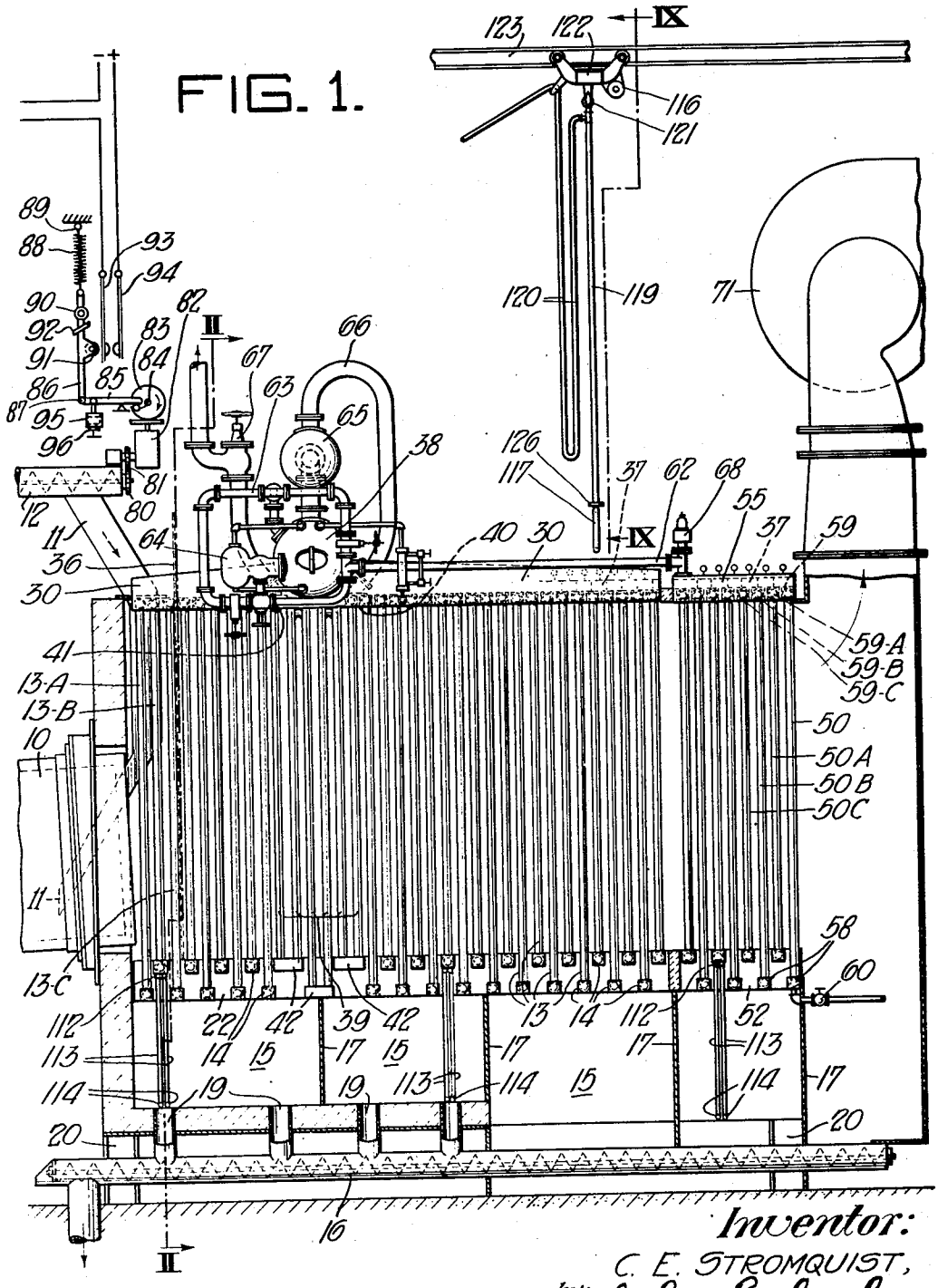
Sept. 19, 1944. C. E. STROMQUIST 2,358,358

WASTE HEAT BOILER

Original Filed Jan. 24, 1941 5 Sheets-Sheet 1

FIG. 1.



