

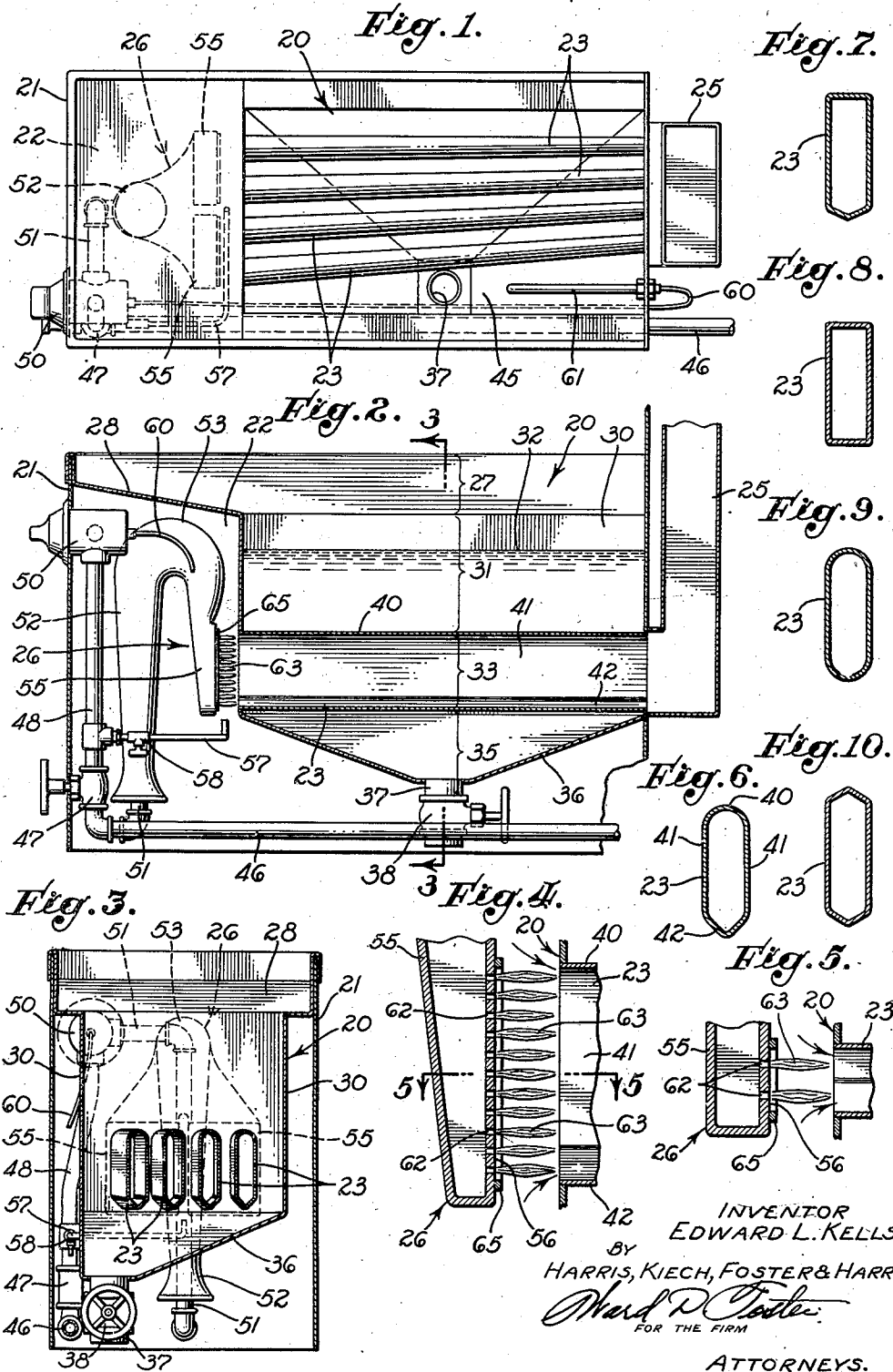
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DEEP FAT FRYER

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DEEP FAT FRYER

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The present invention relates to an improved deep fat fryer of the type employed in hotels, restaurants, and the like. A device of the general type to which the invention refers comprises a rectangular receptacle approximately 14" long for a liquid cooking medium, the receptacle being provided with horizontal heat exchange passage means or tubes in combination with some type of gas burner. In the prevalent type of deep fat fryer, three cylindrical tubes approximately 2½" in diameter are employed for heat transference.

