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3,228,612

LIQUID-COOLED BURNER FOR OPEN HEARTH FURNACES

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2 Sheets-Sheet 1

Fig. 1

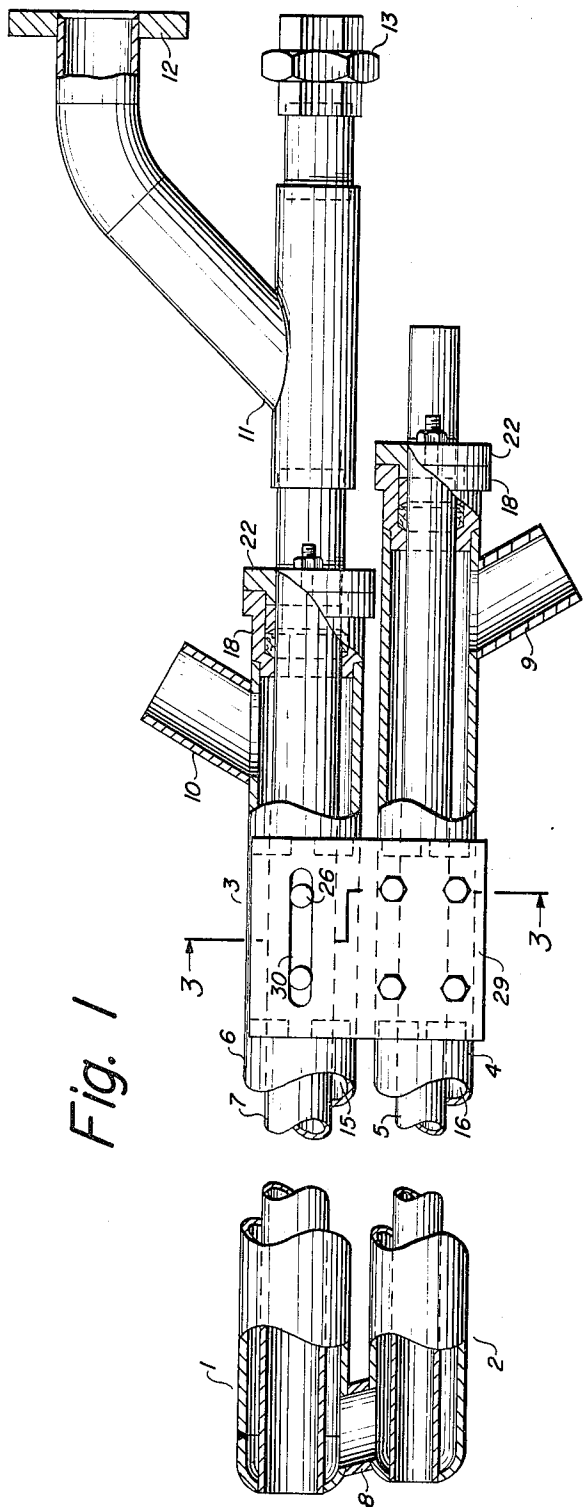
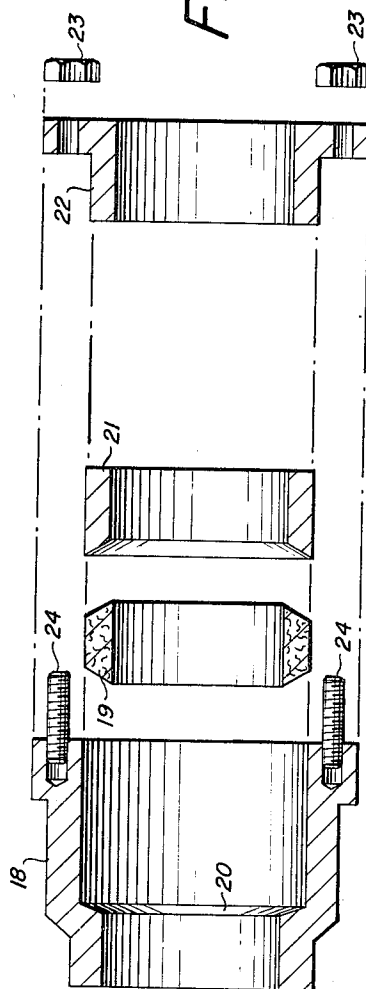