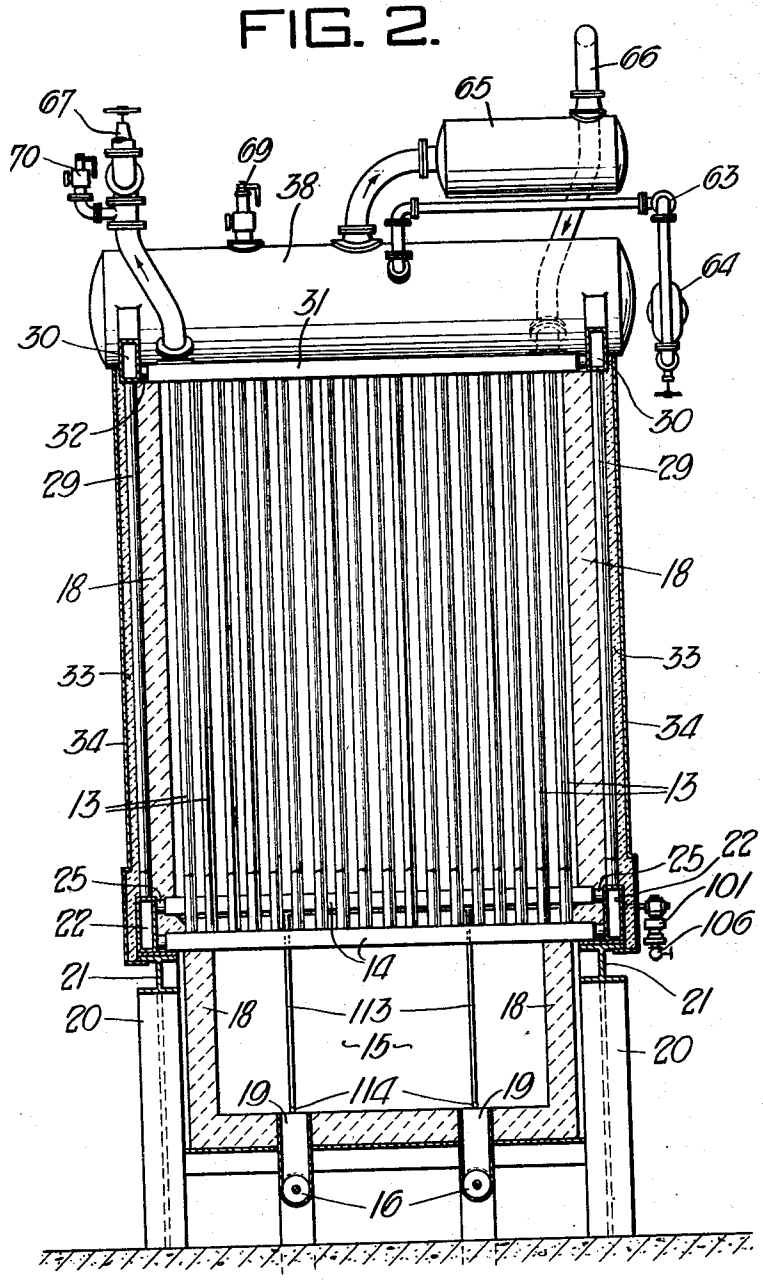
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WASTE HEAT BOILER

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FIG. 2.



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WASTE HEAT BOILER

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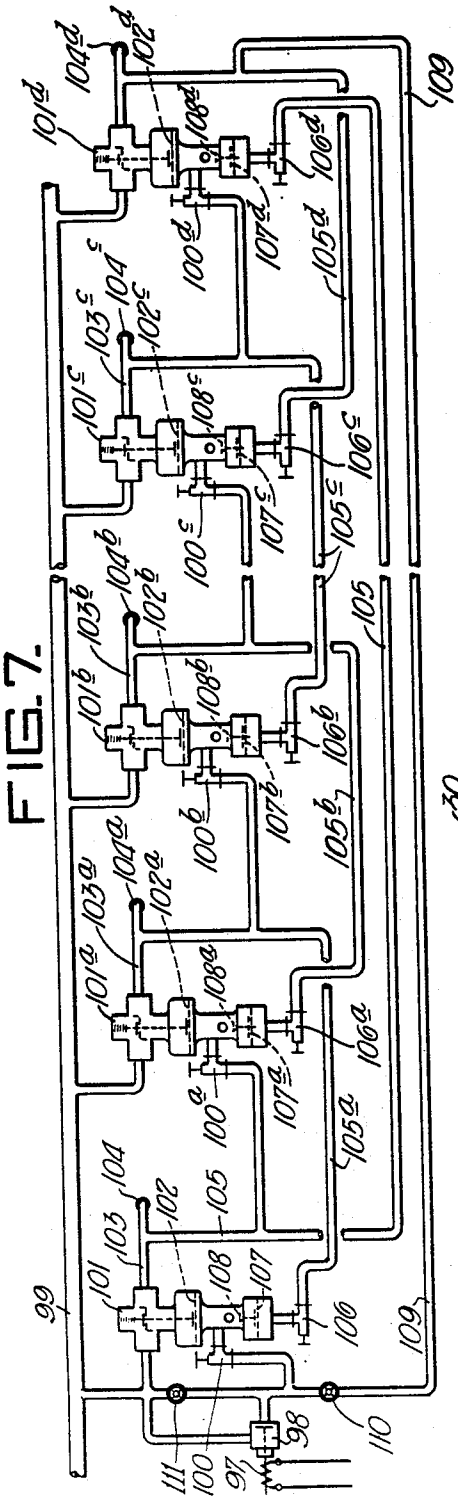