The gas-fired deep fat fryers now manufactured and used are inefficient both with respect to heat transference and with respect to heat generation. In any attempt to achieve efficiency, economy, and simplicity in a deep fat fryer of this general type, numerous problems are encountered and the general purpose of my invention is to meet such problems effectively. These problems, which arise largely from the necessarily limited dimensions of a deep fat fryer, are reflected in the objects of my invention discussed below.

With reference to the receptacle for the cooking liquid and the design and arrangement of heat exchange tubes therein, my invention has the following objects: to provide a fryer requiring a low volume of cooking liquid both to minimize the mass to be heated and to minimize the cost of periodically replacing the liquid; to provide a receptacle and tube arrangement that is relatively simple in construction and relatively easy to clean; to provide relatively extensive areas for heat exchange; to achieve a low heating load per unit area and to do so without the necessity of employing a correspondingly large volume of liquid; to provide extensive heating areas that are for the most part vertical surfaces; to achieve a design for the tubes that inherently creates efficient liquid circulation with special reference to widespread effective wiping action of the tube surfaces by the liquid to favor rapid heat transference; to provide heat exchange tubes of long life free from such items as internal transverse baffles that tend to deteriorate in service; to provide tubes inherently favoring rapid gas flow therethrough with a consequent low film coefficient; to provide tubes that inherently minimize stratification of the enclosed hot gas streams; to provide tubes operating with low draft losses; to provide tubes in which the maximum distance from any point in the enclosed gas stream to the nearest heat exchange surface is short; to provide tubes in which this distance in the hottest upper zones of the tubes is exceedingly short; to provide a tube configuration that minimizes tur-

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bulence and the formation of vortices in the liquid body immediately above the tube; to provide tubes that do not favor the trapping or accumulation of food particles thereon; to arrive at dimensional relationships in tubes effective for highly efficient heat transference, with special reference to the ratio between the width and depth of a tube and the ratio of the length to the cross-sectional area of a tube; and to provide a tube construction that may be fabricated inexpensively.

When the above objects are accomplished in the design of a receptacle and in the design of the tubes therein, any conventional type of burner may be adapted thereto and combined therewith to achieve efficiencies in performance heretofore unattained. The preferred practice of my invention, however, is characterized by the use of a special burner arrangement to achieve further efficiencies.

With reference to the new burner construction, my invention has the following objects: to provide a burner that achieves combustion within the confines of the tubes, thereby using the liquid body for heat insulation and avoiding the necessity of a separate troublesome firebox; to provide a burner that consumes gaseous fuel with satisfactory combustion characteristics including minimum production of carbon monoxide; to provide a burner that favors high velocity flow of hot gases along the inner surfaces of the associated tube; to provide a burner that supports combustion of large quantities of gas in the associated tube, an achievement that is difficult because the tube walls are in effect liquid-cooled; to achieve a burner that utilizes primary air at an exceptionally high rate to favor rapid and complete combustion in the associated tube; to achieve a high loading of the burner ports heretofore unattained in confined burners, thereby developing a high rate of heat generation in the limited combustion space available; to provide a burner construction especially suitable for supporting efficient combustion in a narrow tube; to provide for continuous fuel velocity throughout the burner system; to achieve a stabilized high-velocity flame with a high ratio of primary air without incurring high frequency flutter or whistling of the burner flame; and to arrive at a dimension, spacing and disposition of the burner ports to achieve the desired character of combustion.

