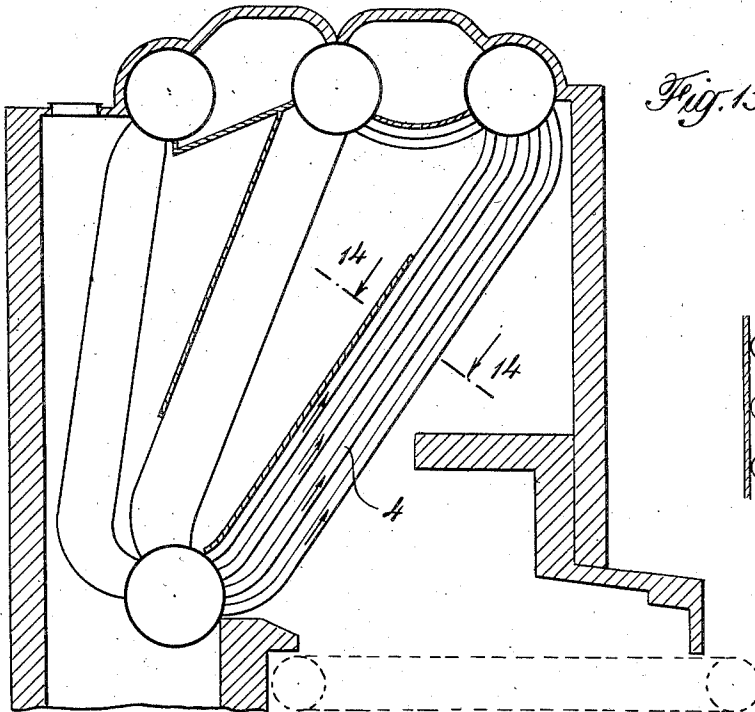


Fig. 13,

Fig. 14,

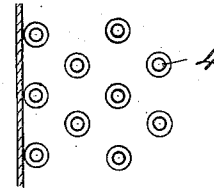


Fig. 15,

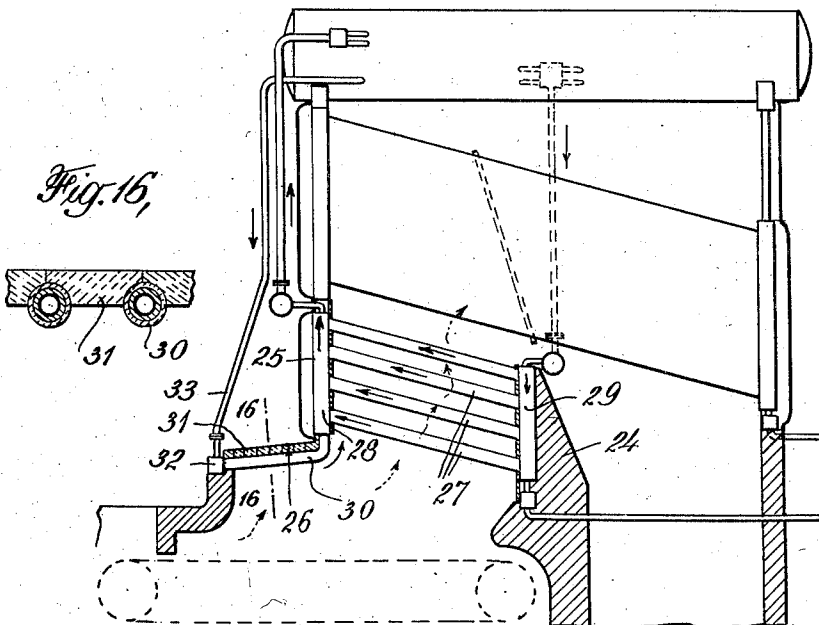
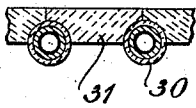


Fig. 16,



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UNITED STATES PATENT OFFICE

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RADIANT HEAT BOILER

Application filed March 27, 1930. Serial No. 439,349.