FIG. 7.

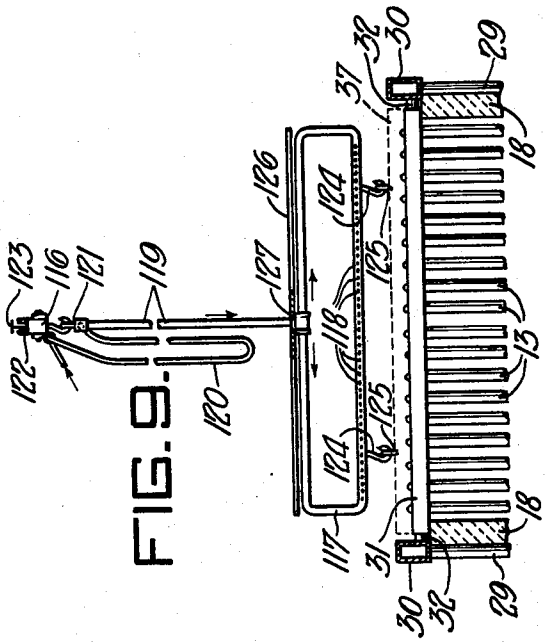


FIG. 9.

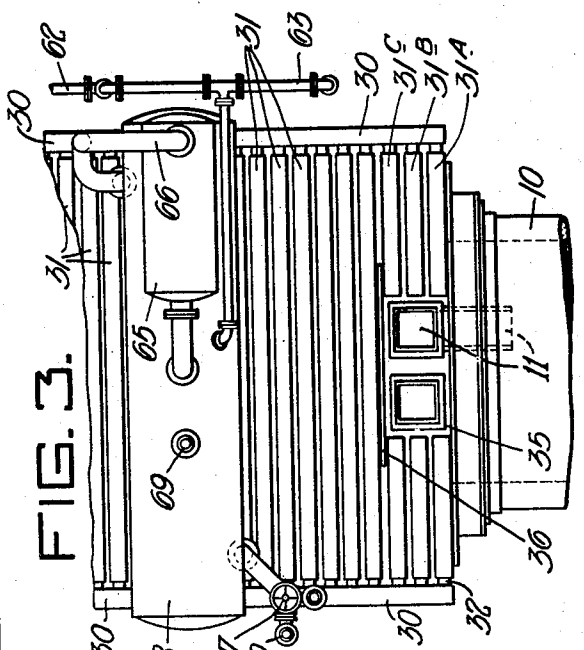


FIG. 3.

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WASTE HEAT BOILER

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FIG. 4.