The above and other objects will be apparent in my following detailed description of a preferred form of my invention, taken with the accompanying drawing.

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In the drawing, which is to be considered as illustrative only:

Fig. 1 is a plan view of a deep fat fryer embodying the invention;

Fig. 2 is a side elevation of the device with various walls broken away to reveal the construction;

Fig. 3 is a transverse section taken as indicated by the line 3—3 of Fig. 2;

Fig. 4 is an enlarged fragmentary section of a burner head and the adjacent end of the corresponding tube;

Fig. 5 is a section taken as indicated by the line 5—5 of Fig. 4;

Fig. 6 is a transverse section of a tube employed in the preferred practice of my invention; and Figs. 7 to 10 respectively are similar views showing other tube configurations that may be used.

The principal parts of the device shown in the drawing include a receptacle or cooker tank generally designated 20, an outer housing 21 providing a burner compartment 22, a series of heat exchange passage means 23, which may be loosely referred to as tubes, extending through the receptacle from the burner compartment to a stack 25, and, finally, a burner generally designated 26 positioned to direct combustion into the tubes. In the present construction the outer housing 21 serves as a box-like base for supporting the receptacle 20, the receptacle being unitary with the housing along its rim.

The receptacle 20 may be regarded as divided into various zones. The upper part of the receptacle forms an expansion zone or space 27 (Fig. 2) into which the cooking fluid may surge without overflow, the wall of the receptacle forming a drainage apron 28 in this zone. Below the expansion space 27 the receptacle 20 is restricted in width to space the side walls 30 of the receptacle from the corresponding side walls of the outer housing 21. Lying below the expansion space 27 and above the series of heat exchange tubes 23 is a cooking zone 31 in which the normal liquid level 32 may be approximately 2 3/4" above the tubes. The vertical extent of the tubes 23 determines what may be termed a heat exchange zone 33 and below this zone is what may be termed a cold zone 35, the term, of course, being relative. In my preferred construction the bottom wall 36 of the receptacle is inclined laterally to one side as indicated in Fig. 3 and is longitudinally inclined to the middle as indicated in Fig. 2, thus leading to a suitable draw-off pipe 37 controlled by a suitable valve 38.

The heat exchange tubes 23 have various cross-sectional configurations in accord with the concepts underlying the above-mentioned objects of my invention. Generally speaking, the tubes should be relatively narrow and relatively deep in cross section, thus providing relatively extensive vertical surfaces. In the present arrangement suitable for a fryer 7" x 14" I employ four tubes 23 of the cross-sectional configuration shown in Fig. 6, each tube having a convex upper wall 40, flat side walls 41, and a V-shaped bottom 42. Such a tube may be formed by suitably bending a single metal sheet. Other cross-sectional configurations for the tubes 23 that may be suggested are shown in Figs. 7, 8, 9, and 10. In all these tubes the cross-sectional axes are unequal.

In my preferred construction the heat exchange tubes 23 are something less than 3 1/2" in vertical dimension, for example, approximately 2 1/2" inside diameter. I have found it to be ad-

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vantageous to make the tubes of tapering configuration to compensate for contraction by cooling of the combustion gases, the tapering serving to minimize the film coefficient. Tapering the width of each tube from approximately 1 3/8" inside width at the burner end to approximately 1 1/8" inside width at the exhaust end is suggested. One feature of employing such tapered tubes is that the tubes may be uniformly spaced and yet lie in converging disposition to provide a relatively wide clearance space 45 (Fig. 1) on the deeper side of the receptacle 20, such a space being desirable both for convenience in periodically cleaning the receptacle and for properly locating a thermostat element.

