May 19, 1953 A. LEMOS, JR., ET AL 2,638,878

WATER HEATER HAVING EXTENSIVE HEAT TRANSFER SURFACES

Filed Jan. 19, 1951 4 Sheets-Sheet 1

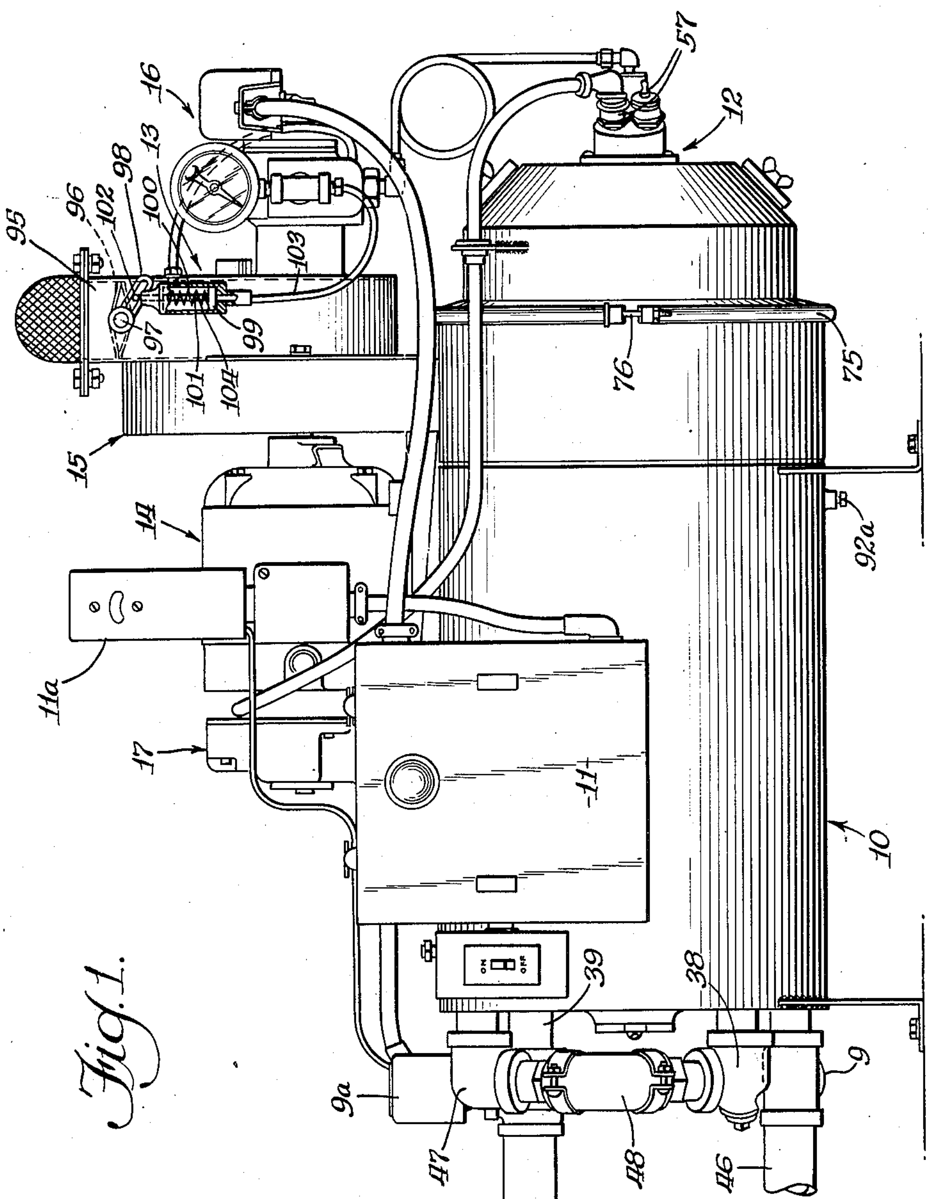

Fig. 1.