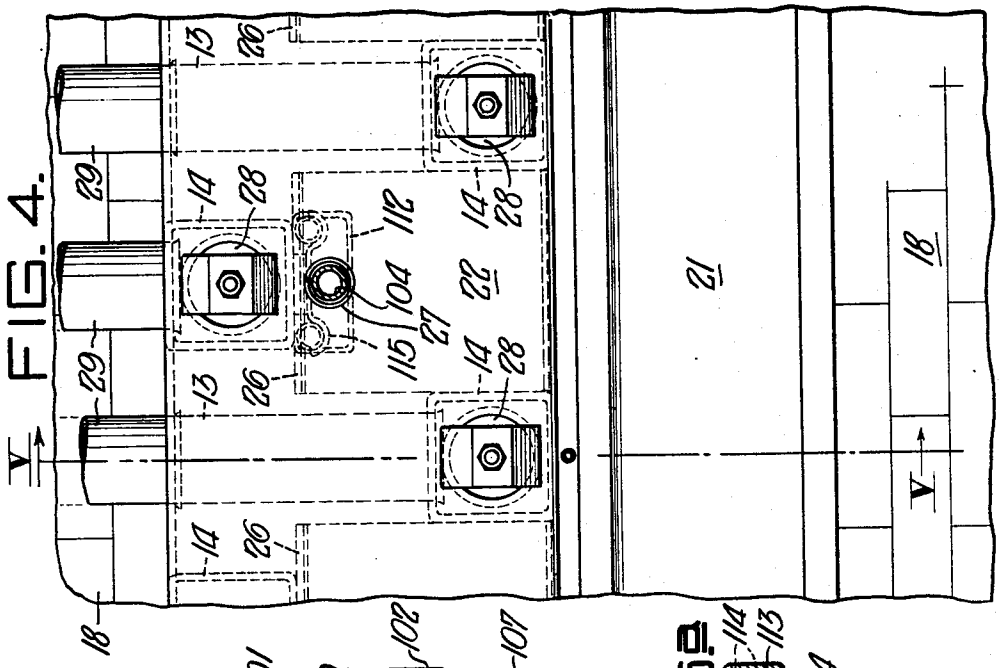


FIG. 5.

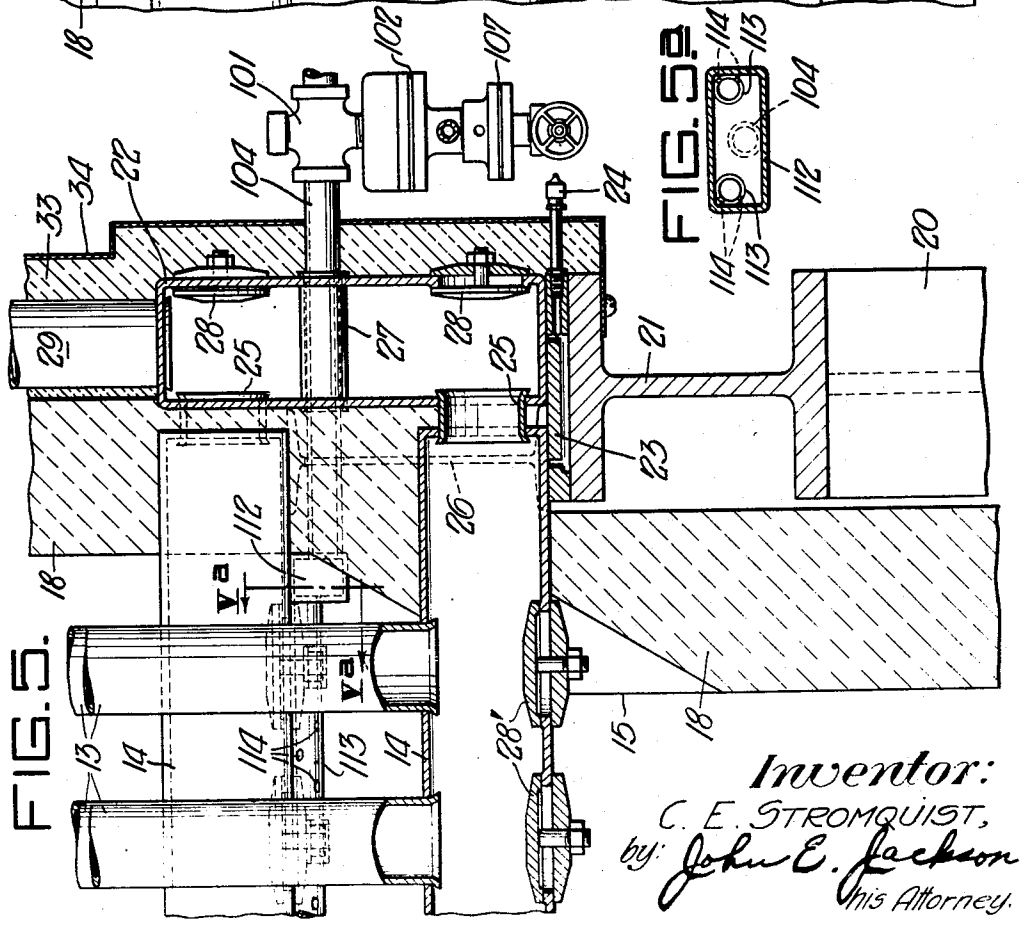


FIG. 5a.

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WASTE HEAT BOILER

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FIG. 8.

