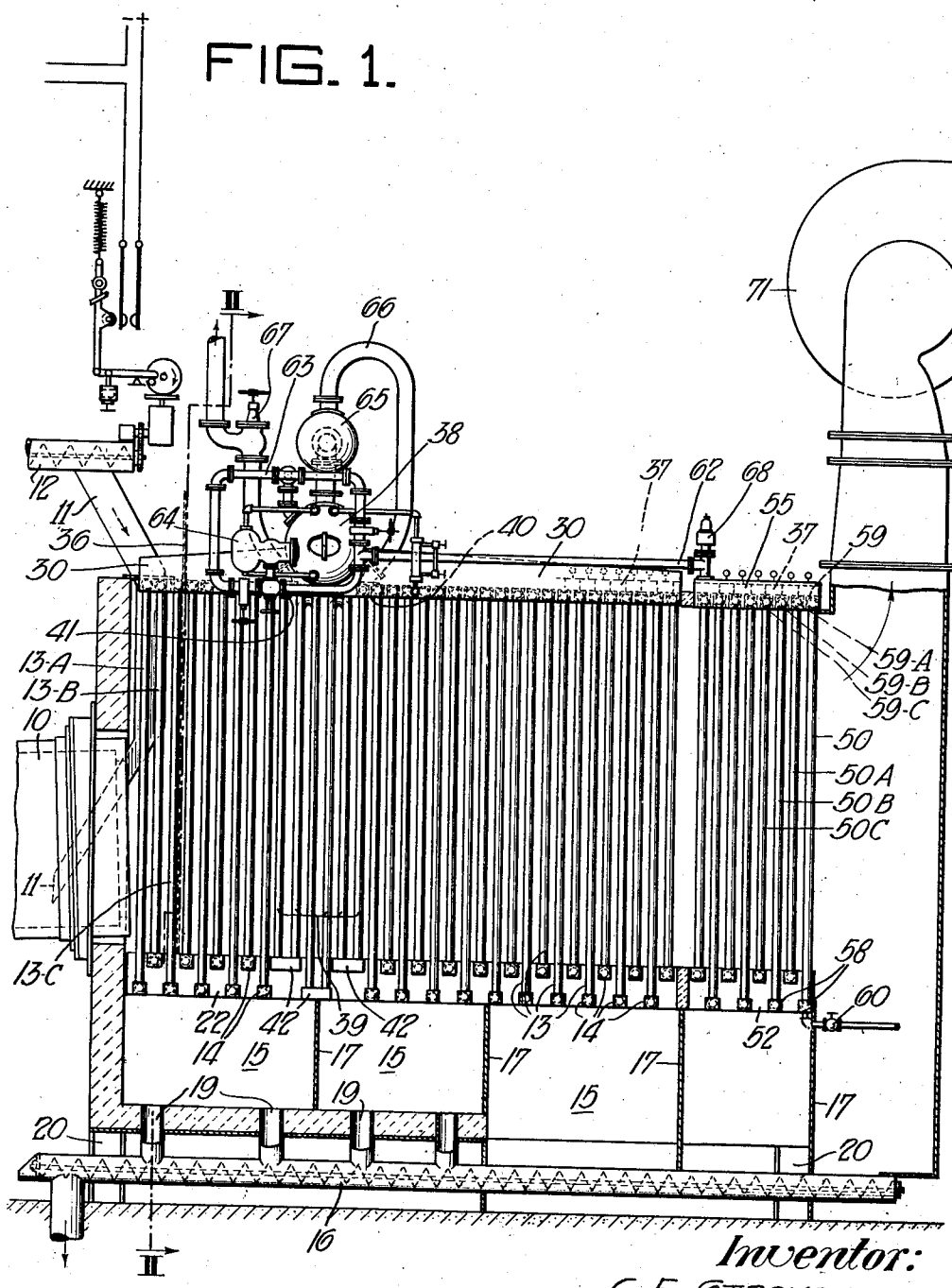
Dec. 19, 1944. C. E. STROMQUIST 2,365,305

WASTE HEAT BOILER

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FIG. 1.