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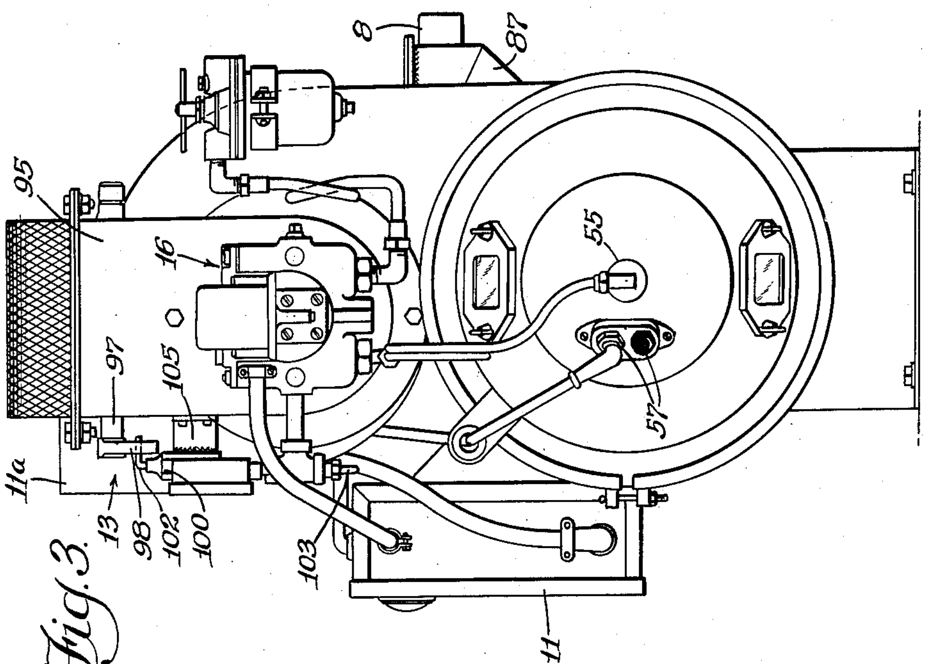