Fig. 2



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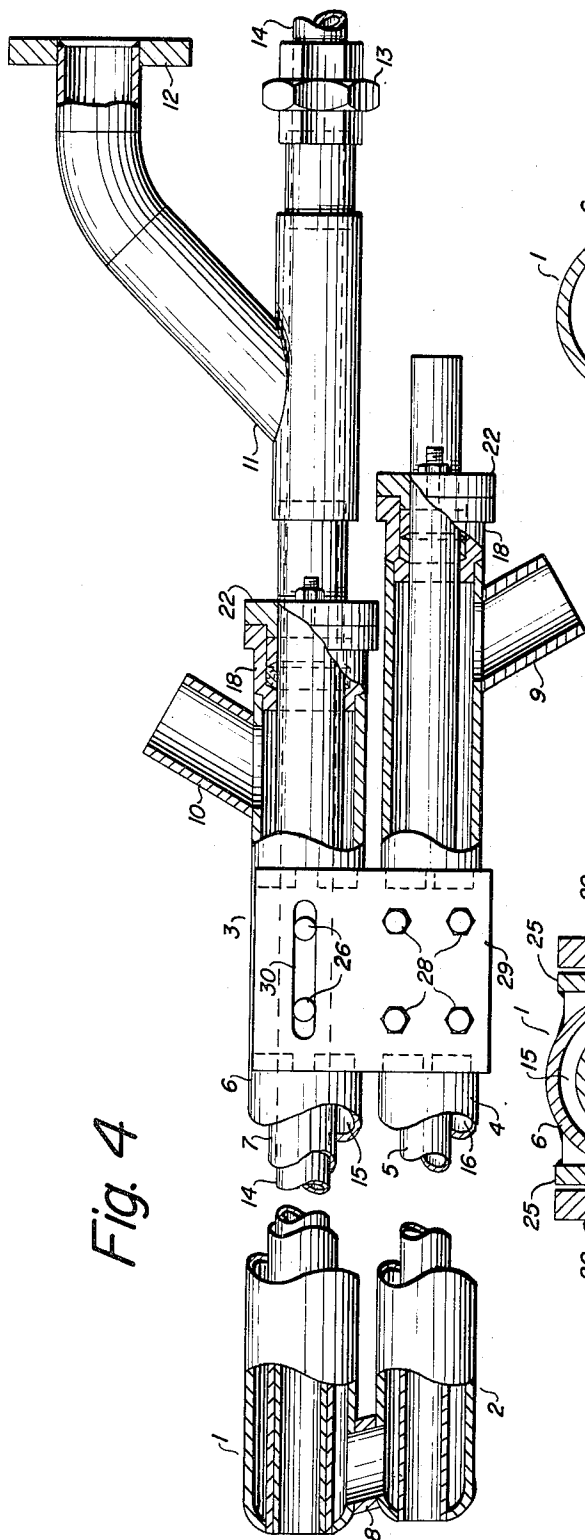


Fig. 4

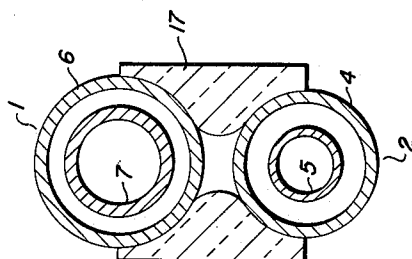


Fig. 5

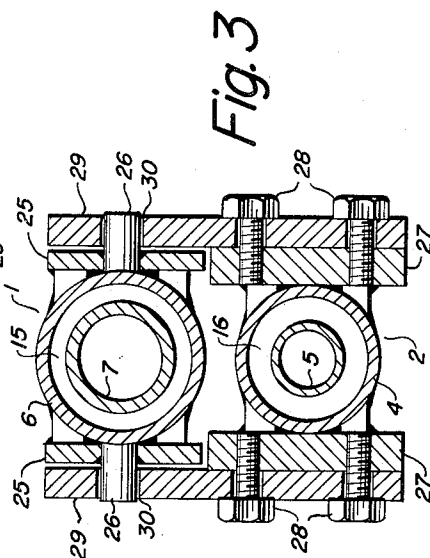


Fig. 3

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LIQUID-COOLED BURNER FOR OPEN HEARTH FURNACES

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4 Claims. (Cl. 239—132.3)