Fuel gas for the burner passes from a horizontal pipe 46 upward through a cut-off valve 47 and through a vertical pipe 48 to a thermostat-controlled valve 50 and is then delivered by a pipe 51 to the intake of a burner manifold 52. The burner manifold forms a gooseneck 53 and may branch to form two burner heads 55, which burner heads may be spaced approximately 3/4" from the intake ends of the heat exchange tubes 23. The two burner heads 55 provide four burner faces 56 (Figs. 4 and 5), there being one burner face opposite each heat exchange tube 23. To provide a pilot flame for the burner the pipe 48 may be provided with a small branch 57 having a pilot light valve 58. For automatic regulation a small tube 60 is shown extending from the thermostat-controlled valve 50 to a thermostat element 61 inside the receptacle 20.

As best shown in Fig. 2, the manifold 52 flares in configuration for a certain distance from the intake end to provide a suitable space for inspiration and initial intermixture of primary air with the gaseous fuel. Beginning at the gooseneck 53 the manifold is substantially constant in cross-sectional area to maintain the velocity of the gaseous stream until the stream reaches the burner heads 55. Each of the burner faces 56 is somewhat less in area than the intake end of the corresponding tube.

An important feature of my burner is the manner in which each burner face 56 is apertured to provide burner ports. It has been found that the necessity for a high rate of heat generation within the extremely limited space available may be met only by circumscribed conditions. Among other factors, the spacing and dimensioning of the burner ports are critical.

The fuel used in the course of developing the present embodiment of the invention is 1100–1120 B. t. u., .62–.65 specific gravity, natural gas composed chiefly of methane and ethane, the gas being supplied at 7" of water pressure at the intake orifice of the manifold, the intake orifice being drilled with a No. 47 standard twist drill. Under such conditions of fuel supply I provide twenty-two spaced ports 62 in each burner face 56, the ports being arranged in eleven rows of two each and being bored by a No. 40 standard twist drill. As best shown in Fig. 4, primary hydroxylation cones 63 form at the ports 62 and, of course, the flame mantle (not shown) extends into the heat exchange tubes 23 and may under certain conditions even reach the stack 25.

Twelve rows of the ports 62 instead of eleven rows may be provided but when an attempt is made to employ thirteen rows it is found that the holes must be placed too close together for efficient operation, the close spacing tending to cause the primary cones to merge and thereby

interfere with the penetration of secondary air. The use of smaller holes in larger number to provide the same total of port area is likewise impractical because the holes must be placed too close together. If an attempt is made to use ports of larger diameter, for example, ports drilled by a No. 38 standard twist drill, the burner flame at time of extinction flashes back into the burner head. It will require merely the skill expected in this art to vary the dimensions and spacing of the ports 62 for optimum combustion with gas of a different character or supplied at different pressure.

A burner constructed in the manner described has a persistent tendency to whistle. I have found that the high pitch noise is generated by a high frequency flutter of the flame, and I have further found that the flutter is caused by secondary air being swept rapidly into the base of the flame and interfering with the flame to such an extent as to make the cones 63 unstable. The whistling seems to be a function of the thickness of the aggregate flames from a burner face, being especially persistent in the thin flames required here, and the whistling is found to occur more readily when a burner face is placed relatively close to the intake end of a tube as required here. One feature of my invention is the discovery that the whistling may be entirely eliminated by placing a suitable wall or baffle around the burner face to change the direction of approach of the streams of secondary air. Figs. 4 and 5, for example, show such a wall 65 encompassing a burner face 56, the wall deflecting the secondary air outward away from the bases of the primary cones 63.

In designing burners of the general character with which we are concerned here, it is customary to provide sufficient port area relative to the B. t. u. combustion to burn 10,000 to 15,000 B. t. u./sq. in. total port area. Any substantially higher port loading has been widely regarded as not feasible in any burner employed in a restricted space. In the present arrangement the twenty-two burner ports 62 burn 6000 B. t. u., the result being a port loading of slightly over 36,000 B. t. u./sq. in., a loading heretofore unattained in such burners.