Fig. 3

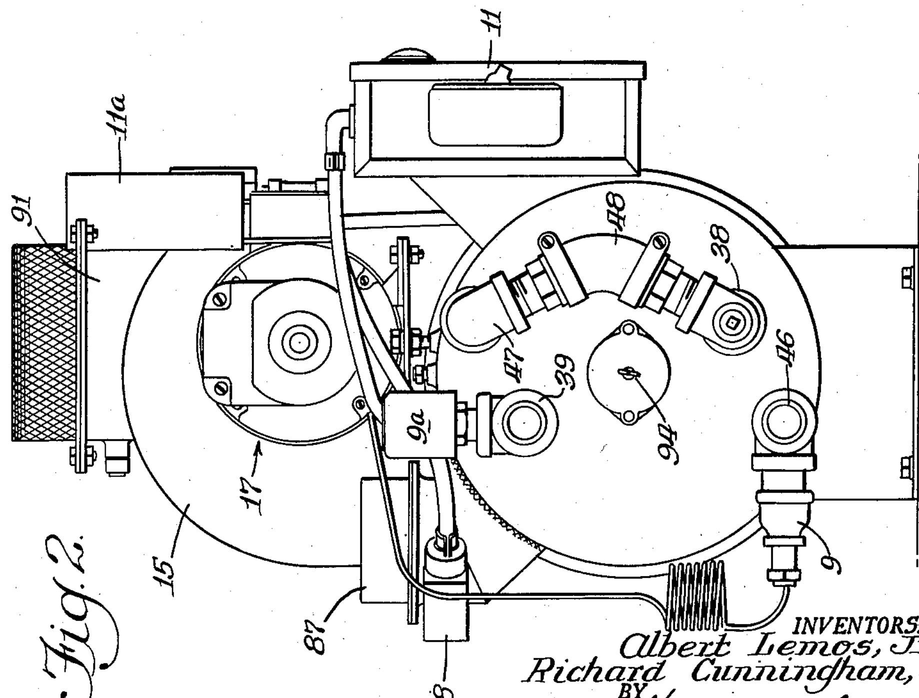

Fig. 2

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WATER HEATER HAVING EXTENSIVE HEAT TRANSFER SURFACES

Filed Jan. 19, 1951 4 Sheets-Sheet 3

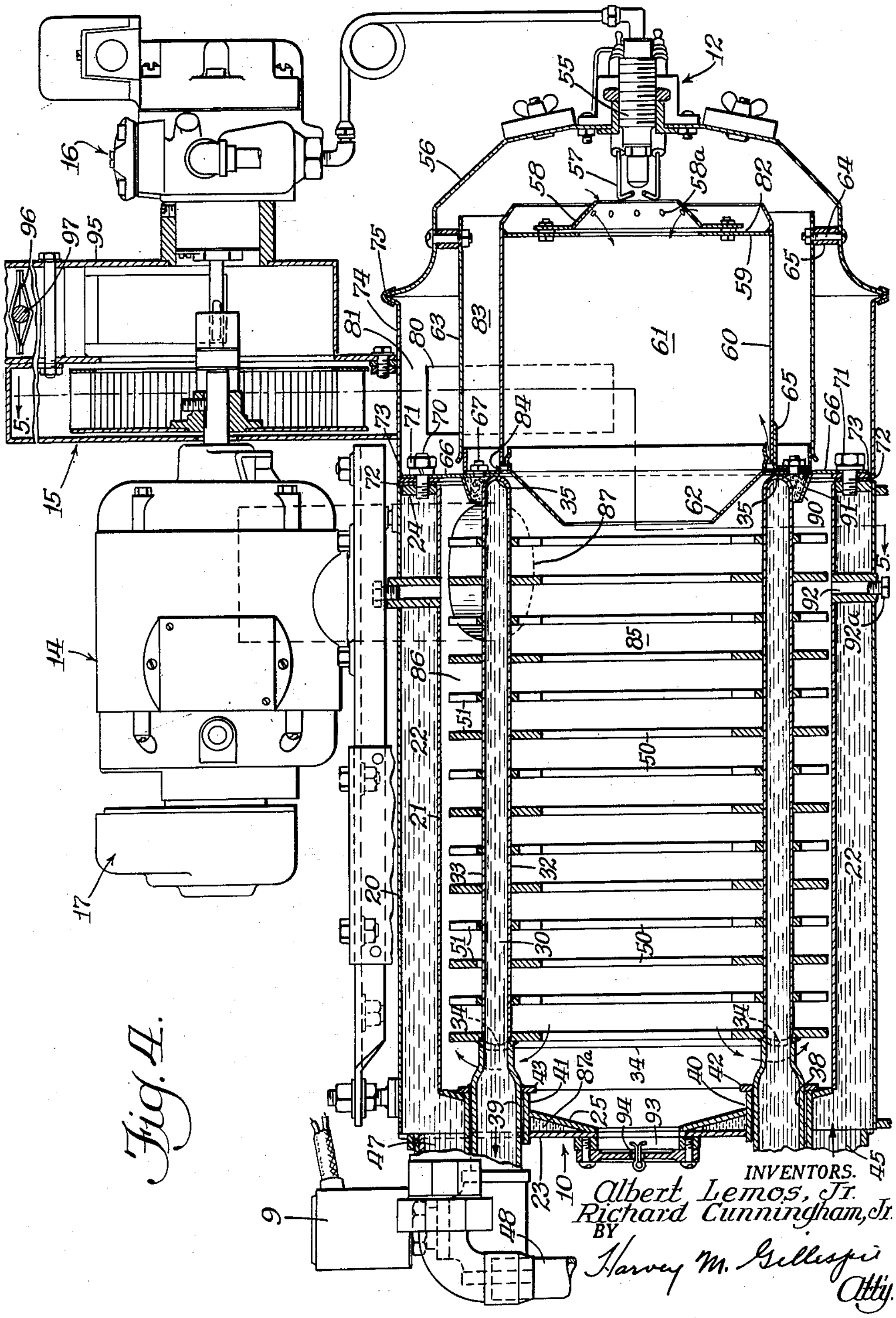

Fig. 4.