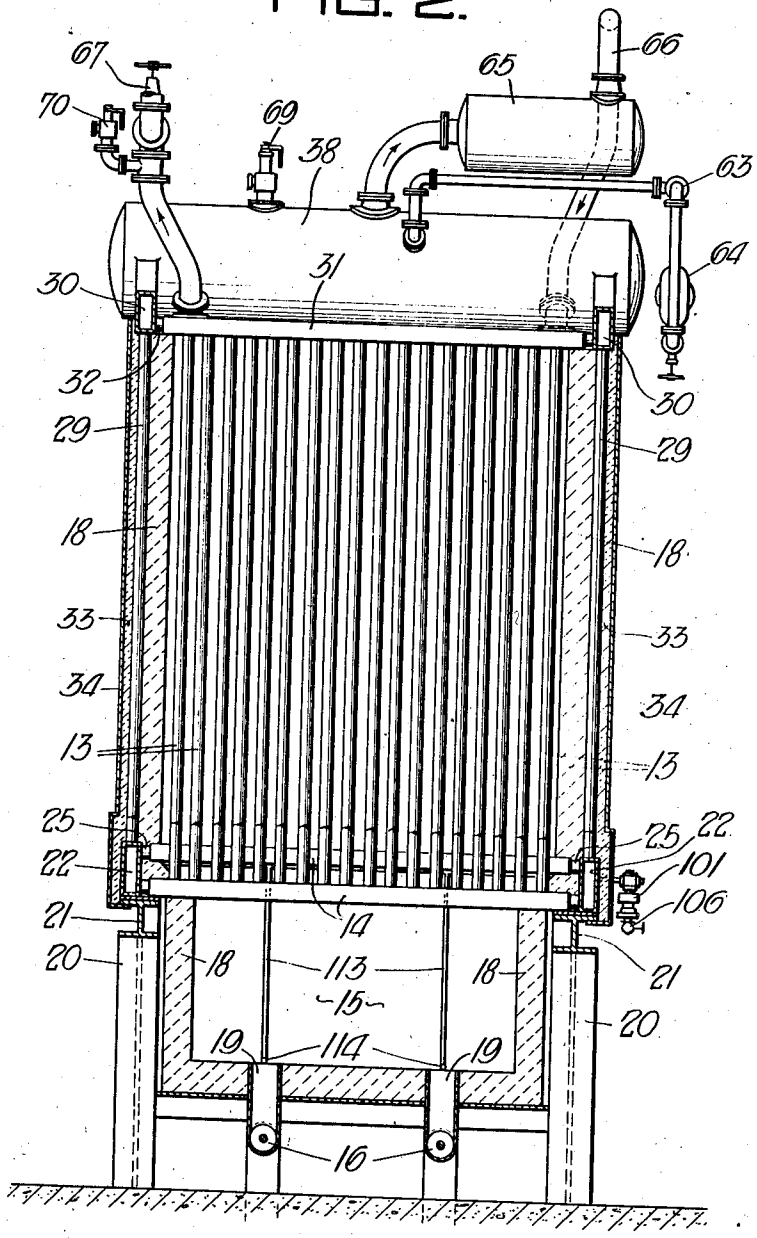
Inventor:
C. E. STROMQUIST,
by: John E. Jackson
his Attorney.

Dec. 19, 1944. C. E. STROMQUIST 2,365,305

WASTE HEAT BOILER

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FIG. 2.



Inventor:
C. E. STROMQUIST,
by: John E. Jackson
his Attorney.

Dec. 19, 1944. C. E. STROMQUIST 2,365,305

WASTE HEAT BOILER

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FIG. 3.