The deep fat fryer shown in the drawing is of relatively small size, being 7" x 14" tank dimensions. Larger sizes are also supplied, one being 14" x 14" and differing from the smaller size in having twice as many heat exchange tubes and burner faces. The outstanding performance of my invention may be appreciated by comparison with a typical 14" x 14" deep fat fryer now in use. The typical fryer under consideration, which has been given the highest rating in standard tests, employs three cylindrical heat exchange tubes 2½" in diameter instead of eight tubes of the configuration described above. The recovery speed of a fryer is, in general, proportional to its ability to raise a normal frying depth of grease from room temperature to 390° F. and this test is used by most laboratories. The prior art fryer with the three cylindrical heat exchange tubes raised its cooking liquid from room temperature to 390° in 17 minutes with a burner input of 37,500 B. t. u./hour. The present 14" x 14" fryer raises its cooking liquid of the same cooking depth to 390° in 11.0 minutes with an input of 48,000 B. t. u./hour. It is apparent that the shortened time period is not attributable solely to the higher B. t. u. input, since the higher input alone would reduce the 17 minutes to 13.3

minutes, not 11 minutes. The efficiency of the new fryer relative to the prior art fryer equals

$$\frac{17 \times 37,500}{11 \times 48,000} = 1.20 +$$

or a 20% gain in efficiency. The speed of temperature increase achieved in my fryer resides in part in the shape and dimension of the heat exchange tubes and in part in the character and loading of the burner.

In comparing my eight tubes with the three 2½" cylindrical tubes, it is found that the total displacement of the eight tubes is 192 cu. in. as against 206 cu. in. and the total heating surface is 714 sq. in. as against 330 sq. in. Because of the increased heating area, the 48,000 B. t. u. input of the eight tubes imposes load on the heating surface of only 67 B. t. u./sq. in., whereas the 37,500 B. t. u. input on the three cylindrical tubes results in the relatively high load of 114 B. t. u./sq. in. This comparison emphasizes the gain in total area for heat exchange achieved by using relatively narrow tubes with extensive vertical areas. The relative cross-sectional areas of the tubes are also important for comparison. The ratio of length of tube to cross-sectional area for a cylindrical tube 2½" in diameter and 14" long is 2.9, and no prior art tubes within my knowledge have had a ratio as high as 5.5. The corresponding ratio for each of the tubes described herein is 6.9 at the firing end of the tube and 10.0 at the exhaust end.

The disclosure herein in specific detail of a preferred embodiment of my invention will suggest to those skilled in the art various substitutions and modifications under my basic concept, and I reserve the right to all such departures from my description that properly come within the scope of my appended claims.

I claim as my invention:

1. A frying apparatus having in combination: a receptacle for cooking liquid; a plurality of heat exchange passage means in said receptacle; gas combustion means including a burner face opposite from and spaced from each of said passage means, said burner face having a plurality of small burner ports spaced apart to form substantially separate primary hydroxylation cones; and means outward from the plane of each of said burner faces to deflect laterally incoming secondary air away from the bases of said primary cones to prevent soniferous fluctuation of the gas streams in the regions of said cones.

2. A frying apparatus having in combination: a receptacle for cooking liquid; a plurality of heat exchange passage means in said receptacle, each of said passage means being relatively narrow in horizontal width to provide predominantly upright heat exchange surfaces; gas combustion means including a burner face opposite from and spaced from each of said passage means, said burner face having a plurality of small burner ports spaced apart to form substantially separate primary hydroxylation cones; and means outward from the plane of each of said burner faces to deflect laterally incoming secondary air away from the bases of said primary cones to prevent soniferous fluctuation of the gas streams in the regions of said cones.

3. A frying apparatus having in combination: a receptacle for cooking fluid; and a plurality of elongated substantially horizontal heat exchange passage means in said receptacle, the longitudinal axes of said passage means converging toward the exhaust ends of the plurality of pas-

sage means, each passage means being relatively narrow and flat and disposed to provide predominantly vertical heat exchange faces, each passage means tapering to diminish in cross sectional area from its inlet end to its exhaust end, the convergence of said axes compensating for the taper of said passage means whereby to provide uniform width of spaces between said passage means.