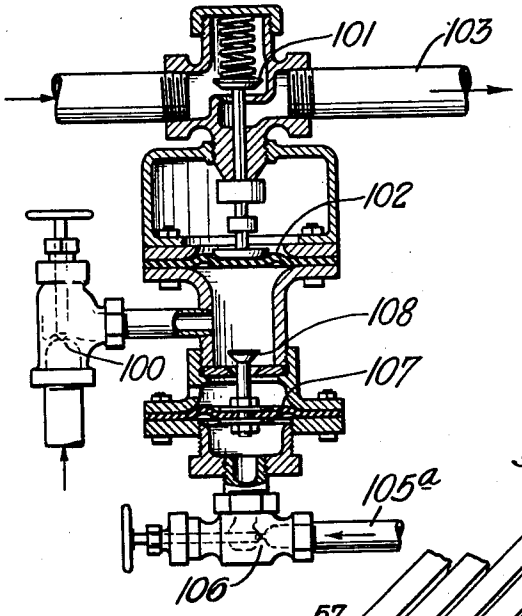


FIG. 6.

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UNITED STATES PATENT OFFICE

2,358,358

WASTE HEAT BOILER

Carl E. Stromquist, Griffith, Ind.

Original application January 24, 1941, Serial No. 375,862. Divided and this application September 9, 1941, Serial No. 410,207

2 Claims. (Cl. 122—392)

The present invention is a division of patent application Serial No. 375,862, filed January 24, 1941, and 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 slinkering 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 proved entirely satisfactory in actual service.

My invention comprises specific improvements on prior designs of waste heat steam boilers consistng 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;

Figure 7 is a diagram showing the pneumatically operated dust blowing apparatus;

Figure 8 is a detail cross section of the pneumatic valve assembly for controlling and distributing compressed air to dust blowers; and

Figure 9 is a transverse section along the line IX—IX of Figure 1 illustrating the hoist operated soot blowing apparatus.

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 dislodgment 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 con-

trol apparatus. The usual type of mechanical spot 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 supplied 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 or 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 sleeve shrunken to fit the tubes. The economizer downcomer circulating tubes (R & L) 51 are similar to the boiler downcomer tubes 29. The economizer water boxes (R & L) 52 are constructed similarly to the lower boiler water boxes 22 but are provided with baffles (R & 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 & L) 53 deflect the water through the lower connecting nipples (R & 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 & L) 61 into the first compartment of the upper water boxes (R & L) 55. The baffles (R & L) 56 deflect the water through the downcomer tubes (R & 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 & L) 51 re-enters the lower header 58 through the connecting nipples (R & L) 54 and recirculates upward through the heating tubes 50. The portion of the water descending through the downcomer tubes (R & L) 51A into the second compartment of the lower water boxes (R & L) 52 passes through connecting nipples (R & 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 & L) 61A into the first compartment of the water boxes (R & L) 55, through downcomer tubes (R & L) 51A and recirculates. The water in header 59B passes through connecting nipples (R & L) 61B into the second compartment of the water boxes (R & L) 55 and into downcomer tubes (R & 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 & L) 52 and through connecting nipples (R & 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.

That phase of the invention relating to the means for dislodging dust and soot on the boiler heating surfaces will now be described. Referring to Figures 1, 7 and 8, the shaft of the raw material feed screw 12 has attached thereto a sprocket 80 operating a gear wheel 81, which is part of a reducing mechanism 82 which operates the variable speed transmission 83. Attached to the driven disk of the variable speed transmission 83 is a cam 84 which engages one end of the hinged lever 85. To the other end on lever 85 and disposed at right angle thereto is attached one end of a bar 86 by means of a pivotal joint 87. The other end of the bar 86 is supported by the tension spring 88 and stationary support 89. The floating bar 86 carries rollers 90 and 91. Behind the floating bar 86 is a stationary bar 92 which by means of a roller 90 diverts the longitudinal movements of the floating bar 86 in such manner that for each stroke of the hinged lever 85 the roller 90 contacts the opposite sides of the stationary bar 92, causing the roller 90 to travel in a unidirectional elliptical plane with each revolution of the cam 84. The insulated roller 91 also attached to the bar 86 thus forces the contact spring 93 against contact spring 94. A dash pot 95 and needle valve 96 retard the speed of the upward movement of the bar 86 against the tension of the spring 88.