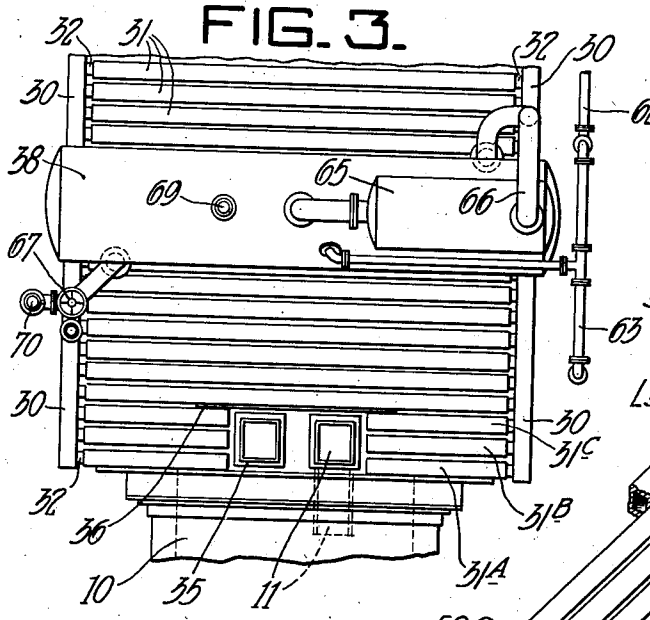


FIG. 6.

Inventor:
C. E. STROMQUIST,
by: John E. Jackson
his Attorney.

Dec. 19, 1944. C. E. STROMQUIST 2,365,305

WASTE HEAT BOILER

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FIG. 4.

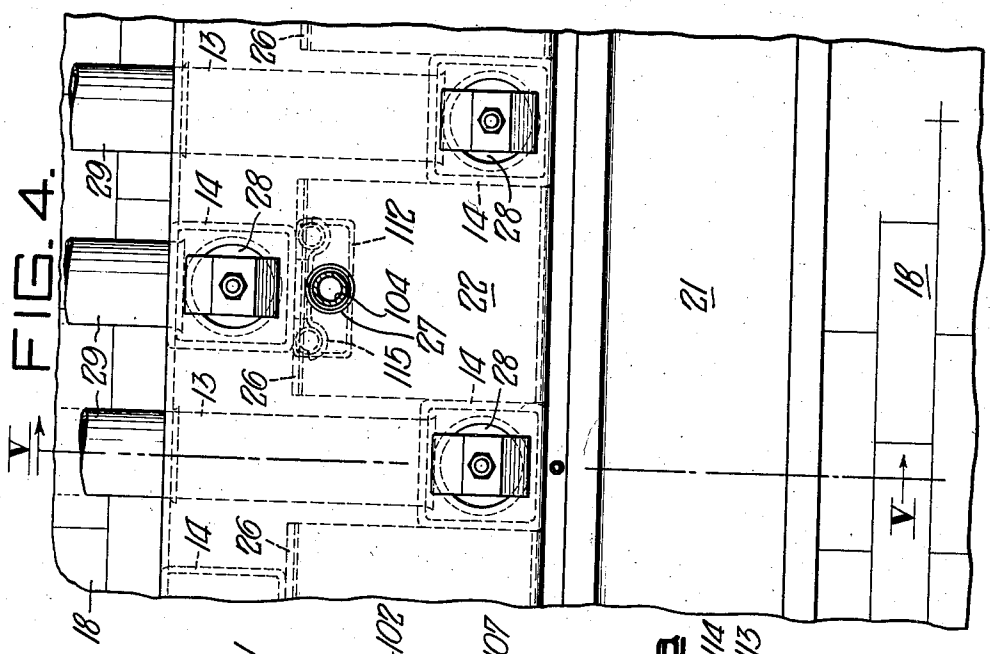


FIG. 5.