4. A frying apparatus having in combination: a receptacle for cooking liquid; and a plurality of substantially horizontal heat exchange passage means in said receptacle, the longitudinal axes of said passage means converging toward the exhaust ends of the plurality of passage means, each of said passage means being relatively narrow in horizontal width to provide predominantly upright heat exchange surfaces and to provide a ratio of length in inches to average cross-sectional area in square inches greater than 5.5 based on a length in the order of 14 inches.

5. A frying apparatus having in combination: a receptacle for cooking liquid; and a plurality of spaced heat exchange means forming single, unobstructed open ended combustion passages spaced from each other in said receptacle, said passages being of diminishing cross-sectional areas from their inlet ends to their exhaust ends, said passages being relatively narrow in one dimension to provide predominantly vertical heat exchange surfaces and a ratio of length in inches to average cross-sectional area in square inches greater than 5.5 based on a length approximating fourteen inches.

6. In a frying apparatus of the character described providing a receptacle for cooking liquid, the combination of: a heat exchange passage across said receptacle positioned for submersion in said liquid; gas combustion means including a burner face at the inlet end of said passage, said burner face having a plurality of small burner ports spaced apart to form substantially separate primary hydroxylation cones, said burner face being spaced from the inlet end of said passage to permit secondary air to be drawn laterally into the passage end; and means extending outward from the plane of said burner face to deflect the laterally incoming secondary air away from the bases of said primary cones to prevent soniferous fluctuation of the gas streams in the regions of said cones.

7. A frying apparatus having in combination: a receptacle for cooking liquid; a plurality of heat exchange means forming unobstructed open ended combustion passages in said receptacle positioned for submersion in said liquid, said passages being relatively narrow to provide a ratio of length in inches to cross-sectional area in square inches greater than 5.5 based on a length approximating fourteen inches; gas combustion means providing a burner face at the inlet end of each of said passages, each of said burner faces having a plurality of small burner ports spaced apart to form substantially separate primary hydroxylation cones, said ports of each face being arranged in a pattern of relatively narrow width conforming substantially to the cross-sectional area of the corresponding passage, each of said burner faces being spaced from the inlet end of the corresponding passage to permit lateral intake of secondary air; and means extending from each of said burner faces toward the corresponding passage to deflect laterally incoming secondary air away from the bases of said pri-

mary cones to prevent soniferous fluctuation of the gas streams in the regions of said cones.

8. A combination as set forth in claim 7 in which said passages progressively diminish from their inlet ends to their outlet ends.

9. A combination as set forth in claim 7 in which said passages progressively diminish in cross section from their inlet ends to their outlet ends and in which the longitudinal axes of the passages converge toward their outlet ends to maintain between said passage means liquid spaces of substantially uniform width.

10. A frying apparatus having in combination: a receptacle for cooking liquid; and a plurality of spaced heat exchange means forming single, unobstructed open ended combustion passages in said receptacle, said passages being of progressively diminishing sectional areas from their inlet ends to their exhaust ends, said passages having a ratio between maximum and minimum cross-sectional dimensions of at least 2 and providing predominantly vertical heat exchange walls, said passages having a ratio of length in inches to average cross-sectional areas in square inches greater than 5.5 based on a length approximating fourteen inches, the longitudinal axes of said passages converging toward the exhaust ends of the passages.

11. A frying apparatus having in combination: a receptacle for cooking liquid; and horizontal heat exchange means having a width not substantially greater than half its vertical dimension and providing predominately vertical heat exchange surfaces, said passage having a single traverse across said receptacle and having a ratio of length in inches to average cross-sectional area in square inches of at least about 6.9, the length of the passage being in the order of 14 inches.