The contact springs 93 and 94 constitute a switch which closes an electrical circuit from the power line + — and the current energizes the solenoid 97 (Figure 7) attached to the solenoid operated valve 98, thus opening said valve. Compressed air is admitted from the main air supply pipe 99 through the open solenoid valve 98 and the restricted opening in the needle valve 100 (see Figures 7 and 8), forcing the pneumatically operated valve 101 open by the exertion of force on the diaphragm 102. The open valve 101 permits compressed air to flow through the pipe 103 and the dust blower element 104, thus dislodging the accumulated dust on the lower headers 14, blowing it into the dust conveyor openings 19 (see Figure 1). Air flows simultaneously through pipe 105, through needle valve 100a to diaphragm 102a, thus opening valve 101a, which permits air to flow through pipe 103a to the dust blower element 104a. Air is also conducted through pipe 105a and needle valve 106 to diaphragm 107, thus opening

valve 100 to atmosphere, which action releases the pressure on the diaphragm 102 and permits the valve 101 to close.

The admission of air through pipe 105a and needle valve 100b now opens valve 101b and admits air to dust blower 104b, pipe 105b, needle valve 106a and diaphragm 107a, thus opening valve 108a and allowing valve 101a to close. All other pneumatic valves 101c, 101d, 101e, etc., in the series operate consecutively, as just described, until the last one has opened, when the air flows through pipe 109 to the globe valve 110 which is normally closed and prevents air from opening valve 101, thus completing the circuit. If it is desired to have the dust blowing apparatus continue to operate indefinitely, the globe valve 110 is left in open position, in which air is conducted through needle valve 100 to diaphragm 102 and opening valve 101, thus starting the apparatus on another circuit.

The globe valve 111 is normally closed, but is for the purpose of manually starting the apparatus if desired. Additional dust blower units as required can be installed in series at the broken piping lines shown on the drawings.

The dust blower elements 104, 104a, 104b, 104c, etc., (see Figures 4, 5 and 9) include a special built-in fitting 112 (see Figures 4, 5 and 5a), located under alternate lower header 14, each fitting serving to distribute air through two branch pipes 113 and nozzles 114, which direct jets of air toward the upper surfaces of the headers 14. Thus the air jets are effective to prevent the dust from arching over the dust screw conveyor 16 and the openings 19. The branch pipes 113 are supported by bars 115 attached to the stems of the hand-hole plates 28 under the headers 14.

In Figures 1 and 9, 116 represents a portable soot blowing apparatus to be used for the purpose of dislodging soot and dust adhering to the vertical tubes 13, consisting of a rectangular frame 117 fabricated from pipe and containing a multiplicity of nozzles 118 which impinge jets of air on the tubes as the apparatus is lowered between the upper headers 31. Compressed air is supplied through the pipe 119 to which is attached a flexible air hose 120. The pipe 119 is suspended by means of an eyebolt 121 to an electric or pneumatic hoist 122 suspended from an overhead trolley traveling on a rail 123. Hooks 124 are attached to the lower horizontal pipe of the soot blower frame 117 for the purpose of engaging the eyebolts 125 and removing the insulating blocks 37. A steel plate 126 having a hole 127 for the air pipe 119, and supported by the upper horizontal pipe of the rectangular frame 117, covers the opening normally closed by the insulating blocks 37 when the pipe frame 117 is lowered into the openings between the upper headers 31 and 59. The hoist 122 is also utilized when lowering the laminated steel armor plates 36 into the gas passage for protecting the boiler tubes 13.

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, comprising upper and lower water boxes, a steam drum communicating with the water boxes, downcomer tubes connecting said upper and lower water boxes, respective upper and lower headers connecting the upper and lower water boxes, vertical tubes connecting the upper and lower headers, a dust chamber located in a plane below said lower headers, said chamber having vertical side and end walls, a dust conveyor below said chamber, ports leading to said conveyor, and means for automatically dislodging dust from the headers and other parts of the boiler and effective to direct it to said conveyor ports.

2. A boiler adapted for direct connection with a kiln or furnace, for utilizing waste heat gases and products of combustion, said boiler having a steam drum, upper water boxes communicating therewith, lower water boxes, downcomer tubes connecting the upper and lower water boxes, upper and lower sectional headers communicating respectively with said upper and lower water boxes, tubes connecting said upper and lower headers, a dust receiving chamber positioned below said lower headers, said chamber having substantially vertical side walls and a substantially horizontal bottom, a conveyor located below the bottom of the chamber and having a plurality of ports leading to said bottom, dust expelling apparatus adapted to intermediately dislodge precipitated dust from the lower headers and related parts so as to continuously force the same toward the ports in the bottom of said chamber leading to the conveyor, and means for automatically effecting the operation of the dust expelling apparatus at predetermined time intervals.

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