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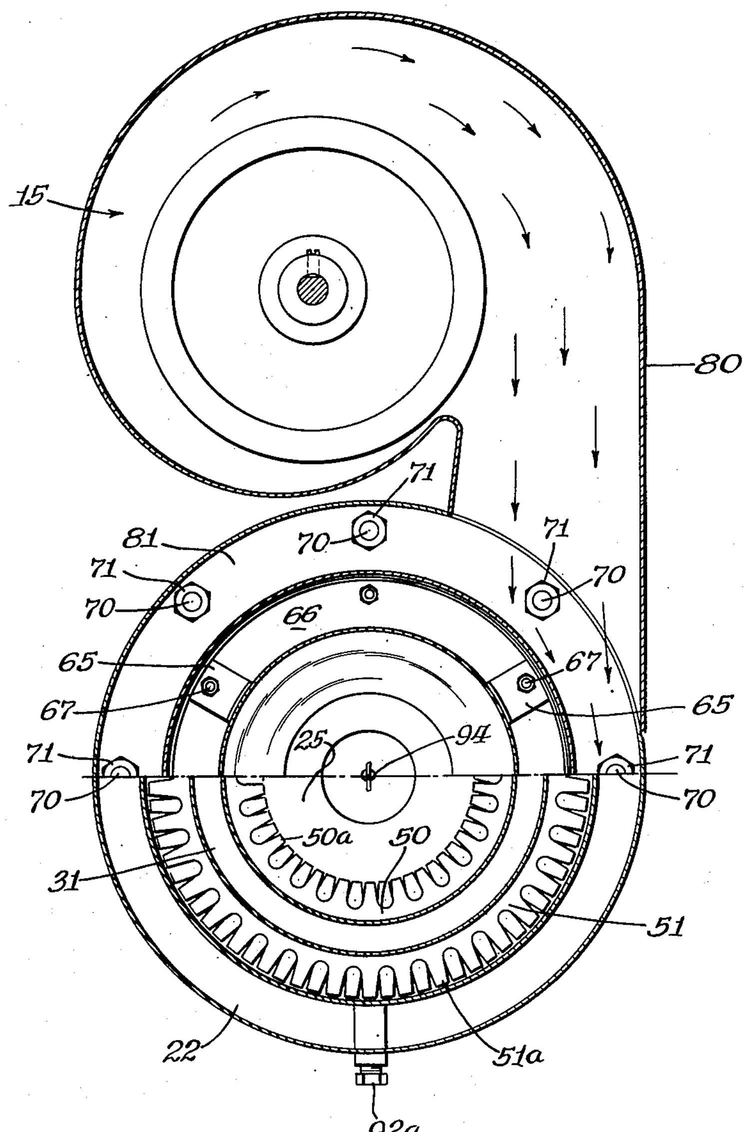

Fig. 5.

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WATER HEATER HAVING EXTENSIVE HEAT TRANSFER SURFACES

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Application January 19, 1951, Serial No. 206,888

5 Claims. (Cl. 122—136)

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This invention relates to improvements in water boilers and has for one of its principal objects to provide an exceptionally compact as well as highly efficient water boiler unit which is particularly well adapted for use where space is at a premium.

Another major object is to effect an improvement in heat transference with the end in view of greater efficiency in the utilization of available heat units, whereby a larger volume of fuel may be burned than is practicable in other boilers of similar size and whereby a correspondingly larger volume of water can be heated in a comparatively small boiler.

The boiler structure of the present invention was designed primarily to supply hot water to the hot water heating system of buses, private or railway office cars and standby hot water heaters for diesel locomotives, automobile parking lots, and for other installations where it is of special importance that the unit be as small as practicable in order to conserve space and at the same time have an exceptionally large output of hot water. But the novel features of the invention are substantially, if not equally applicable, to larger units intended for use where space conservation is not of paramount importance.