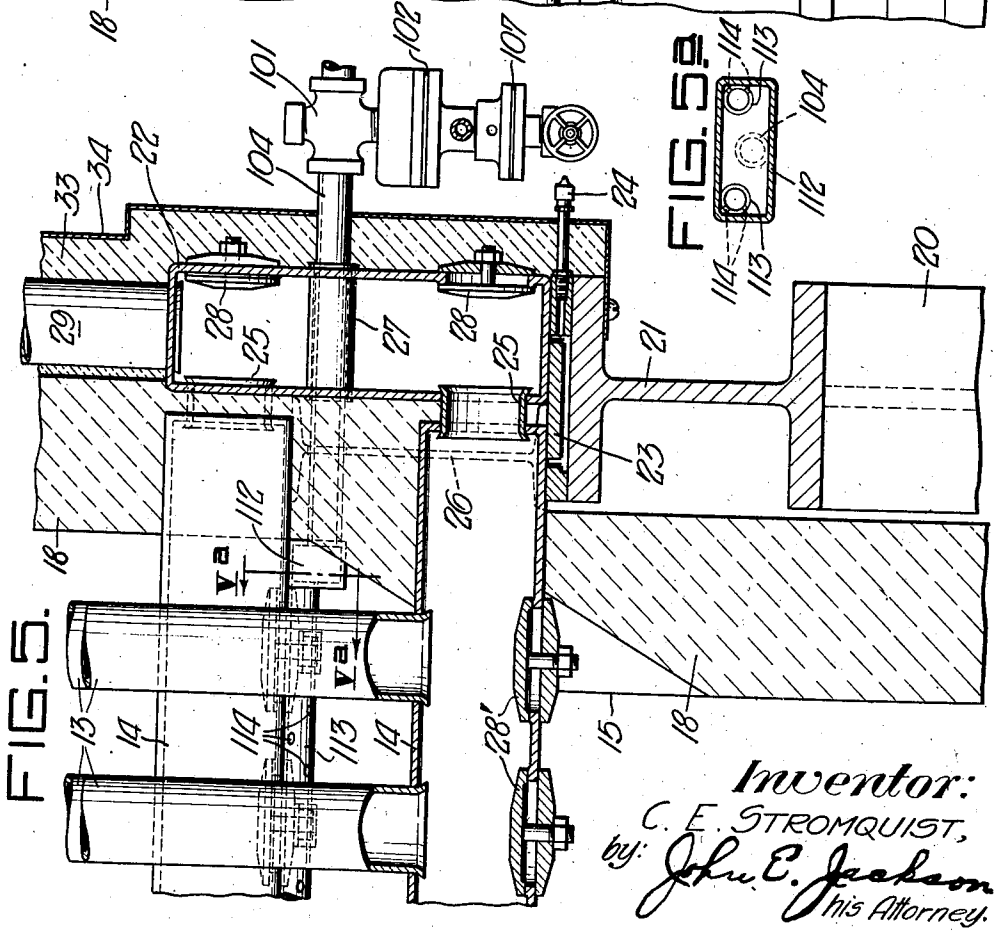


FIG. 5a

Inventor:
C. E. STROMQUIST,
by: John C. Jackson
his Attorney.

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UNITED STATES PATENT OFFICE

2,365,305

WASTE HEAT BOILER

Carl E. Stromquist, Griffith, Ind.

Application January 24, 1941, Serial No. 375,862

3 Claims. (Cl. 122—7)

My invention aims to provide a waste heat steam boiler specially designed for use in connection with cement kilns, with accessory apparatus for dislodging and disposing of dust contained in the waste gases. Although particularly applicable for use in connection with cement kilns, the invention is, of course, not restricted thereto.