This invention relates to steam boilers and is concerned more particularly with a boiler which includes numerous novel features by virtue of which improved combustion and heat absorption are obtained. In addition, the new boiler may have a combustion chamber of much less capacity than is now thought necessary for proper combustion, and the walls of this chamber are protected against burning out by a simple construction much less expensive than the water walls now commonly used for the purpose.

Prior to 1914, it was the common practice in building boilers to set them within six or seven feet above the floor line and only three or four feet above the fuel bed when stoker firing was used, or above the flame entrance in case of gas or oil firing. This limited the furnace volume and resulted in low furnace efficiency, incomplete combustion, and relatively low capacity due to the flame and combustible gases coming in contact with relatively cool boiler surface and being chilled before complete combustion could take place.

In order to improve these conditions, furnace heights were increased from time to time until at present modern boiler furnaces extend up to 20 to 30 feet above the floor line or fuel bed or above the flame entrance. With the advent of powdered coal firing, furnace heights and volumes have been still further increased.

In these large furnaces with refractory settings, the only water cooling the furnace received at first was from the row of boiler tubes facing the furnace, and with better combustion, increased furnace efficiency, and higher furnace temperatures, the cost of maintaining the brickwork rapidly increased. In order, therefore, to reduce the maintenance charges, the walls were lined with heating surface consisting of water tubes connected by headers and pipes to the boiler so as to obtain circulation through the tubes. These water walls ordinarily consisted of either bare tubes or tubes protected by metal or by metal with refractory lined surfaces exposed directly to the furnace.

While such water walls forming an enclosure for the furnace are in general satis-

factory, they are relatively expensive and they absorb relatively large amounts of heat generated in the furnace and radiated from the outer envelope of the flame, this absorption reducing the temperature of the gases entering the boiler heating surface and in some cases chilling the flame so that incomplete combustion results. More recently, boilers have been constructed with radiant bare tube sections in addition to the furnace water walls, the banks of radiant bare tubes being disposed either above or below a furnace of large volume through which the products of combustion pass after the fuel has been completely consumed and burned.

As indicated above, the modern tendency is toward larger and larger combustion chambers so that the gases require more time to pass through the furnace and a more thorough diffusion of the burning gases with air takes place, so as to obtain more nearly complete combustion before the gases enter the heating surface. These chambers are frequently lined with water walls which add substantially to the cost of installation.

My invention is directed to the provision of a boiler unit which serves to bring about a better mixing of the burning gases with oxygen so that the size of the furnace may be materially reduced without reducing the efficiency of combustion, this unit at the same time including relatively inexpensive means for protecting the furnace walls which may be of ordinary refractory. The boiler unit of my invention may be placed within the furnace cavity proper in the open space formerly used as an open chamber for passage of the flame and gases on their way to the boiler heating surface, and may be located directly after and within a short distance of the fuel bed or flame entrance in the direction of gas travel directly ahead of the boiler or other heating surface of which it may be an integral part. Generally speaking, the furnace unit consists of a bank of tubes in various arrangements of spacing and with the tube centers relatively far apart so that the draft loss is small in comparison to the total draft required. These tubes are connected at their ends to headers or drums

which are in turn connected into the water circulation of the boiler proper or to other heating surface.

The tube bank across the furnace chamber or cavity is located directly in the path of burning gases and flame and within the zone of combustion. The bank restricts to some extent the free flow of gases from the fuel bed or flame entrance up through the chamber or cavity up to the boiler proper by imposing in the path of the gases a multiplicity of tubes forming devious passes. The draft in the furnace causes the combustible gases and air to flow at increased velocities through the tube bank and, therefore, turbulent mixing and diffusion of the gases and air are more effective. By reason of the draft loss within the furnace cavity the rate of combustion within the tube bank is increased and the remaining combustible constituents passing up through the tube bank from the fuel bed are burned and completely consumed before they reach the heat-absorbing surface of the boiler. While heat is generated within the tube bank and combustion is being completed due to the intimate mixing of the combustibles with the oxygen of the air with a resultant increase in temperature and consequent increase in volume of the gases, the temperature and volume of the gases do not increase to a maximum due to the fact that the tube surfaces are constantly absorbing heat in proportion to the temperature rise and as a result the gaseous products of combustion leave the tube bank at a lower temperature and volume than would be the case if the tube bank were not in the furnace cavity. The rate of heat absorption within the tube bank, however, is limited in accordance with the thickness and conductivity of the refractory covering of the tubes and its reverberatory action.

