March 5, 1963 F. S. BLOOM ET AL 3,079,910

RECUPERATIVE RADIANT TUBE BURNER MECHANISM

Filed June 27, 1960 2 Sheets-Sheet 1

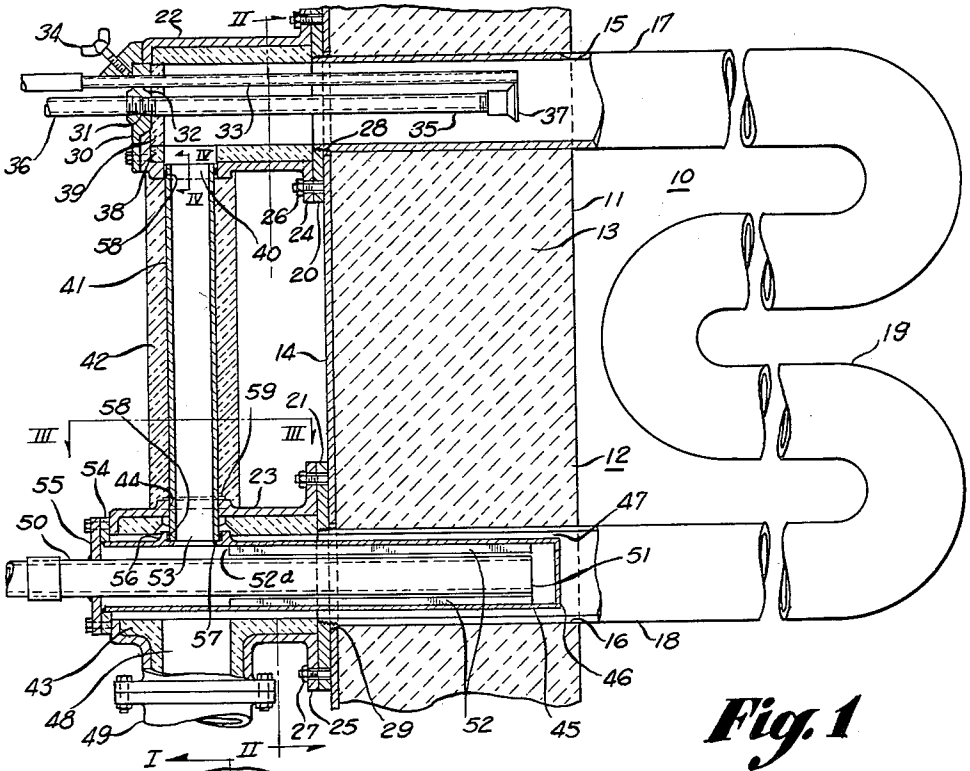

Fig. 1

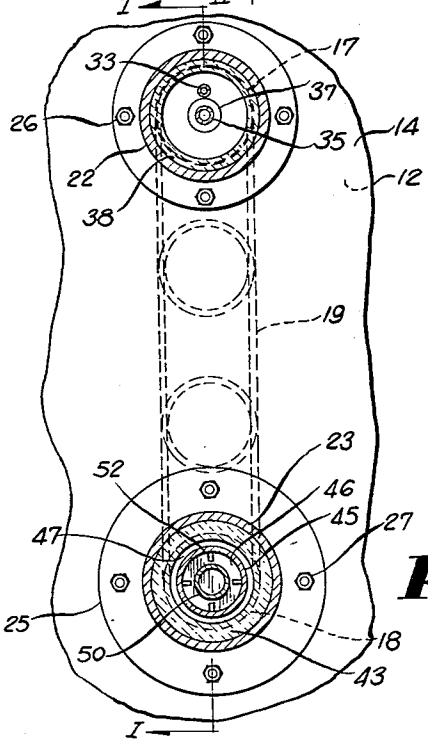

Fig. 2

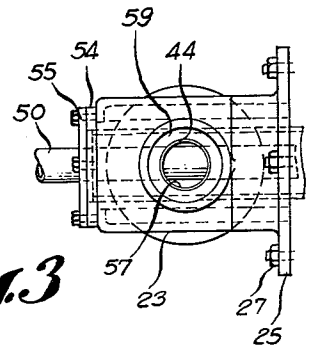

Fig. 3

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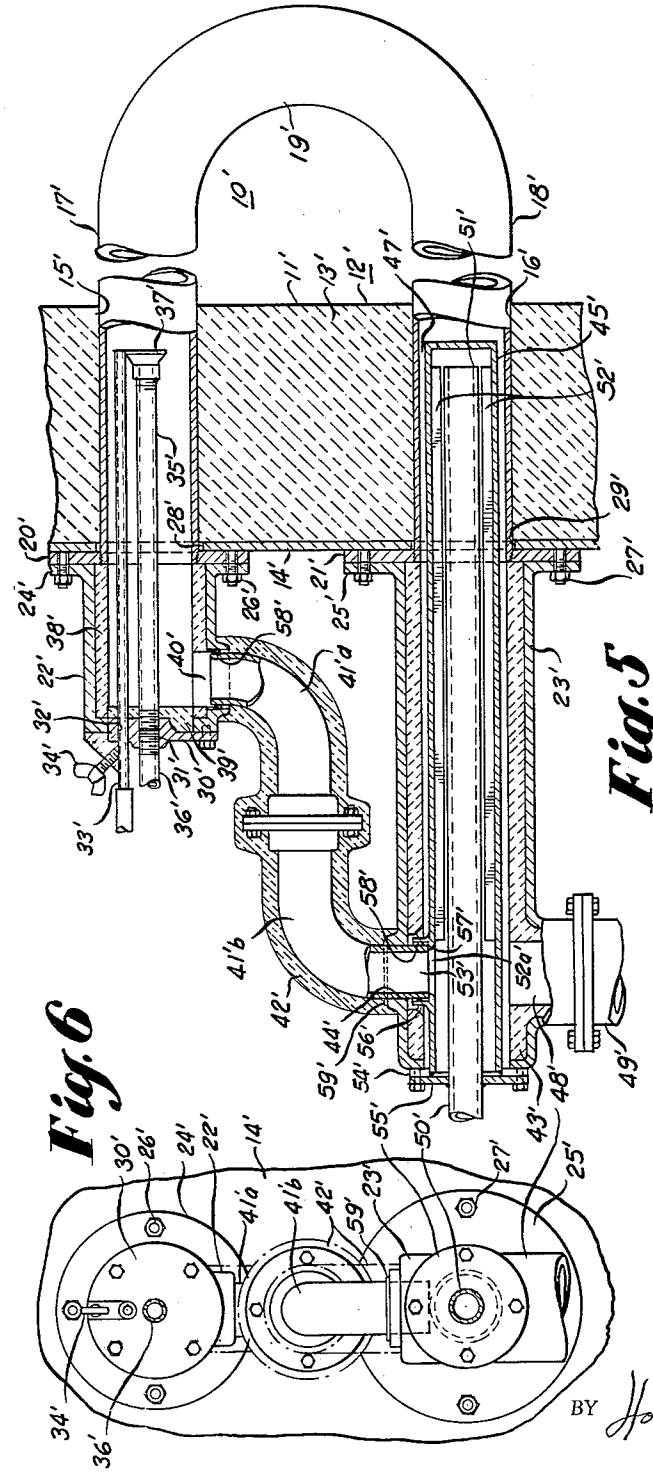

Fig. 5

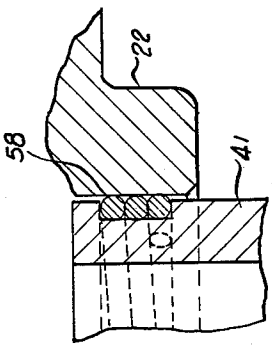

Fig. 4

Fig. 6

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RECUPERATIVE RADIANT TUBE BURNER MECHANISM

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7 Claims. (Cl. 126—91)

This invention relates to recuperative burner constructions of the U-tube, W-tube or similar radiant tube class for continuous or batch furnaces or other heating purposes. More particularly, our invention pertains to a recuperative radiant tube burner having a pair of legs extending through the wall of a furnace or other enclosure with burner and heat exchange elements therein in coaxial relation to such radiant tube legs and with at least the recuperator element extending into the opening through such wall.

