

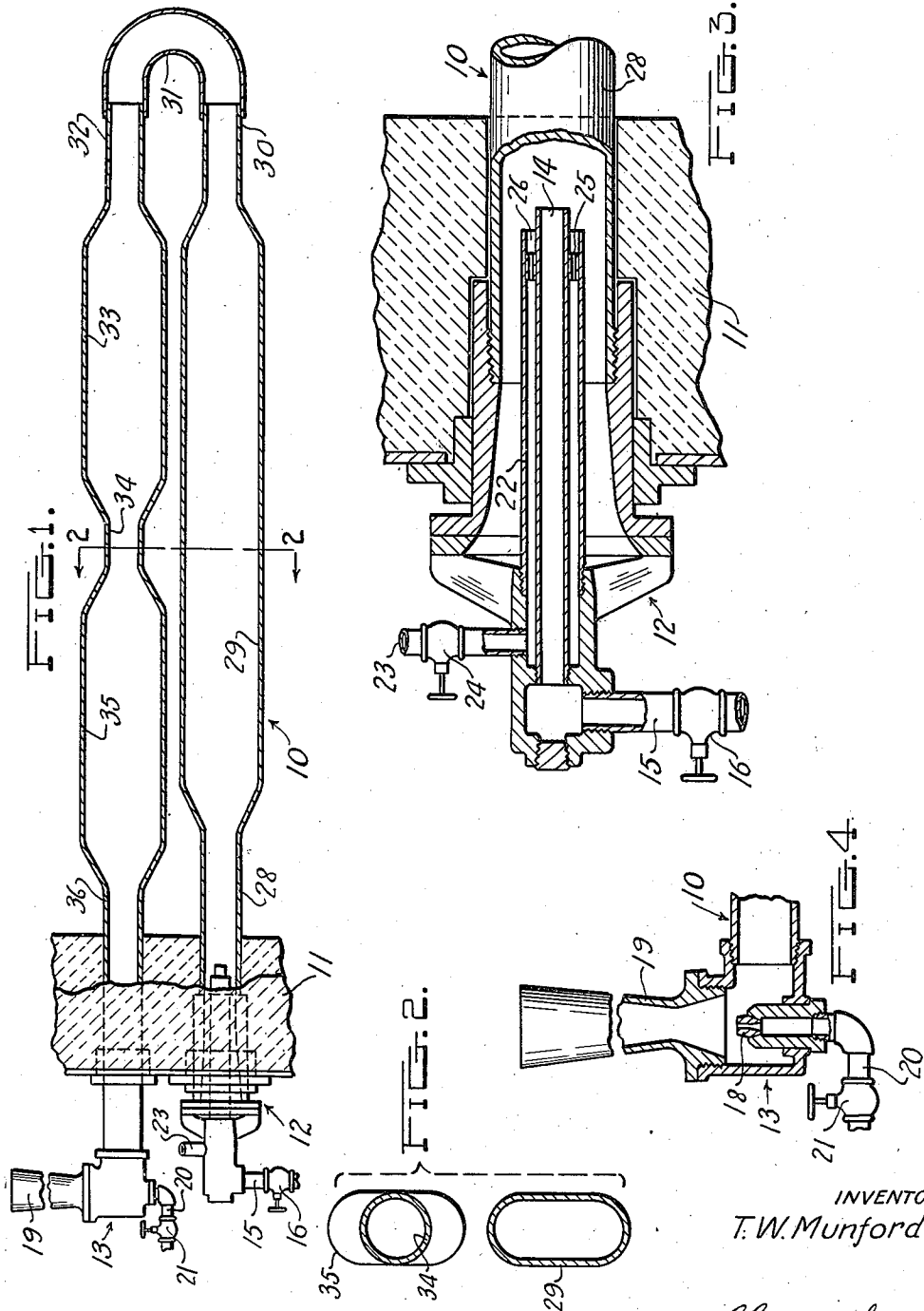
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HEATING APPARATUS

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HEATING APPARATUS

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The invention relates to fuel fired radiator tubes and has for its object to provide a radiator tube of such form that it may be uniformly heated to such high temperatures that it shall have special utility as a heat radiating element in furnace chambers and the like where high temperature heating elements are required. Other objects will more fully appear hereinafter.