The tubes of the new unit and the inner faces of the headers thereof are provided with an outer metallic covering and with additional covering of refractory or insulating material, when required the purpose of these coverings being to limit the rate of heat absorption by the water within the tubes and also to provide a hot or incandescent surface which reflects heat back into the furnace or space between the tubes and thus maintain the gases passing through the tube bank at the temperature required for completing combustion. The character of the covering used will accordingly depend on the type of fuel being burned. In the new unit, the flame and combustible gases enter the tube bank and pass between the widely spaced tubes which are arranged to cause the flame and gases to impinge against the tubes and to change direction, the tubes diverting and splitting up the flowing stratified gases and thus causing an intimate mixing and turbulence which brings about an increase in the rate of com-

bustion within a short length of gas travel and within a short period of time.

The boiler unit of the invention can be installed in a furnace of relatively low height and small volume since complete combustion is obtained more rapidly than is ordinarily the case by reason of the mixing and turbulence in the gas stream produced by the tube arrangement and spacing within the tube bank and because the gases are maintained at the proper temperature for combustion by reason of the rate of heat absorption into the heating surface of the tubes being limited and controlled by the covering thereof. It is, therefore, evident that when the new unit is employed, the time and the volume of chamber required for complete combustion are substantially diminished. Furthermore, the unit of the invention may be so constructed that the side tubes of the bank and their headers form a water cooled enclosure for the furnace, thus eliminating the necessity for the ordinary water wall cooling surface.

The new unit may be installed either as an integral part of the boiler or the invention may be embodied in a self-contained unit which can be installed in boiler settings now in use. In either construction, the heating surface directly facing the fuel bed and flame is made up of protected water tubes spaced relatively far apart and arranged so as to receive the maximum amount of radiant heat. Beyond these tubes, the ordinary heating surfaces will be employed, the water tubes thereof being spaced closely together in the ordinary way to receive the gaseous products of combustion.

With the aforesaid and other purposes in view, the character of the invention may be best understood from the following description of the invention as illustrated in the accompanying drawings, wherein

Fig. 1 is a cross-section through a conventional horizontal water tube boiler furnace and stoker in which the boiler unit and mixer of my invention forms an integral part of the boiler water circulating system;

Fig. 2 is a longitudinal sectional view on the line 2—2 of Fig. 1 and showing one form of tube spacing;

Fig. 3 illustrates an alternate method of spacing the tubes in the radiant furnace boiler;

Fig. 4 is a longitudinal section through one form of water tube of the radiant furnace boiler;

Fig. 5 is a cross-sectional view on the line 5—5 of Fig. 4;

Fig. 6 is a view similar to Fig. 4 showing an alternative construction;

Fig. 7 is a cross-sectional view on the line 7—7 of Fig. 6;

Fig. 8 is a cross-sectional view through a conventional horizontal water tube boiler furnace showing the different method of con-

necting the unit of my invention to the main boiler;

Fig. 9 is a cross-sectional view of a longitudinal water tube boiler showing another method of installing the unit of my invention;

Fig. 10 is a cross-sectional view of a conventional inclined bent tube boiler with the new unit installed;

Fig. 11 is a cross-sectional view of a conventional inclined bent tube boiler with the new unit installed;

Fig. 12 is a cross-sectional view of an inclined water tube boiler showing an alternative method of installing the unit of my invention;

Fig. 13 is a cross-sectional view of an inclined water tube boiler with the front section of the boiler provided with protected water tubes of my invention;

Fig. 14 is a cross-sectional view on the line 14—14 of Fig. 13;

Fig. 15 is a cross-sectional view through a conventional longitudinal drum boiler with a unit of my invention installed; and

Fig. 16 is a cross-sectional view on the line 16—16 of Fig. 15.