This invention relates in general to combination burners for introducing liquid and/or gaseous fuels into a high temperature furnace, and in particular to that type of burner which is provided with a liquid coolant.

In a regenerative reversing type open hearth furnace, it is usual to have one burner in each end wall of the furnace. Efficient operation of the furnace requires the incoming air necessary for combustion to be heated before it enters the hearth. This heating is accomplished by passing the air over a heated brickwork called regenerators. The regenerators are heated by the hot waste gases of combustion. The normal operation of these furnaces therefore requires a periodical reversal of the path of the hot waste gases. The burners are operated intermittently—the burner in one wall is shut off and the burner in the opposite wall is ignited. The flame of the operating burner passes over the liquid bath toward the opposite end wall. The hot waste gases of combustion are directed to the opposite end wall, pass over the inoperative burner positioned in the end wall, to the downtakes, through the regenerators which are heated by the gases and out the furnace stack. Air for the operating burner comes into the furnace through the hot regenerators located on the same side of the furnace, where it is heated by the brickwork. When the regenerators are no longer able to sufficiently heat the incoming air of combustion, the operation of the furnace is reversed, that is, the inoperative burner is ignited and the operating burner is turned off. This intermittent operation results in the upper surfaces of the burner being exposed to the high temperatures of the hot waste gases during the inoperative period and the lower surfaces of the burner being exposed to the high temperatures of the furnace and incoming air during operating periods. It is therefore essential to protect the exposed surfaces of the burners from the high temperatures prevailing in the furnaces.

Substantially all of the prior art burners are of the liquid-coolant type which use water under relatively low pressure and at low temperature as the coolant. Generally two types of burner construction have been used. One type of construction consists of concentrically arranged fuel tubes surrounded by an outer casing or water jacket. The second type of construction consists of fuel tubes arranged in substantially parallel relationship to each other inside an outer casing or water jacket. Liquid fuel is supplied in the lower tube and gaseous, semi-liquid or liquid fuels are supplied in the upper tube. In both types the water coolant is introduced into the water jacket at the nozzle end of the burner either by a tube which is encased in the water jacket itself or by a tube on the outside of the water jacket which is substantially parallel to the outer casing and is connected thereto by a passageway at the nozzle end. These arrangements allow the coolant to flow around the nozzle thence rearwardly through the water jacket to a coolant outlet.

All of the above prior art burners are susceptible to stagnation or entrapment of water in a "dead space" near the front end of the burner in the area exposed to the high temperature of the furnace. This condition results from the lack of positive pressure uniformly distributed across the entire area of the stream of cooling water.

Steam is thus formed by the heating of the stagnant or entrapped water resulting in a loss of the heat transfer capability of the water causing localized overheating resulting in early burnout of the burner. Also, because of the low inlet pressure any sediment brought into the burner with the water is deposited and accumulates in the burner.

It is the primary object of this invention to provide a burner construction of the evaporative-cooler type in which the cooling is so effective that a greater portion of the burner can be exposed to the high temperatures encountered in an open hearth furnace.

It is a further object of this invention to provide a burner of the evaporative-cooler type which can be used in a high temperature furnace and which is so constructed that the water coolant can be used at higher pressures and higher temperatures than heretofore have been used.

It is also an object of this invention to provide a burner of the evaporative-cooler type which has no impediments to the flow of coolant through the water passages thus removing the possibility of water stagnating or being entrapped with its resultant steam formation, loss of heat transfer capabilities and early burnout.

It is a further object to provide means to accommodate the differential expansion and contraction of the various parts of our burner.