The novel features characterizing the subject invention will be pointed out in conjunction with the ensuing detailed description, having reference to the accompanying drawings, wherein:

Fig. 1 is a side elevation of a small size but high capacity boiler incorporating the novel features of the invention and designed more especially for use where conservation of space is a major factor;

Fig. 2 is an endwise elevation of the same unit viewed at the left-hand end of Fig. 1;

Fig. 3 is an endwise elevation as viewed at the right-hand end of Fig. 1;

Fig. 4 is a longitudinal sectional view through the water heater itself, together with a blower for delivering combustion air into the fire chamber, certain other components of the structure being shown in elevation; and

Fig. 5 is a transverse section taken at line **5—5** of Fig. 4.

Some of the major components of the illustrated unit are: the water heater per se or boiler **10**; an oil burner **12**; an electric motor **14**; a blower **15**; a fuel pump **16**, air damper control **13**, and a magneto or other spark voltage generator **17**. Still other major components, such as the switch cabinets **11**, **11**^{a}, stack switch **8**, and thermostats **9** and **9**^{a} for controlling the operation of

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the burner are shown, but not specifically described, since they are of no special significance so far as the subject invention is concerned.

The motor **14** is connected at one end to the magneto **17** and at its other end to the shaft of the blower **15** and fuel pump **16**. The motor operates under the control of the thermostats **8**, **9** and **9**^{a} to drive the fuel pump and blower as well as the magneto and is under the control of various switches and other control devices enclosed in control cabinets **11**, **11**^{a}.

The water heating unit or boiler **10** comprises an outer cylindrical shell **20** within which is disposed concentrically an interior cylindrical shell **21**, which latter forms, conjointly with the outer shell **20**, a water preheating chamber **22** of annular cross-section, as viewed in Fig. 5. This preheating chamber is also referred to herein as an outer water jacket **22**; and the elements of which it is constituted may, conformably, be referred to as the outer water jacket assembly. End plates **23** and **24** and the dished header **25** welded to the shells serve to completely enclose the outer water jacket or preheating chamber **22** so that it is water tight except for inlet and outlet connections.

Inside the interior shell **21** and concentric therewith is the main water heating chamber **30**—otherwise referred to as the inner water jacket. This is annular in form, as viewed in Fig. 5, and consists of concentric inner and outer smooth wall tubes **32** and **33**, having their ends formed with complementary curved flanges, welded together as indicated at **34** and **35** in Fig. 4. A water inlet fitting **38** and water outlet fitting **39** are welded, as shown in Fig. 4, to the left-hand end of the inner water jacket assembly comprising tubes **32** and **33** and conduit fittings **38**, **39** which provide water inlet and outlet conduits which communicate with the inner water jacket **30**. Said fittings **38** and **39** enter the inner water jacket assembly **30** through tubular sleeves **40** and **41** welded to the end plates **23** and **25** of the outer water jacket and heating chamber, respectively. The said fittings **38** and **39** are provided with flanges **42** and **43** which bear against the inner ends of said sleeves.

Water from a feed pump (not shown) or any source of supply enters the outer water jacket or preheating chamber **22** through an inlet port **45** shown at the lower left-hand corner of Fig. 4—which inlet port communicates with the cold water supply source through a pipe **46**—see Figs. 1 and 2. Preheated water discharges from chamber **22** through an outlet port **47** (Fig. 4) and passes by way of a conduit 48 to the inlet fitting 38 where it enters the main water heating chamber or inner water jacket 30, whence it emerges through the outlet fitting 39 and is conducted to the location where it is to be used. If the unit is employed as a part of a space heating system, water from the radiators may be returned to the inlet port 45; but if it is used purely for hot water supply the inlet port 45 is connected to a service water supply line or to a water reservoir, as the case may be.