Embodiments of this invention provide recuperative heating of the combustion air with radiant tubes of the return bend class, such as U-tubes or W-tubes, for use on a tower furnace, in a batch annealing furnace, or in other heating equipment, irrespective of the relative distance between centers of the parallel legs of the tube and the thickness of the wall of such furnace or other enclosure. Moreover, recuperative constructions of this invention can be installed with marked economy of material and labor. Further, varying distances between respective radiant tubes can be accommodated with relative ease for different heating specifications without detrimental clutter, or material change in tube unit piping and installation expense. Still further, in this invention, the recuperative heat exchange capacity of a unit can be selected for the particular service in which the embodiment is to be used.

Other objects, features and advantages of this invention will be apparent from the following description and the accompanying drawings, which are illustrative only, in which

FIGURE 1 is a longitudinal section of a recuperative radiant tube burner mechanism embodiment of this invention taken along line I—I of FIGURE 2;

FIGURE 2 is a view, partly in section, taken along line II—II of FIGURE 1;

FIGURE 3 is a view in plan taken along line III—III of FIGURE 1 with the hot air pipe removed;

FIGURE 4 is a detail view of the seal at the top of the hot air pipe in the embodiment shown in the preceding figures;

FIGURE 5 is a longitudinal section, similar to that taken in FIGURE 1, of another unit embodiment of this invention; and

FIGURE 6 is a front view of the mechanism embodiment shown in FIGURE 5.

Referring to FIGURES 1 to 4 of the drawings, a recuperative radiant tube burner mechanism 10 is illustrated therein mounted in the wall 11 of a tower furnace 12, or other furnace or heat enclosure. Wall 11 may be a side, bottom or roof portion of the furnace or other enclosure and, as shown, comprises heat insulating refractory 13 within a metal shell 14 to which burner mechanism 10 is affixed. Wall 11 has openings 15 and 16 respectively for passage therethrough of an inlet leg 17 and an outlet leg 18 of a conventional W-tube 19, the distance between centers of which legs determine the distance between centers of the openings 15 and 16. Tube 19 may be a W-tube or a U-tube or a radiant tube of another shape in the return bend class having two legs requiring a pair of passages through the furnace enclosure utilizing the same. Such tubes are made generally of alloy steel to withstand

heating to relatively high temperatures to provide the thermal head in furnace 13 desired for the heat treatment of the work material, usually metal, within the furnace.

Such a wall 11 in a higher temperature furnace may have considerable thickness, the length of which thickness is utilized in the illustrated practice of this invention. The outer ends of legs 17 and 18 are threaded and provided with flanges 20 and 21, respectively, affixed thereto by means of such threads. Flanges 20 and 21 are provided with bolt holes for stud bolts, the heads of which are fixed to the furnace structure and project outwardly therefrom in registry with such bolt holes. Outwardly of the respective flanges, there is a burner sleeve 22 and an exchanger sleeve 23 with respective flanges 24 and 25 having bolt holes therein in registry with the bolt holes in flanges 20 and 21 so that when nuts 26 and 27 engage the ends of the aforesaid studs, the recuperative burner mechanism is mounted in place on and in the furnace 12. Preferably, gasket material is interposed between the adjoining faces of the respective flanges and between the tube flanges and shell 14. Shell 14 is provided with openings 28 and 29 through which the return tube legs extend, as shown.

Sleeve 22 is provided with an annular cover 30 having a central opening 31 which is tapped from opposite sides and a pilot opening 32. A pilot light burner 33 extends through opening 32 and is held in adjusted lighting position by a thumb screw 34. A small combustible mixture stream of gas is fed through the center of burner 33 and burns constantly to ignite fuel from a main burner 35, positioned coaxially with inlet leg 17, whenever burner 35 is turned on. A pipe 36 supplies fuel gas, or atomized fuel oil emulsion, to the interior of a fuel tube in burner 35 which leads to and is discharged at the end thereof through a flanged nozzle 37, the burner 35 being ignited by the pilot light burner whenever the fuel supply to tube 35 is turned on. Usually the fuel supply to such a main burner 35 comes from a fuel gas manifold which supplies a plurality of such radiant tube burners mounted on one furnace or on more than one furnace to be operated in concert.