Our burner broadly comprises a pair of spaced substantially parallel fuel tubes each having a rear end and a forward end. Each fuel tube is surrounded by an outer casing or liquid cooling jacket extending from the rear end to the forward end of the fuel tube. One of the outer casings has a liquid coolant inlet at its rear end. The other outer casing has a liquid coolant outlet at its rear end. The liquid coolant jackets are connected at their forward or nozzle ends by a short passageway. The cross-sectional area of each of the pairs of tubes is substantially constant the entire length of the burner. The coolant is introduced into the inlet at the rear of one outer casing, flows forwardly to the connecting passageway at the forward end of the outer casings, through the said passageway to the other outer casing and rearwardly to the outlet pipe in the rear of the said other outer casing.

No internal structures are required to keep the pipes apart. Therefore, there is nothing to impede the flow of water through the coolant passages. This aids in avoiding the possibility of water collecting in a "dead spot" where the heat of the furnace can turn it into steam thus reducing the rate of heat transfer and causing localized overheating and burnout of the burner.

FIG. 1 shows a longitudinal sectional view of the burner assembly;

FIG. 2 is an exploded view of the packing gland at the rear of the burner;

FIG. 3 is a cross-sectional view of the burner assembly taken through line 3—3 of FIG. 1;

FIG. 4 is another embodiment of the invention showing a removable tube inserted into the gaseous fuel line to burn pitch or pitch-like fuels.

FIG. 5 shows the burner encased in a castable refractory.

Referring now to the drawings of the invention, we shall describe our invention in more specific detail. A longitudinal sectional view of the burner assembly is shown in FIG. 1. The burner assembly is made up of two pairs of substantially concentrically arranged tubes, one pair of tubes 1 being placed above the other pair of tubes 2 in a substantially parallel relationship and being spaced therefrom by a spacer assembly 3. Each burner has an outer coolant casing surrounding an inner fuel tube. Only liquid fuel is supplied to the nozzle of the

burner through the lower fuel tube. The upper fuel tube may be used to supply gaseous fuel, liquid fuel or semi-liquid fuel to the nozzle of the burner. The cross-sectional area of each pair of tubes is substantially constant the entire length of the burner. The outer casing 4 of the lower pair of tubes which surrounds the inner fuel tube 5 is connected to the outer casing 6 of the upper pair of tubes which surrounds the inner fuel tube 7, by means of the connecting passage 8. The outer casing 4 is provided with a water inlet 9 near its rear portion. The outer casing 6 is provided with a water outlet 10 near its rear portion. The rear portion of the fuel pipe 7 is connected to a Y-shaped coupling 11. A fuel line flange 12 is fixed to the end of one leg of the Y-coupling 11 so that a gaseous fuel line (not shown) may be attached thereto. A fuel tube coupling 13 is threaded onto the other leg of the Y-coupling 11 for easy attachment of a liquid fuel line (not shown).

The outer casing 6 is made larger in cross sectional area than outer casing 4, to accommodate the larger fuel pipe 7. The larger fuel tube 7 is necessary to accommodate the volume of gaseous fuel necessary to meet the firing requirements of the furnace. In times of gaseous fuel shortage—e.g. coke oven gas in short supply—a fuel pipe 14 may be inserted into the fuel pipe 7, concentrically aligned therewith, to provide a passage for a pitch or tar-like fuel as shown in FIG. 4. The fuel tube coupling 13 makes it possible to couple the liquid fuel line (not shown), without removing the burner from the furnace. In this way the gaseous fuel tube does not become clogged with the residue usually associated with semi-solid fuel and it is only necessary to remove fuel tube 14 to again burn coke oven gas when in plentiful supply.

Although the cross-sectional areas of outer casing 6 and fuel tube 7 are larger than the cross-sectional areas of outer casing 4 and fuel tube 5, the space 15 available for passage of water between tubes 6 and 7 is smaller than the space 16 available for passage of water between tubes 4 and 5. Therefore to remove the amount of water being introduced into the burner at inlet 9, there must be an increase in velocity of the water flowing in passage 15 over the velocity of the water in passage 16. The velocity of the water in both burner tubes is sufficient to prevent any stagnation or stratification of water flow which might result in localized overheating and steam formation, decreasing the heat transfer capabilities of the coolant and resulting in early failure of the burner due to a burnout.