A group of thermally conductive, usually steel, rings 50, fourteen in number in this instance, are welded, with continuous welds, at their peripheries to the interior surface of tube 32; and an equal number of similar but larger diameter thermally conductive rings 51 are likewise welded to the outside surface of tube 33. Each ring or fin 50 is formed to present a continuous series of inwardly projecting circumferentially spaced teeth 50a; and each ring 51 is similarly formed to present a continuous series of outwardly projecting circumferentially spaced teeth 51a. The spaces between consecutive teeth, in each instance, are preferably of the same order of width as the teeth themselves. However, the relative width of the teeth and intervening spaces is not extremely critical. Preferably, the depth of the teeth, radially, is at least a major part of the radial width of the ring and usually is at least equal to two-thirds of said radial width. Generally speaking, the greater the radial depth of the teeth the better, and in every case should be substantial. It is desirable that alternate rings be so positioned circumferentially that their teeth are at least approximately aligned, axiswise of the heating unit, with the spaces between the teeth of the adjacent rings. This is adequately illustrated in Fig. 4 wherein it will be seen that the plane of the section passes radially through the teeth of alternate rings, whereas it passes radially through inter-tooth spaces, as respects the remaining rings. The primary function of the rings 50 and 51 is, of course, to augment the transference of heat into the chamber 30; and they accomplish that result not merely by increasing the surface area exposed to the hot gases but also by creating a kind of turbulence, which experience proves to have the effect of increasing heat transference to a substantially greater degree than could be realized in practice with untoothed rings, or with toothed rings which are not staggered.

The fuel burner 12 comprises a nozzle or spray head assembly 55 located axially of the heater unit and supported by a header 56 which forms a closure for the right-hand end of the unit, as viewed in Fig. 4. Forwardly of the spray head assembly 55 and supported thereby are a pair of spark electrodes 57 which are connected to the magneto 17 (Fig. 1) and serve to ignite the atomized fuel discharged from the spray head.

A stabilizing cone 58 is mounted just forwardly of the spray head and spark electrodes and is bolted to a plate 59 which, in turn, is welded to a tubular sheet metal member 60 surrounding and defining the space 61 known as the firepot; and the latter is terminated forwardly in a frusto-conical sheet metal member 62 known as the flame deflector cone. Concentric with and encircling the tubular member 60 is another tubular sheet metal member 63 known as the air baffle and radiant heat shield. The latter is supported by the header 56 through the medium of several bolts 64, and is centrally located by means of spacers 65. The assembly comprising the tubular member 60, plate 59 and stabilizing cone 58 is supported at its left-hand end, Fig. 4, by three brackets 65a equally spaced circumferentially and welded to the member 60 and, in turn, attached to an annular plate or ring 66 by means of bolts 67. The plate or ring 66 is removably attached to the ring 24 by means of studs 70 and nuts 71. These latter serve also to grip a gasket 72 and a flange 73 which is welded to a tubular shell 74 of the same diameter as the outer shell 20. It will be observed that the right-hand end of shell 74, Fig. 4, is flanged outwardly to match the adjacent edge of the header 56 and that said header and shell are detachably coupled together by means of a band clamp 75, the ends of which are drawn together by a tie-bolt 76 as shown in Fig. 1. The radiant heat shield 63 is unattached at its left-hand end, and such being the case, it will be apparent that by first removing the band clamp 75 the header 56 together with the nozzle 55, spark electrodes 57 and radiant heat shield 63 can be withdrawn from the unit as an integral sub-assembly. Thereafter, the elements 58 to 62 inclusive can be released for detachment by removing the nuts from bolts 67.

A discharge conduit 80 connects the blower 15 with the chamber 81 through the outer shell 74 and is so oriented that the blast of incoming air strikes the baffle 63 tangentially, see Fig. 5, and is thus caused to follow a vortex path around the baffle, thereby creating a whirlwind or turbulence effect. A part of the rotationally circulating air passes through the openings 58a of the stabilizing cone 58 into the firepot 61; another part enters the firepot through an annular slot-like opening 82 between the stabilizing cone 58 and the plate 59; and still another part proceeds along the annular passageway 83 leftwardly, as viewed in Fig. 4, and enters the firepot 61 through a slot-like annular opening 84. It will be clear from the foregoing that the hot gases of combustion are whirling at a rapid rate within the firepot 61 and that they continue to whirl at a like rate as they emerge from the opening in flame detector cone 62 and enter the heat transfer chamber or bore 85.