Sleeve 22 is provided with a refractory lining 38 and cover 30 has an insulating lining 39 on its inner face. A side opening 40 extends through sleeve 22 and the lining thereof to accommodate the upper end of a hot air pipe 41 supplying the combustion air at elevated temperature around the fuel tube of burner 35 to combust with the fuel gas issuing from nozzle 37. The fuel flow rates and combustion air flow rates may be correlated or left relatively independent depending upon the control system employed for such burners, the fuel being turned down when the burner is to operate at reduced capacity with or without, as desired, a corresponding reduction in the flow of combustion air. Pipe 41 is surrounded by refractory insulation 42 in the form either of preformed or castable lagging to inhibit loss of heat and promote personnel safety.

Exchanger sleeve 23 is lined with refractory insulation 43 and is provided with a side opening 44 for the passage therethrough of the lower end of pipe 41. An inner heat exchange in the form of tube 45 having a closed end 46 is positioned coaxially relative to the axis of return leg 18 and extends through the sleeve 23 into the outer end of leg 18. The inner end of tube 45 terminates in wall 11 and hence does not take away from the heating effect of the portion of leg 18 inwardly of the inner face of that wall. Heat exchanger tube 45 is laterally spaced from the inside of leg 18 and of sleeve 23 to provide an annular passage 47 for gases being exhausted from radiant tube 19, such gases yielding heat to the outside of

exchanger 45 and end 46 for transmission therethrough to the incoming combustion air which after heat exchange passes as hot air through pipe 41 to the outside of burner 35. The cooled exhaust gases are discharged through a side opening opening 48 in sleeve 23 and pass to an outlet pipe 49 having a refractory lining, which outlet pipe may be connected to an eductor or fan, or both, to send such exhaust gases on to the stack or flue that is used for the discharge of waste gases.

The suction in conduit 49 is also operative to aspirate combustion air through an inlet air pipe 50 which extends longitudinally within exchanger 45 and terminates at 51 outwardly of end 46. Preferably, longitudinally extending, radial heat exchange fins 52 are provided on the inner surface of exchanger 45 to aid in transmitting heat from the exhaust gases to the incoming combustion air. Such combustion air flows through the interior of pipe 50, makes a return bend at the inner end and flows through the annular space 52*a* past fins 52 before entering pipe 41 through a side opening 53 in exchanger 45. The outer end of exchanger 45 may be welded to a flange 54 while the outer end of air inlet pipe 50 may be welded to an annular cover plate 55, such flange and cover plate having registered bolt openings therethrough for affixation thereof to the outer end of sleeve 23.

Side opening 53 is provided with a cylindrical flange 56 and has an annular shoulder 57 against which the lower end of pipe 41 may rest. As shown in detail FIGURE 4, pipe 41 is peripherally recessed at its upper and lower ends for a labyrinthine wire seal 58 which may consist of a few spiraling turns of wire in the recess where it may be held by tack welding or brazing. The wire turns project slightly beyond the outside diameter of pipe 41 enough to substantially close the space to the opposed cylindrical inside surface of flange 56 and of opening 40, with the result that in operation, at elevated temperatures, the wire turns expand and effectively form a labyrinthine seal against the flow of gases therethrough. Moreover, such pipe 41 may be assembled in position by axial sliding movements relative to openings 40 and 53, thereby dispensnig with threaded or union joints. A collar 59 on pipe 41 may also be provided around the top of opening 53 to inhibit exhaust gas leakage through opening 44 around the outside of pipe 41. At other places, such as the faces of flanges and covers, suitable gasketing is preferably employed.