Early in the development of the art of manufacturing Portland cement, attempts were made to utilize the heat of the waste gases discharged from the clinkering kiln. These gases, being the products of combustion of the fuel used in calcining the raw materials, composed of limestone, clay, slag, etc., contain a considerable amount of dust evolved from the raw materials. This hot dust is tenacious or abrasive, or both, depending on the composition of the raw materials used, and therefore tends to adhere to the boiler surfaces and also to wear away the metal at zones of high velocity. Conventional types of boilers and apparatus used for generating steam by burning of fuel directly under the boilers have been heretofore slightly altered in attempts to adapt them for use as waste heat boilers. This resulted in considerable difficulty caused by the dust accumulation on the boiler surfaces, thus obstructing the flow of gases, interfering with the draft, and by dust eventually wearing holes in the boiler tubes, thus requiring costly premature replacements and repairs.

Boilers of the prior art that have previously been designed for waste heat service either lack certain essential features or contain certain objectionable features and have therefore not proven entirely satisfactory in actual service.

My invention comprises specific improvements on prior designs of waste heat steam boilers consisting of certain novel parts combined and arranged as defined with particularity in the appended claims, to provide a workable installation which overcomes the above mentioned deficiencies which are inherent in prior art installations.

The essential features of a successful waste heat boiler apparatus embodying the present invention will be readily understood from a consideration of the appended claims when read in connection with the following specification and the accompanying drawings, in which:

Figure 1 is a longitudinal vertical view of the boiler (just inside of the brick sidewall);

Figure 2 is a transverse vertical section taken along the plane of the line II—II of Figure 1;

Figure 3 is a plan of front portion of the boiler;

Figure 4 is an enlarged longitudinal view of the lower portion of the boiler;

Figure 5 is a transverse section of Figure 4 taken along line V—V;

Figure 5a is a detail of a portion of the soot blowing apparatus;

Figure 6 is an isometric view taken from the right end of Figure 1 showing a portion of the economizer and illustrating the course of the water circulation.

To obtain practical and workable results in the operation of a waste heat boiler to be used in connection with a cement kiln, the principal essential features embodied in my invention are as follows:

First—the utilization of straight vertical boiler tubes, economizer tubes, and superheater tubes. This is to prevent dust from lodging on the tubes, which in the case of the usual horizontal or inclined tubes insulates the upper area of the tubes, thus reducing the effective heating surface, to prevent blocking the gas passages between adjacent tubes caused by dust accumulation in the form of bridges; and to eliminate inaccessible dust pockets such as form in the use of bent tube boilers.

Second—the provision of a sectional tube header. This is to facilitate the dislodgement of dust from the lower headers and to permit access to the entire area of all tubes by means of lancing apparatus entered between the upper headers.

Third—the provision of means to induce a rapid water circulation. Water circulation is accelerated by means of downcomer tubes, located outside of the direct gas passage. This provides a rapid equalization of temperature of all surfaces of the boiler corresponding with the developed pressure when quickly subjected to the heat of the incoming gas discharged from the kiln, thus eliminating excessive strain from unequal expansion. This also eliminates local circulation within each individual vertical steam generating tube, as in the case with boilers not provided with downcomer tubes outside of the direct gas stream in which the rising steam bubbles restrict the downward flow of the water.

Fourth—the provision of improved dust control apparatus. The usual type of mechanical soot blowers are inadequate for properly dislodging the dust in waste heat boilers used in connection with cement kilns. In my invention special apparatus are provided to facilitate control of and disposal of dust.

Referring now to the drawings, in Figure 1 the numeral 10 represents a rotary cement kiln sup-