The various features of novelty and invention will be fully described in connection with the accompanying drawing forming part of this specification and wherein,—

Fig. 1 shows the improved heating apparatus partly in elevation and partly in section and as extending through the wall of a furnace chamber which is to be heated;

Fig. 2 is a cross sectional view on line 2—2 of Fig. 1; and

Figs. 3 and 4 are section views of parts shown in elevation in Fig. 1.

The heat radiator tube is generally indicated at 10 and is shown as of hair-pin type with its intake and exhaust ends extending through a wall 11 of a furnace chamber which is to be heated. Fuel is delivered to the intake end of the tube 10 by means generally indicated at 12, and air for supporting combustion of the fuel is induced to enter said end by a draft producing means generally indicated at 13 at the exhaust end of the tube.

The means 12 for delivering fuel to the radiator tube includes a fuel delivery tube 14 to which fuel gas is supplied by a pressure gas supply pipe 15 having a regulating valve 16. The fuel tube 14 is shown as extending a substantial distance into the inlet end of the radiator tube 10 primarily to compensate for the thickness of the furnace wall 11. The fuel tube 14 is of relatively large cross sectional area without any constriction at its discharge end such as would tend to prevent the fuel stream from maintaining its integrity for a substantial distance after discharge from the tube.

It is essential to the successful firing of the radiator tube that the combustion supporting air be induced to enter the intake end of the tube by draft producing means at the exhaust end of the tube, and said means preferably takes the form of jet entraining apparatus consisting of a jet orifice nozzle 18 positioned to discharge into an eductor tube 19 which forms in effect an extension of the radiator tube. The fluid pressure supply pipe for the nozzle is indicated at 20 and is provided with a regulating valve 21 to permit the entraining effect to be adjusted as desired.

Inasmuch as the strong draft through the ra-

diator tube tends to pull the flame away from the fuel tube and thus causes it to go out, means are provided for constantly insuring ignition of the air and fuel where they initially intermix in combustible proportions and the means herein disclosed for that purpose will now be described. Surrounding the fuel tube 14 in spaced relation is a tube 22 to which preformed combustible mixture under pressure is supplied by a supply pipe 23 having regulating valve 24. In the tube 22 near its outlet end is a ring 25 through which the fuel tube 14 passes and which is provided with a plurality of relatively small passages through which the mixture supplied to the outer tube 22 must flow to pass from the latter. The fuel tube 14 extends beyond the tube 22 and the space between the two tubes at the discharge side of the ring 25 constitutes an annular combustion chamber 26 for the combustible mixture flowing through said ring. The outer ends of the tubes 14 and 22, therefore, become highly heated and along with the high temperature gases issuing from said chamber constantly insure ignition of the fuel issuing from the inner tube 14.

In order to permit the burning of a greater volume of fuel in the radiator tube 10 than could possibly be burned if the tube were of uniform cross sectional area through its length, the present invention provides a radiator tube of special form as will now be described. Where the tube passes through the furnace wall 11 and for a substantial distance into the furnace chamber, it is circular as indicated at 28. This circular part 28 is followed by part 29 whose cross sectional area is somewhat greater than the preceding section and which is oblong in cross section and of greater length than the preceding part. This difference in contour between the two parts 28 and 29 materially speeds up intermixing of the air and fuel in the composite stream as it flows from the part 28 to the part 29 with the result that combustion is correspondingly accelerated but not to such degree as to cause objectionable spot heating. The increased liberation of heat is compensated for by the greater heat absorbing surface of the part 29 and consequently the tube does not become overheated. Since combustion tends to decelerate due to the air and fuel becoming diluted with products of combustion, the present invention provides for repeated acceleration of combustion by following the expanded part 29 with parts 30—35 of which parts 30, 32 and 34 are preferably circular and of the same cross section area as the first part 28 whereas the parts 33 and 35 are

preferably of the same cross sectional contour and area as the part 29. This periodic expansion and contraction of the gases promotes intermixing of the gases in the stream as will now be readily understood with the result that combustion of residual fuel will be accelerated and combustion completed before the gases reach the exhaust end of the tube. The last portion 36 of the tube where it passes through the furnace wall 11 is preferably circular in cross section and of the same diameter as the first portion 28. It will be readily appreciated that in a hair-pin tube the bend 31 is also an important factor in materially stirring up the gases as they flow therethrough.

The first expanded part or section 29 is of relatively greater importance than the other expanded sections 33 and 35, it being noted in this connection that the last named sections are severally shorter than the first section 29. The short width or minor axis of the several expanded sections is preferably the same as the diameter of the preceding round section as is clearly shown in Fig. 2 whereby the gases in flowing from the round into the oblong section of the tube expand only in two opposite directions, it having been found that the turbulence or stirring produced in the gases by this arrangement gives the best results.

The advantages of a radiator tube constructed in accordance with the present invention may be stated as follows:

(1) Owing to the greater internal volume than a circular tube of equal length, a longer time is available for the combustion process to reach completion. This is particularly important when burning a fuel rich in CH_4 and other gases which may have naturally slow burning characteristics.

(2) As the burning stream enters the enlarged section of the tube, space is provided for natural expansion away from the outer core of the stream, and this outward movement induces a turbulent area at the core thus promoting thorough mixing of the air and fuel in the process of burning. Owing to the tube form, ample space is provided for flow through the tube on either side of the turbulent area without excessive friction losses.

(3) In spite of the fact that turbulence is produced in successive parts of the tube, no localized heating is produced since the turbulent areas are separated from the tube walls by those portions of the total gas stream flowing along the walls in substantially stream line flow under the influence of the draft source at the exhaust end of the tube.

(4) By utilizing a radiator tube of the type herein disclosed, the amount of fuel that can be burned in the tube is greatly in excess of what could be burned if the tube were of uniform cross sectional area through its length, and consequently, the utility of the tube is correspondingly increased due to the high temperature to which it can be heated.

What I claim is:

1. In combination, a radiator tube, and means for burning fuel therein comprising a suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging fluid fuel thereinto, and said tube having an oblong section preceded and followed by a circular section whose diameter is substantially the same as the minor axis of the oblong section.

2. In combination, a radiator tube, and means

for burning fuel therein comprising a suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging fluid fuel thereinto, and said tube being of hair-pin type and having between its bend and its intake end an oblong section preceded and followed by a circular section whose diameter is substantially the same as the minor axis of the oblong section.

3. In combination, a radiator tube, and means for burning fuel therein comprising a suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging fluid fuel thereinto, and said tube being of hair-pin type and having in each of its legs an oblong section preceded and followed by a circular section whose diameter is substantially the same as the minor axis of the oblong section.

4. In combination, a radiator tube, and means for burning fuel therein comprising a suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging fluid fuel thereinto, and said tube being of hair-pin type and having in each of its legs an oblong section preceded and followed by a circular section whose diameter is substantially the same as the minor axis of the oblong section, the oblong portion between the intake end of the tube and its bend being longer than the other oblong portion.

5. In combination, a radiator tube, and means for burning fuel therein comprising power operated suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging unignited fuel thereinto, and said tube for a portion of its length remote from the last named means being of greater cross sectional area than in the preceding portion of the tube.

6. In combination, a radiator tube, and means for burning fuel therein comprising power-operated suction producing means coupled to the exhaust end of the tube for inducing combustion supporting air to enter the intake end of the tube, means at the air intake end of the tube for discharging unignited fuel thereinto, and said tube comprising an alternate succession of restricted and expanded sections.

7. A combustion chamber consisting of a radiator tube having a substantial portion of its length between its ends of greater cross sectional area than the next preceding and following portions and the distance between the intake end of the tube and the point where said portion begins being many times less than the distance between the point where said portion ends and the exhaust end of the tube, said enlarged portion being oblong in cross section and the next adjacent portion being circular and the diameter of the circular portion being substantially the same as the short axis of the oblong portion.

8. A combustion chamber consisting of a radiator tube having a substantial portion of its length between its ends of greater cross sectional area than the next preceding and following portions and the distance between the intake end of the tube and the point where said portion begins being many times less than the distance between the point where said portion ends and the ex-

haust end of the tube, and said tube intermediate the ends of the last mentioned distance having at least one additional enlarged portion of shorter length than the first mentioned portion.

5 9. A combustion chamber consisting of a radiator tube of hair-pin type having between its bend and its intake end a portion which is oblong in cross section and which is preceded and followed by a circular portion whose diameter is
10 substantially the same as the minor axis of the oblong portion.

10. In combination, a combustion chamber consisting of a radiator tube having an alternate

succession of circular and oblong sections, means for flowing unignited fuel into the intake end of the tube, means for producing a strong draft through the tube whereby to cause air to stream into the intake end of the tube and flow towards the exhaust end thereof to support combustion of the fuel as it flows through the tube, and means at the intake end of the tube for insuring that ignition of combustible mixture resulting from intermixing of the flowing air and fuel shall occur as and when said mixture is initially formed. 5 10

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