To cool the burner in operation in the furnace, water is supplied under pressure into the outer casing 4 through the inlet port 9. The water flows forwardly through passage 16 to the nozzle end of the burner, through the connecting passage 8 to the outer casing 6, makes a 180° turn and flows backwardly through passage 15 at a higher velocity to the water outlet port 10, thence to an expansion tank (not shown). In the expansion tank, a portion of the circulating water flashes into steam and leaves the system. The remaining water is recirculated to again cool the burner. In this manner the heat from the burner walls is removed as latent heat and the circulating water is maintained at its saturation temperature for its particular flowing pressure. As a result there is no excessive rise in the water temperature in the burner and the water velocity prevents overheating of the outer casing. The water velocity, or flow rate, is thereby sufficient to prevent the formation of steam in the burner with a resultant localized overheating and early burnout of the burner cooler.

The burner which may be approximately fourteen (14) feet in length, is inserted into the furnace at about a 7° angle to the furnace hearth and extends into the furnace for approximately eight feet. The portion of the burner which extends into the furnace is exposed to the highest temperatures, being directly within the heat affected zone. Therefore, we may further protect this section of the burner from the high furnace heat by encasing the middle portion of the burner in a castable refractory material 17

as shown in FIG. 5. In addition, the castable refractory on the burners reduces the amount of heat transferred from the furnace to the burner. Although this heat quantity is small compared to the total heat quantities in the furnace, it is nevertheless the high temperature level heat that is important in steel making.

As noted above, approximately eight feet of the burner will be in a heat-affected zone in the furnace. The heat-affected area of the burner will expand to a greater degree than will the cooler rear portion of the burner. Also, the hotter outer casing will expand to a greater degree than will the inner fuel tube which is more fully protected by the cooling water. The uneven expansion of the front and back areas of the outer casings and the uneven expansion of the outer casings and the interior fuel tubes set up stresses in the metallic fuel tubes and outer casings which may be of sufficient strength to break the welds and pull the tubes apart. For this reason, each pair of tubes is equipped with a packing gland expansion joint at the rear of the burner. Since both pairs of tubes have the same type of packing gland expansion joint and each of the tubes is subjected to the same type of uneven expansion only the upper packing gland expansion joint, FIG. 2, will be described.

The gland body 18 of the expansion joint is welded to the outer casing 6. A suitable O-type sealing ring 19 made of a suitable material such as cotton impregnated with graphite, neoprene, or other rubber-like resilient material is inserted into the body of the gland so that it seats on the shoulder 20. A cylindrical ferrule 21 is then inserted into the gland, said ferrule abutting the sealing ring 19. The backing ring 22 seats on the ferrule 21 and when the nut 23 is drawn up on the bolt 24, the backing ring 22 bears against the ferrule 21 which in turn compresses the sealing ring 19. The sealing ring 19 is forced inwardly to form a tight seal around the fuel tube 7 thus preventing leakage of water toward the rear of the burner. The fuel tube 7 can move freely within the sealing ring 19 thus allowing the said fuel tube 7 to contract or expand independently of the outer casing 6. It is also possible for the outer casing 6 to contract or expand independently of the fuel tube 7. The independent movement of the outer casing 6 and fuel tube 7 prevents the formation of stresses in the tubes thus preventing the failure of any welds in the burner.

The pairs of tubes of the burner assembly are spaced apart and kept in substantially parallel relationship by the spacer assembly shown in FIGS. 1 and 3. Referring to FIG. 3, the cooler saddles 25 are welded to the outer casing 6. Pins 26, extending through the cooler saddles are welded to the outer casing 6. Cooler saddles 27 are welded to the outer casing 4. Spacer or side plates 29 are bolted to the cooler saddles 27 by means of bolts 28. Pins 26 extend through elongated slots 30 of the spacer plates 29.