Referring now to the drawings, there is indicated somewhat diagrammatically in Fig. 1, a conventional horizontal water tube boiler 1 set over a furnace 2 which lies directly over the stoker fuel bed 3. Within the furnace is located a bank of protected water tubes 4 which lead at the front end of the setting to vertical headers 5 and are connected at the rear to vertical headers 6. These headers are connected to the boiler circulation system by nipples 7 so that the bank of tubes and headers form a self-contained unit. The flame and combustible gases from fuel bed 3 pass up around and between the protected tubes 4 before entering the heating surface of the boiler section 1, and the tubes 4 receive heat by direct flame impingement, by the scrubbing of the gases on the tube surface and by radiation from the outer envelope of the flame. The tubes cause the flowing gases to be broken up and mixed, and in order to secure further mixing and turbulence, baffles 8 may be provided to divert the gases in their passage through the tube bank.

The side wall tubes 9 are located along the side walls of the furnace and extend below the main body of tubes in bank 4 so as to protect the side walls in the space between the fuel bed and the bank. Front headers 5 and rear headers 6 form a water cooled area for the absorption of heat and also provide a front and rear water cooled wall. Thus front headers 5, rear headers 6 and side wall tubes 9 form a rectangular box enclosure for the boiler furnace.

Referring to Fig. 2, the inner faces of the headers 5 may be bare or covered with metal

or refractory faced plates 10 which are held against the face of the headers by bolts which pass between adjacent headers and extend to the outside where they engage clamps bearing against the outside faces of the headers.

The spacing of the tubes which comprise the bank 4 may be as shown in Fig. 2 or the spacing may be increased or diminished in accordance with the fuel being consumed. Where the spacing of ordinary 4" tubes in a boiler is on approximately 7" centers, the tubes of the radiant bank may be on 14" to 28" centers, the spacing and arrangement being selected to provide the desired mixing without imposing excessive draft losses. The tubes may be staggered as illustrated or they may be arranged with variable spacing throughout part or all of the tube bank or in rows with the tubes in one row staggered relative to those in adjacent rows, the purpose of such arrangements of the tubes being to obtain most effective diffusion, diversion and mixing of the burning gases and the arrangement selected being to some extent dependent upon the type of fuel being burned.

Fig. 3 shows one form of spacing in which the tubes are arranged in parallel rows to provide lanes for the flame and gases to pass up through the furnace tube section or an alternative arrangement may be used in which the parallel rows of tubes are staggered in the same manner as the individual tubes in Fig. 2. Such an arrangement is likely to be most satisfactory in burning powdered fuel provided the tubes in the rows are spaced apart to permit the gases to envelop them to some extent, this action producing the desired turbulence. In an alternative arrangement, the tubes may be placed in contact with each other to form water cooled partitions in the furnace interior, an observation and slag door 11 being provided between the headers for the purpose of cleaning the tubes. This arrangement is not so advantageous, however, as one in which the tubes are spaced apart, since it does not produce the same degree of turbulence and acceleration of combustion.

In Fig. 4 there is shown a longitudinal section of a tube of the new unit with one form of tube covering. The tube 12 is enclosed within a metal cylinder 13 made of convenient lengths preferably shrunk in place. The outside of this cylinder is provided with corrugations, dovetail slots, pockets or other irregularities which make it possible to secure the refractory or insulating covering material 14 thereon. The refractory extends around the tube in sections for its entire length. If desired the tubes may be covered as illustrated in Fig. 6. In this form the tube is enclosed in a covering 15 of an insulating or refractory material over which is a heat resistant metal covering 16.

The purpose of the tube coverings is to control the heat absorbed by the fluid in the tube interior and also to maintain a temperature on the outside surface of the tube sufficient to support combustion. The outside covering also protects the boiler tube from the erosive and oxidizing action of the flame and ash and in addition, the comparatively cool fluid in the tube tends to keep the surface covering cool enough so that its life in operation is prolonged. The metal sleeve in intimate contact with the tube throughout its circumference and length strengthens the tube against bursting and increases its resistance to bending.