In operation, the radiant tube burner mechanism 10 utilizes the high heat content of the waste gases exiting through return leg 18 in a recuperative manner by transferring as much as possible of that heat content through walls of the recuperator tube 45 to the incoming combustion air passing through air inlet 50. Simultaneously, such action reduces the quantity of heat that would otherwise pass into wall 11. The heated combustion air flows out of the lower portion of device 10 upwardly through insulated pipe 41 and into sleeve 22 and inlet leg 17 of radiant tube 19 around the main fuel tube of burner 35 for the achievement in the portion of radiant tube 19 within furnace 12 of maximum heating temperature for the fuel rate used at the time being. Additionally, inasmuch as the recuperator and burner elements are in coaxial position relative to the axes of the inlet and outlet legs of the radiant tube, respectively, those legs can be very close together without impairing the recuperative heat exchange action. Still further, the piping connection between recuperator and burner portions of device 10 is relatively simple and inexpensive; it can be made quickly and does not clutter the outside of the furnace or other heating enclosure to which the device is applied. Moreover, although the embodiments illustrated operate as a suction system under induced draft, they are equally operable as a pressure system pursuant to which a blower would be connected in advance of the inlet of the air inlet tube 50 as a substitute for, or supplement to, the suction equipment connected to outlet pipe 49.

In the modified embodiment illustrated in FIGURES 5 and 6, parts thereof corresponding in construction and functioning to parts in the preceding embodiment, are provided with the same reference numerals, respectively, with the addition of a prime accent thereto. The modified embodiment illustrates a practice of the invention on, for example, a relatively higher heat exchange capacity, relatively smaller center-to-center distance U-tube unit having the inlet and outlet legs 17′ and 18′ close together. The relatively higher heat exchange is obtained by extending the recuperative element longitudinally outwardly, as shown, for a greater distance for the incoming combustion air. Such length and heat exchange capacity of the recuperative portion of mechanism 10′ can be selectively varied in advance for the service demand for the particular unit. As shown, the pipe 41 remains a simple piping operation still relatively free of clutter in that the upper portion 41′*a* and the lower portion 41′*b* are elbows having flanges at the meeting joint for bolted completion of the connection. It thus will be seen that the invention is flexible in practice to accommodate different sizes and capacities of return bend radiant tubes and service severities, with retention of advantages enumerated above.

Various modifications may be made in portions of the illustrated embodiments and other embodiments provided without departing from the spirit of our invention or the scope of the appended claims.

We claim:

1. A recuperative radiant tube burner mechanism for a furnace or the like, comprising, in combination, a return bend radiant tube having an inlet leg and an outlet leg having portions adapted to extend in respective passages through a wall of a furnace or the like, a burner having an axially extending fuel tube, mounting means to mount said fuel tube on a furnace or the like wtih said fuel tube in coaxial position relative to the inlet leg of the return bend radiant tube, said mounting means adapted to hold the inner end of said burner so as to terminate substantially within the thickness of a wall of a furnace or the like, said fuel tube being radially spaced by said first-named mounting means from the inside of said inlet leg to provide a heated combustion air space around said fuel tube leading into said inlet leg, an axially extending recuperator having an inlet and an outlet for combustion air, mounting means to mount said recuperator on a furnace or the like with said recuperator in coaxial position relative to the outlet leg of said return bend radiant tube, said last-mentioned mounting means adapted to hold the inner end of said recuperator substantially within that portion of said outlet leg adapted to be within the thickness of a wall of a furnace or the like, said recuperator being radially spaced by said last-mentioned mounting means from the inside of said outlet leg to provide an exhaust gas space around said recuperator at least within said outlet leg, means for conducting exhaust gases from said outlet leg axially past and outside said recuperator in heat exchange relation therewith, and pipe means connecting the combustion air outlet in said recuperator with the combustion air space around said fuel tube.

2. A recuperative radiant tube burner mechanism as set forth in claim 1 in which said pipe means are peripherally recessed adjacent the ends thereof, said respective mounting means having cylindrically opposed portions surrounding said recesses in assembled position and expandable wire turns are provided substantially filling the space between the bottom of said recesses and said opposed portions, said wire turns being adapted to expand in use to overfill said space and form a relatively gas-tight seal.