plied by pulverized raw material through the usual feed pipe 11 and screw conveyor 12. The hot dust-laden gases emitted from the kiln immediately enter the front end of the boiler passing between a plurality of front banks of steam generating tubes such as 13A, 13B, and 13C. In my invention the usual hot dust chamber is eliminated, which results in a great reduction of radiation losses. The hot dust emitted from the kiln 10, upon striking the comparatively cooler banks of boiler tubes 13, is quickly reduced in temperature. In striking the tubes 13, the dust particles, in horizontal motion, are instantly halted, turned in a downward direction, and strike the lower sectional headers 14 which are at the same temperature as the tubes 13. After passing down between the lower headers 14 into the dust chamber 15, the dust has been cooled to such a degree that the dust removal screw conveyors 16 are not subjected to excessive temperature. The dust chamber 15 is partitioned by removable cast iron or refractory baffles 17 to prevent the gases from bypassing the banks of tubes 13. The dust chamber 15 has vertical sidewalls 18 in preference to the usual inclined or sloping sides, which old design causes the dust to slide and form a compact mass that arches over the openings leading into the dust conveyors. In the vertical sided chamber, as shown in Figure 2, the accumulated dust rolls by gravity into the openings 19 and thence to the conveyors 16 without a tendency to form the objectional compact arch above mentioned.

In Figures 2 and 5, I show structural steel columns 20 and horizontal beams 21 which support the lower headers 14 and lower water boxes 22. Immediately above the beams 21, as best seen in Figure 5, lubricating plates 23 are inserted, which function to reduce the resistance to the relative horizontal creeping movements of the parts during the expansion and contraction resulting from variations in temperature. The plate is cored and means are provided for the injection of lubricants through suitable fittings, such as that shown at 24.

The lower connecting nipples 25 are expanded into the lower headers 14 and water boxes 22 in accordance with the standard high pressure boiler construction. Header supports 26 are inserted under the alternate headers 14 for the purpose of retaining them at a higher elevation, the reason for which is to provide ample openings for the dust to pass between the headers into the dust chamber 15. In the lower water boxes 22, sleeves 27 are expanded into both sidewalls. These sleeves are adapted to coact with automatic dust blowers 104 to be subsequently described. Hand-hole plates 28 are of the usual type and provide for accessibility in expanding the tube ends of the downcomer circulating tubes 29 and the connecting nipples 25. The headers 14 are provided with similar hand-hole plates 28' for access to the lower ends of the steam generating tubes 13. The space between the refractory walls 18 and the steel sheathing 34 is filled with insulation 33. In Figure 2, the numeral 30 represents the upper water boxes which are supported by the downcomer tubes 29. The upper sectional headers 31 are supported by the steam generating tubes 13 and connected to the upper water boxes 30 by the connecting nipples 32.

In Figures 1, 2, and 3, three or more upper headers 31, 31A, 31B, and 31C, etc., are in two sections and shortened to provide an opening for the raw feed pipe 11 and the manhole frames 35. In three or more rows of the steam generating tubes, 13, 13A, 13B, and 13C, the tubes directly opposite the kiln 10 are omitted; (a) to permit access to the nose ring of the kiln 10, (b) to permit sudden expansion of the gases in leaving the kiln, and (c) to prevent injury to such tubes when back rings in the kiln are being shot. In Figure 1, the numeral 36 represents a laminated steel armor plate which is lowered into the gas passage in front of the tubes directly opposite the kiln opening for the purpose of protecting the tubes 13 when back-rings in the kiln are being shot. Removable insulating blocks 37 are provided to cover the upper headers 31, 31A, 31B, 31C, etc., and also economizer headers 59, 59A, 59B, 59C, etc. Thus the blocks seal the openings between the headers and also prevent radiation of heat from the headers to the atmosphere. The blocks 37 are made removable for the purpose of facilitating operation of soot blowing apparatus 116, to be subsequently described.