A conventional horizontal water tube boiler is shown in Fig. 8 fired by oil, gas or powdered fuel, and having one form of the new boiler unit 4 installed in the furnace with water tubes 9 extending along the side walls. The boiler unit is connected to the boiler circulating system by front headers 17 and rear headers 18 which are connected by elbows 19 to the front and rear headers 5 and 6 of the radiant furnace boiler, downflow piping 20 and riser piping 21 leading from headers 17 and 19 to the boiler drum. This type of the new unit can be installed in existing boiler furnaces at a small expense and without raising the boiler or making extensive changes in the setting.

Another method of installing the radiant furnace boiler in the furnace of a conventional horizontal water tube boiler is shown in Fig. 9, wherein the tube bank 4 is arranged with the tubes at right angles or across the tubes of the conventional boiler above. The headers 21 in this arrangement become the side wall cooling surface and the front line of tubes 22 and rear line 23 form the front and rear wall cooling surface. As in the construction shown in Fig. 8, the new furnace unit is connected to the boiler circulating system by headers and piping to the boiler drum.

In Fig. 10 there is shown a conventional bent tube boiler with the furnace bank of tubes 4 disposed in the furnace at right angles to or across the boiler tubes.

In Fig. 11 there is illustrated a bent tube boiler with the furnace unit headers connected to the front and bottom boiler drums and the tube bank set in the furnace with the tubes parallel to the conventional boiler tubes.

Fig. 12 shows diagrammatically a conventional multi-drum bent tube boiler with the new furnace boiler forming an integral part thereof so as to provide a self contained boiler and furnace unit. The protected tubes 4 are connected at their ends with boiler drums which are in turn connected with the other boiler drums of the unit.

In the conventional bent tube boiler of Fig. 13, the furnace boiler tubes 4 are placed so as

to form the front bank of tubes of the boiler. The spacing of the tubes 4 is shown in Fig. 14.

Fig. 15 illustrates a conventional longitudinal drum boiler with a furnace in the space between bridge wall 24 and front wall 25 and below arch 26. The new furnace boiler 27 is located between the front and bridge walls with the front headers 28 and rear header 29 connected to the boiler circulation system as shown. The water cooled arch 26, where used, may consist of covered tubes 30, between and on top of which is tile 31, the tubes being connected at the rear end directly to the front header 28 and at the front end to header pipe 32, which is connected to the boiler circulation system by pipe 33. The arrangement of tubes 30 and tile 31 is shown in Fig. 16.

With any of the illustrated arrangements of the bank or rows of tubes, it will be apparent that I have provided means in the path of travel of the burning gases, by which stratification in the gas stream is broken up and the gases recombined so that a highly efficient combustion is obtained due to the resulting turbulence. In the ordinary combustion chamber, approximately 80% of the combustion occurs in the 25% of the chamber which lies nearest the fuel bed or flame entrance. The gases then travel through the remainder of the chamber along the path of least resistance to the boiler surface, the combustion of the remainder of the unburned fuel being completed in this portion of the chamber. Heretofore the chamber in the majority of cases has been entirely free of obstructions to the flow of the gases, and that has resulted in the gases flowing through the chamber along a well-defined stream-line path without turbulence. Gas flow of this sort is not such as to accelerate combustion and as a consequence larger and larger chambers have been required to give the burning fuel and gases sufficient time to combine with the oxygen of the air for combustion so that complete combustion is obtained before the gases reach the boiler heating surface.

With the tubes of the invention installed in the manner described, these tubes act as water-cooled deflecting elements which effect mixing of the gases and air and produce turbulence, diffusion and diversion, which results in the gases being completely consumed in a much less period of time than would otherwise be necessary. As a result, a large chamber with a relatively long gas travel is not required. The tubes while directly in contact with the hot gases do not chill them below the temperature of combustion since the tube surface is maintained at a high temperature due to control of the rate of heat absorption provided by varying the thickness and kind of refractory carried by the tubes. The refractory covered tubes also reflect heat back into the gases and since the

tubes are on relatively widely spaced centers, they do not increase the draft required to any important degree.

The tubes and headers also provide a convenient means for protecting the side and end walls of the furnace and they thus effect substantial economies, since they permit the use of small combustion chambers and avoid the necessity of providing the expensive water walls now in common use.

What I claim:

1. A tube for use in a furnace chamber comprising a tubular water shell of metal, an outer metallic sleeve shrunk thereon, and a coating of heat-insulating material over said sleeve and interlocked therewith.