During the period of time when a burner is inoperative, the upper surfaces of the burner are subjected to the heat of the waste gases in their movement to the regenerators. These upper surfaces, being hotter than the lower surfaces of the burner, will expand to a greater extent than will the protected lower surfaces. On the other hand, when the burner is operating, the lower surfaces are exposed to the heat of the incoming air and will expand more than the upper surfaces of the burner which are somewhat protected from the hot incoming air. Both of these conditions of uneven expansion of the pairs of tubes, if such tubes were rigidly connected, could result in the buckling of one pair of tubes or in the tearing of the welds at the nozzle end of the burner. It is therefore important that the parallel pairs of concentric tubes be capable of expanding or contracting independently of each other. This is accomplished by providing the slots 30 in the spacer assembly shown in FIGS. 1 and 3. During the inoperative period, the upper pair of tubes, fuel tube 7 and outer casing 6 will tend to ex-

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pand more than the lower pair of tubes, fuel tube 5 and outer casing 4. The expansion must be in a rearward direction since outer casings 6 and 4 are attached to each other by welding coolant passage 8 thereto, and outer casings 6 and 4 are attached to the fuel tubes 7 and 5, respectively, by welds at the said fuel tubes outlet ends. The pins 26 welded to outer casing 6 will slide in the slot 30 thus allowing the rearward expansion of the said pair of tubes to occur without any damage to the burner. Conversely during the operative period outer casing 4 and fuel tube 5 will be exposed to the hot temperatures of the incoming air and will expand more than the outer casing 6 and fuel tube 7. The spacer assembly being welded to outer casing 4 will move with the expansion of this said outer casing 4. The slot 30 in spacer plate 29 will allow this rearward movement to occur without damage to the burner.

In a specific example of the use of our burner, we constructed a burner which had an overall length of 13 feet 4 inches. The lower pair of concentrically aligned tubes comprised a fuel tube made of schedule 40 steel pipe having an inside diameter of 1.6 inches and an outside diameter of 1.9 inches and a coolant jacket made of schedule 80 steel pipe having an inside diameter of 3.36 inches and an outside diameter of 4.0 inches. The upper pair of concentrically aligned tubes comprised a fuel tube made of schedule 40 steel pipe having an inside diameter of 2.5 inches and an outside diameter of 2.875 inches and a coolant jacket made of schedule 80 steel pipe having an inside diameter of 3.826 inches and an outside diameter of 4.50 inches. The burner was inserted into an open hearth furnace for a distance of 8 feet.

Water at the rate of 155 gallons per minute under a pressure of 42 pounds per square inch gauge and at a temperature of 245° F. was supplied to the inlet port 9 of the burner. The outlet water temperature was found to be 260° F. and had a pressure of 27 pounds per square inch. The velocity of the water flowing forwardly in the lower water jacket was 8.2 feet per second. This increased to a velocity of 10.0 feet per second in the upper water jacket.

After the burner had been in continuous operation for one month (approximately 90 heats of steel were processed) it was removed from the furnace and the tubes were examined by cutting them in half in a lengthwise direction. No evidence of accumulated sediment nor any evidence of corrosion or erosion due to entrapped water and subsequent steam formation was noted.

In another furnace campaign with a burner cooler of the same design, the pressure in the closed system was raised so that the cooling conditions changed. Water at the rate of 135 gallons per minute under a pressure of 200 pounds per square inch gauge and at a temperature of 360° F. was supplied to the inlet port of the burner. The outlet water temperature was found to be 370° F. at a pressure of 160 pounds per square inch gauge.

With operation of the burner cooler at the aforementioned pressures and several intermediate pressures the burner performed well, thus indicating a wide flexible range of cooling ability.

Although we have described our invention as a combination gas and oil burner particularly adapted to be used in an open hearth furnace, it will be understood that it can be used with other types of furnaces and that we can use any desirable combination of fuels and we can use liquid fuel or gaseous fuel alone. We do not wish to be limited to the exact and specific details shown and described but can use such substitutions, modifications or equivalents thereof as are embraced within the scope of our invention.