The boiler tubes 13, 13A, B, C, etc., are separated into front and rear banks or groups, both similar and connected in like manner to the upper and lower headers and water boxes. The steamdrum 38 of the boiler, located between and above the two banks of boiler tubes, is supported by and connected between the upper water boxes 30 similar to conventional types of boilers equipped with box headers. Adjacent the drum 38 on each side, the upper water boxes are gradually enlarged, as shown in Figure 1, to provide free entry of steam from the water boxes 30 into the drum 38. In the space between the front and rear banks of boiler tubes 13 and directly below the boiler drum 38 there is a superheater, consisting of tubes 39, the ends of which are expanded into the inlet header 40, outlet header 41, and connecting boxes 42. The superheater tubes 39 are preferably smaller than the boiler tubes, have internal cores, and are provided with external cast metal special shaped sleeves shrunken to fit on the tubes. The economizer heating tubes 50, 50A, 50B, 50C, etc., are preferably smaller than the boiler tubes 13 and are provided with external cast metal special shaped sleeves shrunken to fit the tubes. The economizer downcomer circulating tubes (R and L) 51 are similar to the boiler downcomer tubes 29. The economizer water boxes (R and L) 52 are constructed similarly to the lower boiler water boxes 22 but are provided with baffles (R and L) 53, 53A, 53B, etc., to create contraflow of gas and water through the economizer. The upper economizer water boxes 55 are provided with baffles 56, 56A, 56B, etc., having leak holes 57, 57A, 57B, etc., to prevent air binding. Provision is made for varying the size of the leak holes 57, etc., by the use of an adjustable valve mechanism.

Where corrosive water conditions prevail, suitable materials for the purpose will be provided in the construction of the economizer.

The water and steam circulation will now be described, chiefly in connection with Figures 1, 2, and 6. The letters R and L which prefix certain reference numerals denote Right and Left as the boiler is viewed in Figure 2 or from the kiln end thereof. The water supply enters the first compartment of the economizer lower water boxes 52 through the stop and check inlet valves 60, the water pressure being necessarily maintained somewhat greater than the pressure developed in the boiler. The baffles (R and L) 53 deflect the water through the lower connecting nipples (R and L) 54 into the lower header 58. It then flows up through the row of heating tubes 50 into

the upper header 59, through the upper connecting nipples (R and L) 61 into the first compartment of the upper water boxes (R and L) 55. The baffles (R and L) 56 deflect the water through the downcomer tubes (R and L) 51 and 51A, into the first and second compartments, respectively, of the lower connecting boxes 52. The portion of the water descending through the downcomer tubes (R and L) 51 re-enters the lower header 58 through the connecting nipples (R and L) 54 and recirculates upward through the heating tubes 50. The portion of the water descending through the downcomer tubes (R and L) 51A into the second compartment of the lower water boxes (R and L) 52 passes through connecting nipples (R and L) 54A and 54B into headers 58A and 58B, then upward through heating tubes 50A and 50B, into the upper headers 59A and 59B. The water in the header 59A passes through connecting nipples (R and L) 61A into the first compartment of the water boxes (R and L) 55, through downcomer tubes (R and L) 51A and recirculates. The water in header 59B passes through connecting nipples (R and L) 61B into the second compartment of the water boxes (R and L) 55 and into downcomer tubes (R and L) 51B and 51C. The water in downcomer tube 51B recirculates through the lower headers 58B and heating tubes 50B. The water in downcomer tube 51C enters the third compartment of the lower water boxes (R and L) 52 and through connecting nipples (R and L) 54 into headers 58C, then up through heating tubes 50C into header 59C. The water circulation thus continues successively through the remaining sections of the economizer until it leaves through the economizer outlet pipe 62.

The above described means for recirculation of water in an economizer is a novel arrangement which greatly increases the rate of heat transfer over the conventional type of economizer.

The baffles 56, 56A, 56B, etc., are provided with respective bypass openings 57, 57A, etc. which may be termed leak holes which are effective to prevent vapor binding in the upper economizer water boxes 55. The water leaves the economizer through the outlet pipe 62 as shown in Figure 1. The required amount of water to maintain the proper level in the boiler is fed through the pipes 62 and 63 (Figure 1) and the feed water regulator 64 into the boiler drum 38. With the boiler in normal operation, since the incoming water is of a lower temperature than that in the boiler, it will immediately flow down through the downcomer tubes 29 into the lower water boxes 22 (which are embedded in the boiler wall as shown in Figure 2), thence through the lower connecting nipples 25, headers 14, into the steam generating tubes 13, upper headers 31 and upper water boxes 30, where the steam bubbles are drawn towards the drum 38 and liberated into the steam space. The circulation is continuous through the individual sectional headers and corresponding downcomer tubes, thereby always maintaining a positive directional flow equivalent to the natural thermal acceleration produced by the upward force of the steam bubbles formed in the steam generating tubes. In addition thereto, the lower water boxes provide for adequate equalization of pressure throughout the entire boiler.