3. A recuperative radiant tube burner mechanism for a furnace or the like having a wall, comprising, in combination, a radiant tube having an inlet leg and an outlet leg having a portion adapted to extend through a wall of a furnace or the like, an axially extending burner co-

axial with the axis of said inlet leg and adapted to have its inner end terminate substantially within the thickness of a wall, an axially extending recuperative heat exchanger tube coaxial with the axis of said outlet leg and having a substantial part thereof within said portion of said outlet leg adapted to be within the thickness of a wall, said heat exchanger tube having an outlet for combustion air in an outer portion thereof and combustion air inlet means extending through an outer portion thereof, said heat exchanger tube having a closed inner end and adapted to separate said combustion air and exhaust gases and a pipe connecting the interior of said heat exchanger tube with the interior of said inlet leg adapted to be positioned outwardly of a wall to conduct combustion air heated by heat exchange with said exhaust gases to said burner.

4. A recuperative radiant tube burner mechanism as set forth in claim 3 in which the inner end of said combustion air inlet means terminates adjacent but outwardly of said inner end of said heat exchanger tube, said heat exchanger tube is provided with longitudinally extending, radial fins for heat exchange and said pipe is provided with slidable, expandable seal means which are relatively gas-tight and respectively operative at least during an operation of said mechanism.

5. A recuperative radiant tube burner mechanism for a furnace or the like, comprising, in combination, a conventional radiant tube having an inlet leg and an outlet leg, said legs having portions adapted to extend into respective openings in a wall of a furnace or the like, a burner having an axially extending fuel tube coaxial with said inlet leg, an axially extending recuperative heat exchanger, extending into said outlet leg and spaced inwardly therefrom to provide a passage for exhaust gases along the outside of said heat exchanger, means forming an outlet for combustion air in said heat exchanger, means forming a combustion air inlet in said heat exchanger in return bend relation to said outlet, said above-named means separating said inlet and outlet from each other and a pipe connecting the combustion air outlet of said heat exchanger with said inlet leg to conduct combustion air heated by heat exchange with said exhaust gases to said burner.

6. In a furnace or the like, in combination, a member having an opening therein with a cylindrical surface to receive the end of a pipe, a pipe having a portion adapted to be slidably inserted in said opening for passage therethrough of a heated fluid, said portion of said pipe having a cylindrical outer surface opposed to said surface of said member, a peripheral recess in at least one of said surfaces and a plurality of turns of temperature-expansible wire positioned in said peripheral recess in retained relation thereto before assembly of said surfaces into opposed position and normally projecting beyond said one of said surfaces, a distance substantially sufficient substantially to extend at temperatures below elevated normal operating temperature of a furnace or the like to the opposed surface without obstructing positioning of said surfaces, whereby a labyrinthine seal joint develops between said member and said pipe at elevated temperatures.

7. A recuperative radiant tube burner mechanism for a furnace or the like, comprising in combination a return bend radiant tube having an inlet leg and an outlet leg having portions adapted to extend into respective passages through a wall of a furnace or the like, an axially extending burner having a fuel tube, mounting means to mount said burner on a furnace or the like with said fuel tube generally in axial registry with the axis of and radially spaced from the inlet leg of the return bend radiant tube to provide an annular combustion air space for recuperatively heated combustion air, an axially extending recuperator having an inlet and an outlet for combustion air, mounting means to mount said recuperator on a furnace or the like with said recuperator generally in axial registry with the axis of the outlet leg of the return bend radiant tube, said recuperator being radially spaced by said last-mentioned mounting means from the inside of said outlet leg to provide an exhaust gas space around said recuperator at least within said portion of said outlet leg, means for conducting exhaust gases from said outlet leg axially past said recuperator in heat exchange relation therewith, and pipe means connecting said outlet for combustion air in said recuperator with said combustion air space around said fuel tube to supply recuperatively heated combustion air to said combustion air space.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,079,910 March 5, 1963

Frederick S. Bloom et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 62, for "exchange" read -- exchanger --; column 3, line 5, strike out "opening", first occurrence; line 41, for "dispensnig" read -- dispensing --; line 73, after "inlet" insert -- end --; column 5, line 32, after "exchanger" strike out the comma; column 6, line 7, after "surfaces" strike out the comma; same column, line 14, for "in combination" read --, in combination, --.

Signed and sealed this 1st day of October 1963.

(SEAL)
Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents