This invention relates to improvements in combustion and space-heating systems, and more particularly to an improved flame suppressor tube.

A primary objective realized in the presently improved combustion system, consists in a virtually evenly heated element defining an elongate zone of primary combustion of a finely divided carbon or projected hydrocarbon flame; such an element defining a combustion chamber, being readily renewable at moderate cost, further being by preference of sectional construction, enabling partial replacement if needed, all in an arrangement requiring no ceramic refractory baffles, ducts, chambers or like elements usually required to be erected or at least assembled in situ.

The foregoing and numerous other objects and advantages will more clearly appear from the following detailed description of a presently preferred embodiment of the improvements, particularly when considered in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic end view of an assembly of ducts as same would be used in the heating system of an oven for bakery goods;

Fig. 2 is horizontal, part-sectional view taken in a horizontal plane, as indicated by line 2—2 of Fig. 1;

Fig. 3 is a fragmentary sectional view in vertical plane through the lower portion of an oven, and particularly showing the sectional shape of certain of the cross tubes or ducts;

Fig. 4 is a side elevational view of assembled, perforate plates forming sections utilized in forming a profusely perforate flame-suppressor tube constituting a combustion chamber;

Fig. 5 is a transverse sectional view through an intermediate portion of the flame suppressor tube and an enclosing sheet metal duct;

Fig. 6 is a diagrammatic view, being an elevation in perspective showing the radiant ducts, flue ducts and flue gas recirculation arrangement in connection with a typical oven, the latter being here shown only in outline, and

Fig. 7 is a fragmentary vertical sectional view of parts in the flame-entering end region of the combustion chamber.

Referring now by characters of reference to the drawing, the oven structure which, as such, is or may be of conventional character, includes a bottom or floor portion 10, a top closure or roof 11, and a front wall element 12 which is provided with an access opening normally closed by door 13. The rear wall 14 together with end walls 15 and 16 serve to complete the enclosure of the chamber to be heated. It is of course a preference that the enclosing wall portions of the oven be thermally insulated for obvious reasons of economy. No novelty is herein claimed for the oven per se, hence only a general description thereof is included for better showing of relation of the heating elements thereon.

In the heating of a space of rectangular plan, as in the oven disclosed, there are preferably utilized a pair of longitudinal circulating tubes or ducts arranged along the inside lower portion of the front and back walls 12 and 14 respectively, of the oven, such tubes being indicated at 20 along wall 14, and at 21 along the lower portion of wall 12. The ducts or tubes 20—21 are preferably of sheet metal suitably formed and jointed so as to present a section of rectangular aspect as shown by Fig. 5. In actual installations, the tube 21 may be and is usually of somewhat smaller sectional area than the tube 20.

The longitudinal ducts 20 and 21 are cross-connected by a plurality of spaced tubes 22, the nature, arrangement and sectional shape of which will best appear from Fig. 3. Each of the cross tubes 22 is open at its ends into the opposite longitudinal tubes 20 and 21 each of the latter being provided with ports or openings (not shown) and which correspond in shape and area to the section of the tubes 22.

The cross tubes 22 are preferably, but without restriction, of some polygonal section, and as an ultimate preference are of diamond shape, the adjacent tubes being mutually spaced, and all of the cross tubes located slightly above the bottom 10 of the oven, so as to permit a free circulation of the heated air fully about each of the cross tubes. It is a further preference for better control, direction and baffling of convection air currents rising from the cross tubes as well as the longitudinal ducts 20 and 21, to arrange the cross tubes in groups, and to incline the tubes of each such group so that the major axes thereof are sloped toward the adjacent group of tubes which will appear from Fig. 3, two such groups are shown, with the major axis of each diamond tube inclined toward a vertical median plane across the oven chamber.

As will later appear and be fully described, the primary combustion of fuel occurs within the duct or tube 20, whence the products of combustion pass via the cross tubes 22 into duct 21. At one or each end of duct 21 there is provided a flue gas connection into a vertical duct, which latter are indicated respectively at 23 and 24, and which merge or converge into a chambered structure 25 connected through a duct 26 to the inlet eye of a centrifugal blower 27. The outlet or discharge from blower 27, which latter positively discharges the flue gases, is branched, one branch 30 of which is directed to the stack for discharge, and another branch 31 of which is utilized for recirculation of a portion of the hot gases into the burner end of duct 20, for recirculation and further heat recovery. Suitable dampers (not shown) may be provided for varying the proportion of flue gases delivered respectively to the branches 30 and 31.

As will appear from Fig. 7, the tube 20 is somewhat longer than the perforate combustion chamber therein (later described) so as to provide an antechamber 28 into which the flame nozzle FN of the burner GTB extends, and also into which the recirculating duct 31 is connected.

Referring now somewhat more in detail to the combustion system as such, there is located coaxially with and within the tube or duct 20, a flame tube generally indicated at 40 which is spaced inwardly of the walls of duct 20, the latter, now obviously, serving as an enclosure for the flame tube.

As a source of the combustibles together with air for burning same, any type of readily dispersible fuel may be utilized such as oil, gas, powdered coal or the like, the burner unit being shown and preferred as of gun type and indicated as GTB. The latter is provided with the flame nozzle FN, projected toward the adjacent open end of the flame tube 40. The burner is provided with a blower wheel BW or like positive propulsion agency for propelling the air, and usually therewith the combustible substance through the nozzle FN.
It is a preference that the element 40 serve as a flame suppressor, in the sense that, although it must necessarily be provided with plenary outlet area for the products of combustion and any small proportion of the combustible which continues in process of burning, nevertheless the member 40 is so designed and constructed that the flame will not be principally confined to the space therein, as a zone of primary combustion beyond the nozzle of the burner GTB. In operation the angle and rate of projection of the air-combustible mixture are such that actual burning occurs substantially over the full length of the member 40, the outer end, being that end opposite the burner, being closed as by a suitable end plate designated at 41.

The flame tube is preferably of metal, and may consist of a metal which is highly resistant to oxidation, such as stainless steel sheet fabricated in tube form or, as preferred, may be built up of a series of substantially uniform and virtually planar plates, as shown in Figs. 4 and 5. In the example disclosed, the flame suppressor tube defining the combustion chamber, consists of a linear series of sections, each section including four similar flats or plates 42 each of which is sufficiently perforate in character, being provided with a great number of openings 43 which are about evenly distributed over each plate. Solely by way of instruction but without limitation, these openings, in the case of a flame tube the maximum cross dimension of which is of the order of 8 to 10 inches, will usually be, if circular, of the order of 1/4 to 1/2 inch in diameter, but possibly in larger units of a range up to 1/2 inch size, it being noted as a distinct preference that the aggregate area of the openings through the several sections of the flame tube, should at least equal the aggregate area of the outlets from the enclosing tube 20, which in the present instance may be identified with the several openings indicated by the numerals 44 establishing communication between the duct 20 and the several cross tubes 22.

Although the flame tube or combustion chamber 40 may be built up entirely of the perforate plates such as 42, it is a preference that the lower portion of this member be imperforate, so that the hot gases will emanate only from the central and upper portions of this member. In such case, assuming a hexagonal tube 40, the two lowermost sectional plates forming the faces indicated at 45 are imperforate as far as the openings 43 are concerned, but are otherwise similar to the sectional plates 42. These plates to form the perimeter of a unit length or tubular section of the duct 40, is affected by means of angular bracket members 46, each of a length proportioned to the plates about as shown by Fig. 4, the sections being provided with openings in their end regions to accommodate assembly bolts 47. In addition to providing for the perimetral assembly of the requisite number of the substantially planar plates 42 and 45, the angle bracket members 46 are each provided through each face, with a pair of spaced bolt openings as will appear from Fig. 4 and indicated at 50, such that the bracket members also serve to permit endwise assembly of the tubular sections formed of the plates. The burner end of the flame suppressor tube 40 may be left entirely open, while the corresponding end of tube 20 may be provided with a partial closure plate 28A having a central aperture of a size more than sufficient to accommodate the nozzle and thus provide a port 20A for admission of secondary air. The opposite end of tube 20 is closed, as and above briefly mentioned, the opposite end of tube 40 is closed with a hexagonal plug insert indicated by numeral 41, which may be bolted into position through the use of bracket members such as 46, on the endmost section of the tube.

It is preferred that the plates 42 and 45 be of substantial gauge or thickness, and formed of a cast ferrous metal such as cast iron or steel, with preference to certain alloys known to be highly resistant to high-temperature effects over long periods of time, without warping or other deformation. It is a preference, in order to insure against sagging of the member 40 when of substantial length, and in order to maintain the correct position of the combustion chamber 40 within the enclosing duct 20, to provide the perforate tubular structure with a series of ferrate feet 51, attachment to which may be made by the same bolts or like elements 47 as are utilized for assembly of the lower plates 45 in the region of the feet.

It is thought that the function of the combustion chamber and immediate pertinent parts, and of the duct system therewith, will have become apparent from the foregoing detailed description of elements, but it may be noted for completeness that, as the burning fuel is projected into the flame suppressor tube 40, substantially complete combustion will take place therein, the speed of blower wheel BW in the burner being so regulated as to result in a flame length which is substantially equal to the length of the combustion chamber identified with the space in tube 40. Based on actual usage, burners 20 are obtained with a regulation of fuel feed to the burner GTB so proportioned to the air discharged by the blower wheel BW, that the tubular member 40 will be kept at a temperature of 900 to 1000 degrees F., although such statement of range should not be taken as limiting. Under such conditions, very little flame will be apparent upon observation, exteriorly of the combustion chamber 40, although at times small nonprojected flames will appear close to and in wiping contact with the outside surfaces of the perforate plates, it being highly desirable that there be avoided any protracted flame contact with the sheet metal tube 20. Regulation of flame characteristics may be effected in some degree by control of area of opening 28B, as by any simple form of damper or shutter (not shown), to vary the secondary air aspirated through this area.

As the combustion is more or less complete within the member 40, the gases normally within the duct or tube 20 consist primarily of hot products of combustion. Due to the displacement effect resulting from the projection of the air and flame by the burner, and due further to the aspirating effect of the fan 27, the hot burned gases will be moved rapidly outwardly through the side openings in duct 20, thence through the cross tubes 22 which are rapidly heated once the system is put into operation. The cross tubes in turn discharge into the longitudinal duct 21 parallel to the duct or tube 20. The gas being somewhat reduced in temperature by thermal exchange in the oven, the flue gases moving upwardly through ducts 23 and 24 are somewhat cooled, and are moved in the fan intake enclosure 25, thence proceed into and through the fan 27, part of the combustion gases at this point being impelled to the stack through connection 30, and the remainder passed downward through duct 31. This latter as earlier mentioned, is a recirculation duct for the flue gases and delivers a certain proportion thereof back into the duct 20 specifically as disclosed, into antechamber 28 so as to provide for further utilization of the heat remaining therein.

Brief reference was heretofore made to the advantage of inclination of the major axes, and the grouping of the diamond tubes 22. By so arranging the cross tubes they serve in a sense as baffles, and the air warmed thereby, is caused to converge in a central region of the oven or other space, thence proceeding upwardly until approaching or reaching the inner surface of the top of the oven, whence the now divided stream will proceed downwardly along the end walls of the oven for reheating and further circulation. Such a control of the convection current within the oven has been found to conduct to uniformity of temperature in the various baking zones of the enclosure.

For brevity and simplicity of illustration and description, the structure disclosed is partly diagrammatic. It
has been found that in actual installations, a shallow mechanical compartment (not shown) formed as by an outer sheet metal enclosure coating with wall 16, can be used to house the burner, the blower 27, together with elements 25 and 26, and such control dampers or valves as desired, all in position for easy access for any purpose of control or service attention.

Although the invention has been described by particularized reference to a single preferred embodiment, the detail of description is to be understood solely in an illustrative, rather than in any limiting sense, numerous variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. A flame suppressor tube comprised of tubular sections arranged in end-to-end relation, each tubular section including a plurality of substantially rectangular plates angularly arranged in edge-to-edge relation to form a tube of polygonal cross-section, a plurality of said plates being provided with numerous openings, a plurality of bracket members each having portions overlapping a pair of adjacent corner portions of the plates of one section and the axially adjoining portion of adjacent corner portions of the next section, fastening elements connecting each corner portion to its overlapping bracket members and supports attached along one side of the tube.

2. A flame suppressor tube comprised of tubular sections arranged in end-to-end relation, each tubular section including a plurality of substantially rectangular plates angularly arranged in edge-to-edge relation to form a tube of polygonal cross-section, a plurality of bracket members each having portions overlapping a pair of adjacent corner portions of the plates of one section and the axially adjoining pair of adjacent corner portions of the next section, fastening elements connecting each corner portion to its overlapping bracket member portion to provide for end-to-end assembly of the plates of axially adjacent sections, and a plurality of axially spaced supports attached along one side of the tube.

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