The whirling hot gases in the heat transfer chamber 85 move forwardly, that is leftwardly as viewed in Fig. 4, while at the same time being urged outwardly from the longitudinal axis of bore 85 by the centrifugal force resulting from the whirling action. Thus, the hot gases are kept in agitation and in intimate contact with the interior surface of the inner tube 32 and with the rings 50 and teeth 50*a* thereof. Manifestly, if the rings 50 were not dentured, as above described, there would be pockets of cooled gases between adjacent rings which would behave to a great extent as thermal barriers and thus keep the hot gases from making fully effective contact with the heat-absorbing surfaces. The inter-tooth spaces prevent or at least lessen the formation of such thermal barriers, while at the same time the staggering of the teeth as between consecutive rings introduces enough impedance to the forward movement of the hot gases so that the heat is efficiently extracted therefrom without allowing the gases to become trapped to any serious extent. Furthermore the turbulence of the flame and hot gases insures complete combustion of the gaseous fuel and insures repeated wiping contact of the flame and hot gases with the toothed rings 50 and with the surfaces of the tube 32 between said rings so as to procure high efficiency in heat transfer.

The gases of combustion move the entire length of chamber 85, as viewed in Fig. 4, and then enter the left-hand end of the annular passageway 86, along which they proceed in the opposite direction to a flue 87, Figs. 2 and 4, near the right-hand extremity of said passageway.

The partially cooled gaseous product of combustion traversing passageway 86 gives up a portion of its residual heat to the water in the inner water jacket 30 and a further portion to the cold water in the outer water jacket or preheating chamber 22; and by the time it reaches the flue 87 its temperature has dropped to a low value. Hence, very little heat is lost. Obviously, the staggered inter-tooth spaces of rings 51 have much the same effect as the analogous spaces between the teeth of rings 50.

The inner water jacket or main heating chamber 30 contains only a small quantity of water; and that coupled with the large heat transfer area afforded by the rings 50 and 51, in conjunction with the exposed surfaces of the inner and outer tubes 32 and 33, makes it possible to heat large bodies of water at locations remote from the boiler, for example, the radiators of a railway car heating system or to deliver "stand by" heat to the engines of diesel locomotives and/or bus engines stationed in a parking lot. The described arrangement of the heat absorbing rings and their teeth produce a high degree of turbulence in the heating chamber 85, together with the further arrangement whereby a major portion of the residual heat is absorbed by the water in the outer water jacket 22 makes for extraordinary efficiency of fuel utilization.

The revolving gases of combustion give rise to turbulence not only in the heating chamber 85 but also in the passageway 86, and this is responsible in large degree for the efficiency with which the heat is transferred to the water in both the inner and outer water jackets.

A feature of the invention which should not be overlooked is that the water in the outer water jacket serves, in effect, as a thermal insulator so that it is not necessary to lag the outside of the unit. The preheated water is never so hot as to give rise to inordinate losses via the outer shell 20, either by way of conduction or radiation. Similarly, the water in chamber 87a at the left-hand end of the unit, Fig. 4, which chamber forms an integral part of the outer water jacket, serves also as an insulating medium, making it unnecessary to lag that end of the unit and also prevents overheating of the end wall or header 25.

Another feature contributing to the high efficiency of the described heater is that the structure of the main or inner water jacket assembly comprising the tubular members 32 and 33 together with rings 50 and 51 is supported at its right-hand extremity in a ring 90 of fire clay or other suitable material which, in turn, is supported by a frusto-conical flange 91 welded to the plate 66. The ring 90, while affording ample physical support, is effective to restrict losses due to thermal conduction away from the very hot inner water jacket.