The steam leaving the drum 38 passes through a separator 65, thence through the separator outlet pipe 66, superheater inlet header 40. tubes 39 and the usual stop and check valve 67 to the steam main. The economizer, boiler, and superheater are equipped with conventional safety valves as indicated at 68, 69, and 70 in Figures 1 and 2.

The gas travel is in a single pass, impinging on the front bank of the steam generating tubes 13, the superheater tubes 39, the rear bank of the boiler tubes 13, and the economizer tubes 50, thence discharged through the induced draft fan 71.

In installations where the dust conditions permit, baffles are inserted between certain rows of tubes in the rear zone of the boiler and in the economizer to increase gas velocity. Also, where dust conditions permit, the tubes are staggered so as to attain maximum heat transfer.

Means originally disclosed herein for dislodging dust and soot on the boiler heating surfaces are clearly illustrated, described and claimed in my Patent No. 2,358,358, issued September 19, 1944, which is a division of the present case.

Although I have described with great particularity certain characteristic features of the embodiment of the invention herein illustrated, it is not to be construed that I am limited thereto, since various changes in arrangement and substitutions of equivalents may be made by those skilled in the art without departure from the invention as defined in the appended claims.

I claim:

1. A boiler adapted for direct connection with a kiln or furnace, for utilizing waste heat gases and products of combustion, including upper and lower water boxes connected by downcomer tubes, lower headers communicating therewith, upright tubes communicating with the lower headers, a supporting structure, and a lubricating plate on which the water boxes and the lower headers bear, said plate having passages therein with openings extending to the surfaces on which the water boxes and headers bear, and a fitting to facilitate the introduction of a lubricant through said passages whereby the water boxes and headers are supported with freedom to permit the same to move relatively to one another under the influence of expansion and contraction due to temperature variations.

2. A boiler adapted for direct connection with a kiln or furnace, for utilizing waste heat gases and products of combustion, said boiler comprising a steam drum, a pair of spaced upper water boxes communicating with the drum at its opposite ends, a pair of lower water boxes connected with the upper water boxes by respective downcomer tubes shielded by being enclosed in respective walls, a series of upper headers connecting said upper water boxes, a plurality of sets of vertically spaced lower headers spanning the space between said lower water boxes and communicating therewith at different elevations, and respective sets of straight vertical boiler tubes connecting the said several lower headers with the said several upper headers, the vertical spacing of said lower sets of headers being adapted to provide spaces between the alternate headers of large area to facilitate dust removal.

3. A boiler adapted for direct connection with a kiln or furnace, for utilizing waste heat gases and products of combustion, said boiler comprising a horizontal steam drum, a pair of spaced water boxes with top walls inclined upwardly toward and communicating with the lower portion of the steam drum at its opposite ends, a pair of lower horizontal water boxes connected with said upper boxes by respective straight vertical downcomer tubes shielded by being enclosed in re-

spective walls, a series of upper horizontal headers spanning the space between and connecting said upper water boxes, a plurality of sets of vertically spaced lower horizontal headers spanning the space between said lower water boxes and communicating therewith at different elevations, and respective sets of straight vertical boiler tubes connecting the said several lower horizontal headers with the said several upper horizontal headers, the vertical spacing of said lower sets of headers being adapted to provide spaces between the alternate headers of large area to facilitate dust removal.

CARL E. STROMQUIST.