2. A tube for use in a furnace chamber comprising a tubular water shell of metal, an outer metallic sleeve shrunk thereon, and a coating of refractory material over said sleeve and interlocked therewith, said material being capable of becoming incandescent at high temperatures.

3. A tube for use in a furnace chamber installation comprising a tubular shell of metal, an outer metallic sleeve thereon and in intimate contact therewith, the sleeve having interlocking projections, and a coating of refractory material over said sleeve and interlocked with said projections.

4. A tube for use in a furnace chamber installation comprising a tubular shell of metal, an outer metallic sleeve thereon, said sleeve having dove-tail projections, and a coating of refractory material over said sleeve and interlocking with said projections.

5. In a boiler installation, the combination of a furnace chamber, means for introducing fuel into the chamber for ignition and combustion therein, heat-absorbing surface beyond the furnace chamber in the direction of flow of the gases of combustion, and a bank of water tubes within the furnace chamber with a substantial proportion of the tubes in said bank lying in that part of the chamber where combustion of the gases is taking place, the tubes in said bank extending substantially transverse to the direction of flow of the gases and providing a plurality of tortuous passages for the gases through said bank, whereby diffusion and turbulence in the burning gases are produced, said tubes being provided with a covering maintained relatively cool by the contents of said tubes and permitting abstraction of heat from said gases to a limited and controlled extent such as not to interfere with combustion of said gases.

6. In a boiler installation, the combination of a furnace chamber, means for introducing fuel into the chamber for ignition and combustion therein, heat-absorbing surface beyond the furnace chamber in the direction of flow of the gases of combustion, and a bank of water tubes within the furnace chamber

with a substantial proportion of the tubes in said bank lying in that part of the chamber where combustion of the gases is taking place, the tubes in said bank extending substantially transverse to the direction of flow of the gases and providing a plurality of tortuous passages for the gases through said bank, whereby diffusion and turbulence in the burning gases are produced, said tubes being provided throughout their entire length and circumference with a covering of material acting as a reflector of heat and serving to transfer heat to the contents of said tubes at a rate selected to avoid interference with combustion of said gases.

7. In a boiler installation, the combination of a furnace chamber, means for introducing fuel into the chamber for ignition and combustion therein, heat-absorbing surface beyond the furnace chamber in the direction of flow of the gases of combustion, and a bank of water tubes within the furnace chamber with a substantial proportion of the tubes in said bank lying in that part of the chamber where combustion of the gases is taking place, the tubes in said bank extending substantially transverse to the direction of flow of the gases and providing a plurality of tortuous passages for the major portion of the gases through said bank, whereby diffusion and turbulence in the burning gases are produced, the major portion of the tubes in said bank lying in the chamber in the path of the gases throughout their passage through said bank, certain other tubes of said bank lying along the side walls of the chamber and providing protection therefor, and headers constituting the ends of the chambers, each tube connecting a pair of headers at opposite ends of the chamber.

8. In a boiler installation, the combination of a furnace chamber, means for introducing fuel into the chamber for ignition and combustion therein, heat-absorbing surface beyond the furnace chamber in the direction of flow of the gases of combustion, and a bank of covered water tubes within the furnace chamber and in the zone therein where combustion is taking place, said tubes extending substantially transverse to the direction of flow of the gases and being arranged in rows parallel to the direction of flow of the gases with the tubes of one row staggered with relation to those of adjacent rows, said tubes being provided with individual coverings serving to reflect heat and to transmit heat to the contents of the tubes at a selected rate, and said tubes being spaced and arranged to provide a plurality of tortuous paths through the bank for the major portion of the burning gases, said gases being diffused, diverted, and rendered turbulent in said bank with an increase in their rate of combustion.

9. A tube for use in a furnace chamber installation, comprising a tubular shell of

metal, an outer metallic sleeve thereon, said
sleeve having projections on its outer surface,
and heat-insulating material mounted on the
outer surface of said sleeve and held in place
by being interlocked with said projections.

5 In testimony whereof I affix my signature.

HARRISON E. KLEFFEL.

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