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We claim:

1. A liquid-cooled burner for use in high temperature furnaces, having a structure comprising:

- (a) a pair of spaced substantially parallel fuel pipes each having a rear end and a forward end,
- (b) a liquid-coolant jacket surrounding one of said fuel pipes and spaced uniformly therefrom to form a coolant passage and extending from the rear end to the forward end thereof,
- (c) a liquid-coolant jacket surrounding the other of said fuel pipes and spaced uniformly therefrom to form a coolant passage and extending from the rear end to the forward end thereof,
- (d) a water inlet at the rear end of one of the said liquid-coolant jackets,
- (e) a water outlet at the rear end of the other of said liquid-coolant jackets,
- (f) a liquid-coolant passage connecting the forward ends of said water jackets,
- (g) packing glands comprising a packing gland body secured to each of the said liquid-coolant jackets, a sealing ring inserted therein to communicate with the shoulder thereof, a ferrule abutting said sealing ring, a backing ring seating on said ferrule, said backing ring bearing against said ferrule to encompass the said sealing ring to prevent leakage of water rearwardly through the packing gland but allowing free movement of said fuel pipes encircled by said sealing ring,
- (h) means to permit one liquid-coolant jacket to move relative to the other liquid-coolant jacket.

2. A liquid-cooled burner for use in a high temperature furnace as claimed in claim 1 in which the said means of subparagraph (h) for rendering one liquid-coolant jacket slidably movable relative to the other liquid-coolant jacket, is a spacer assembly, said spacer assembly comprising a pair of cooler saddles secured to the liquid-coolant jacket of one of the fuel pipes, a pair of spacer plates secured to the said pair of cooler saddles, a pair of cooler saddles secured to the liquid-coolant jacket of the other fuel pipe, a pair of pins secured to the liquid-coolant jacket of the said other fuel pipe, said pins extending radially outwardly from the surface thereof through a pair of slots in the said spacer plates, said pins being freely movable longitudinally in said slots in said spacer plates.

3. A liquid-cooled burner for use in high temperature furnaces, having a structure comprising:

- (a) a pair of spaced substantially parallel fuel pipes each having a rear end and a forward end,
- (b) a liquid-coolant jacket surrounding one of said fuel pipes and spaced uniformly therefrom to form a coolant passage and extending from the rear end to the forward end thereof,
- (c) a liquid-coolant jacket surrounding the other of said fuel pipes and spaced uniformly therefrom to form a coolant passage and extending from the rear end to the forward end thereof,
- (d) a water inlet at the rear end of one of the said liquid coolant jackets,
- (e) a water outlet at the rear end of the other of said liquid-coolant jackets, and
- (f) a liquid-coolant passage connecting the forward ends of said water jackets,
- (g) means to permit the fuel pipes to move relative to the liquid-coolant jackets surrounding the said fuel pipes,
- (h) said means comprising a pair of cooler saddles secured to the liquid-coolant jacket of one of the said fuel pipes, a pair of spacer plates secured to the said pair of cooler saddles, a pair of cooler saddles secured to the liquid-coolant jacket of the other fuel pipe, a pair of pins secured to the liquid-coolant jacket of the said other fuel pipe extending radially outwardly from the surface thereof, through a pair of slots in the said spacer plates, said pins being

freely movable longitudinally in said slots in said spacer plates.

4. A liquid-cooled burner for use in a high temperature furnace, comprising:

- (a) a pair of spaced, substantially parallel, fuel pipes each having a rear end and a forward end, 5
- (b) separate liquid coolant jackets surrounding each of said fuel pipes and extending from the rear end to the forward end thereof,
- (c) each of said jackets being fixedly secured to the forward end of its respective fuel pipe and being 10 movably secured to the rear end of its respective fuel pipe by a packing gland,
- (d) a liquid coolant inlet at the rear end of one of said jackets,
- (e) a liquid coolant outlet at the rear end of the other of said jackets,
- (f) a liquid coolant passage connecting the forward ends of said jackets, and

(g) means in substantially spaced relationship to said forward ends securing said jackets to each other in movable relationship.

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