It is preferable where sufficient space is available to mount the unit in horizontal posture, as depicted; but it will operate equally well in vertical posture and may be so mounted whenever space limitations demand. When the unit is mounted in a horizontal position, any accumulation of condensation on the walls of the passage 86, when the unit is out of service, may be drained

through part 92 by removing the plug 92a. When the unit is supported in a vertical position wherein the end at the left of Fig. 4 serves as the bottom of the unit, the said condensation will drain into the space 93 and discharge through a central opening 94.

In order to prevent undue cooling of the heating chamber, when the fire is momentarily shut off, the air inlet passage 95 is provided with a normally closed damper 96. The damper is supported on a shaft 97 which extends out of the air passage 95 and is provided with a slotted operating lever 98. A piston 99 operating in a cylindrical fitting 100 is provided with a stem 101, the upper end 102 of which is turned at an angle and extends into the slot of the damper operating arm 98. A tube 103 connects the cylinder 100 with the oil pump 16 so that when oil is delivered under pressure to the spray head the oil pressure will also be transmitted through the tube 103 to the piston 99 so as to move the piston upwardly and thereby open the damper 96. When operation of the fuel pump is discontinued a coil spring 104 returns the piston 99 to its lower position (Fig. 1) and, therefore, moves the damper 96 to a position to substantially close the air inlet duct 95. The fitting 100 may be secured to the inlet conduit 95 by means of a bracket 105.

While we have illustrated and described only one embodiment of our invention, it will be evident that there are numerous possible modifications and alternatives within the purview of our broad inventive concept. And although the invention is singularly well adapted for incorporation in a small highly compact water heating unit such as that shown and described, it is none the less useful and practicable for employment in larger units. Hence, we do not wish to be limited either as to the particular details of construction or as to the size of the unit—the only intended limitations being those clearly indicated by the express terms of the appended claims.

We claim:

1. A boiler structure of high capacity in relation to its size comprising, in combination, a cylindrical water jacket comprising concentrically arranged tubular sections, the inner section of which defines the side wall of a cylindrical heat transfer chamber, a fuel burner including a cylindrical firepot located at one end of said water jacket and means for directing combustion air into the firepot tangential to its side wall and operative to form a vortex flame and to direct said flame and hot gases of combustion axis-wise into the heat transfer chamber of said water jacket, and a plurality of thermally conductive rings of identical construction arranged co-axial with and metallically bonded to the inner wall of said water jacket and spaced apart axis-wise thereof, whereby the vortex flame and hot gases swirl around the heat transfer chamber between said rings, each of said rings having a plurality of circumferentially spaced teeth projecting toward the axis of the water jacket, the teeth of each ring being of a depth, radially, at least equal to a major portion of the radial width of the ring and arranged in staggered relation with the teeth of adjacent rings to provide tortuous passages for directing portions of said swirling flame and gases axially of said heat transfer chamber.

2. A boiler structure according to claim 1 characterized by the provision of a cylindrical structure surrounding said water jacket and cooperating therewith to define an annular passage com-

municating with the heat transfer chamber at the end remote from said firepot and adapted to receive the hot gases from said heat transfer chamber and further characterized by the provision of a second group of toothed rings secured to the outer surface of said water jacket and projecting radially outwardly in said annular passage into close relation to said cylindrical structure, each ring of said second group being formed with outwardly extending teeth having a depth equal at least to a major portion of the radial width of the ring and arranged in staggered relation relative to the teeth of adjacent rings to provide tortuous passages for directing portions of the hot gases axially of the said annular passage.

3. A boiler structure according to claim 2 characterized in that said cylindrical structure is provided with spaced walls defining a second water jacket having inlet and outlet ports and means connecting the said outlet port with the interior of the first mentioned water jacket.

4. A boiler structure according to claim 3 characterized in that the second group of toothed rings are metallically bonded to the outer surface of the first mentioned water jacket.

5. A boiler structure according to claim 4 characterized in that the second water jacket includes a water containing end portion which extends substantially across the heat transfer chamber at the end remote from said firepot and provides a water cooled fire wall at the said remote end of said heat transfer chamber.

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