12. A frying apparatus having in combination: a receptacle for cooking liquid; substantially horizontal heat exchange means providing a substantially horizontal open-ended combustion passage therethrough, said passage having an effective horizontal cross-sectional dimension not substantially greater than half its vertical dimension, and said passage having a ratio of length in inches to average cross sectional area in square inches greater than 5.5 based on a length approximating fourteen inches.

13. A frying apparatus having in combination: a receptacle for cooking liquid; a substantially horizontally disposed elongated heat exchange means having a substantially horizontal combustion passage therethrough; burner means disposed at one end of said passage and being arranged to project a flame directly into said passage, said burner means having a plurality of ports arranged to form a flame of substantially the same configuration as said passage and of cross-sectional area not exceeding the cross-sectional area of said passage, said ports being spaced from one another and adapted to form separate primary hydroxylation cones; and means on said burner means and extending outwardly from the sides of said ports to deflect incoming secondary air away from said primary hydroxylation cones.

14. A frying apparatus having in combination: a receptacle for cooking fluid; a plurality of substantially horizontal heat exchange passage means in said receptacle, each of said passage means being of diminishing cross-sectional area from the inlet end to the exhaust end of the passage means, said passage means being relatively

narrow in horizontal width to provide predominantly upright heat exchange surfaces; gas combustion means providing a burner face spaced from and directed toward each of said passage means, said burner face having a plurality of small ports spaced apart to form individually separate primary hydroxylation cones; and means on said burner faces and extending outward from the plane of each of said burner faces to deflect laterally incoming secondary air away from the bases of said primary cones to prevent soniferous fluctuation of the gas stream in the regions of said cones.

15. A frying apparatus comprising in combination: a receptacle for cooking liquid; and an elongated substantially horizontal single pass heat exchange means extending through said receptacle for heating cooking liquid, said means providing a substantially horizontal combustion passage diminishing in cross-sectional area from its inlet end to its exhaust end, said passage being narrow in width to provide predominantly upright heat exchange surfaces, the passage having unobstructed open ends to provide free gas flow, and the ratio of the length in inches of said heat exchange means to its cross-sectional area in square inches being greater than 5.5, said length being in the order of fourteen inches.

16. A frying apparatus having in combination: a receptacle for cooking liquid; and a plurality of spaced heat exchange means forming separate, unobstructed open ended combustion passages spaced from each other in said receptacle, each of said passages having a ratio of length in inches to cross-sectional area in square inches greater than 5.5 based on a length approximating fourteen inches, the ratio between vertical and horizontal cross dimensions of the passages being at least 2, each of said passages making a single traverse across said receptacle.

17. A frying apparatus having in combination: a receptacle for cooking liquid; and a plurality of spaced horizontal heat exchange means forming spaced unobstructed open ended combustion passages separated from each other in said receptacle, each of said passages being not more than half as wide horizontally as vertically to provide predominantly upright heat exchange surfaces, each of said passages having a ratio of length in inches to average cross-sectional area in square

inches greater than 5.5 based on a length in the order of fourteen inches.

18. A frying apparatus having in combination: a receptacle for cooking liquid; a plurality of spaced heat exchange means forming passages in said receptacle positioned for submersion in said cooking liquid, each of said passages being of progressively diminishing cross-sectional area from its inlet end to its exhaust end, each of said passages being relatively narrow to provide a ratio of length in inches to average cross-sectional area in square inches of at least 5.5 based on a length in the order of fourteen inches; gas combustion means providing a burner face at the inlet end of each of said passages, each of said burner faces having a plurality of small ports spaced apart to form individually separate primary hydroxylation cones, said burner faces being spaced from the corresponding passage ends to permit secondary air to be drawn laterally into the passage ends; and means positioned outwardly from the plane of each of said burner faces to deflect the laterally incoming secondary air away from the bases of said primary cones to prevent soniferous fluctuation of the gas streams in the regions of said cones.

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