April 11, 1961 E. DURHAM 2,979,039

FLUID HEATING UNIT

Original Filed May 20, 1954 3 Sheets-Sheet 1

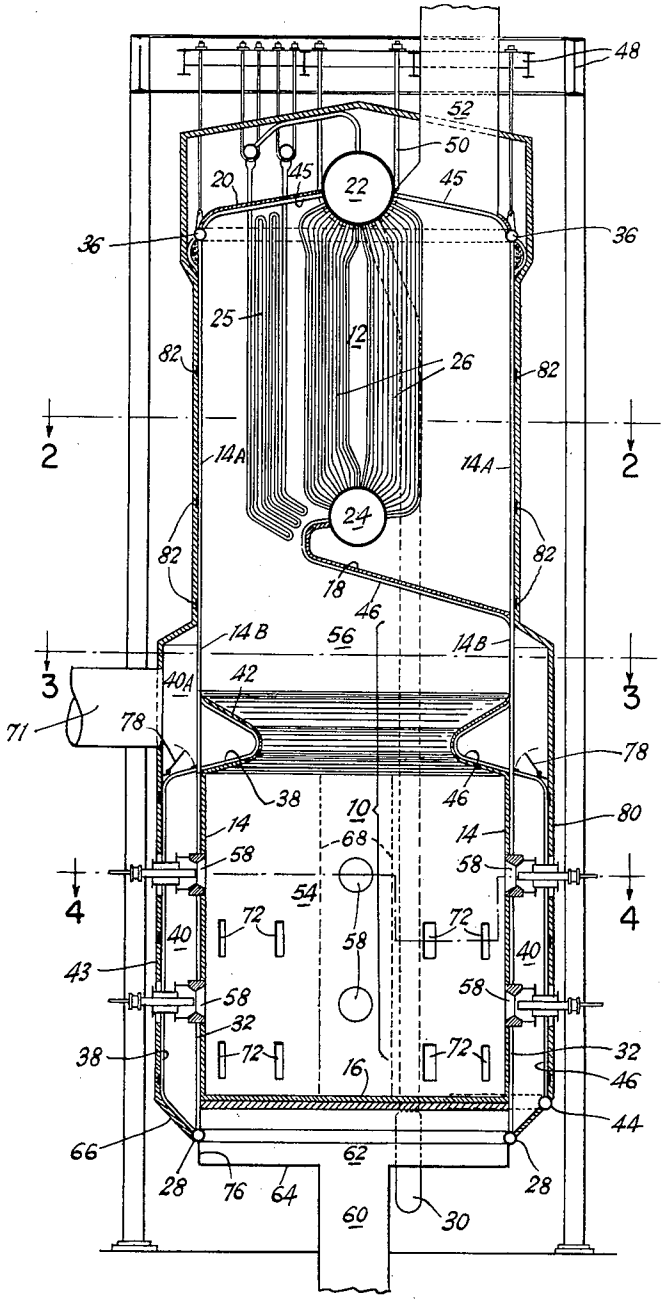


FIG. 1

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FLUID HEATING UNIT

Original Filed May 20, 1954 3 Sheets-Sheet 2

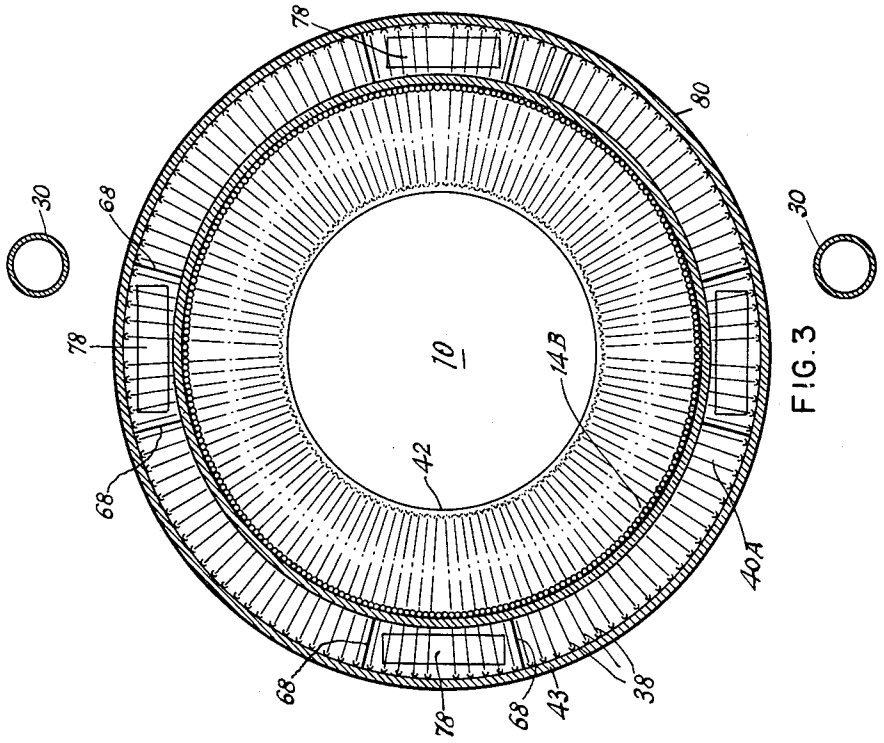


FIG. 3

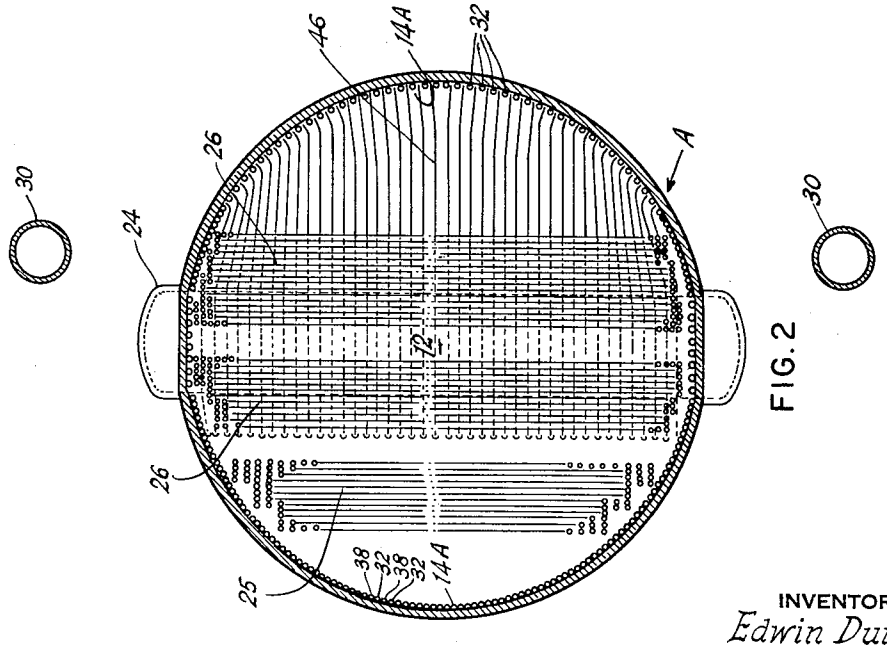


FIG. 2

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April 11, 1961 E. DURHAM 2,979,039

FLUID HEATING UNIT

Original Filed May 20, 1954 3 Sheets-Sheet 3

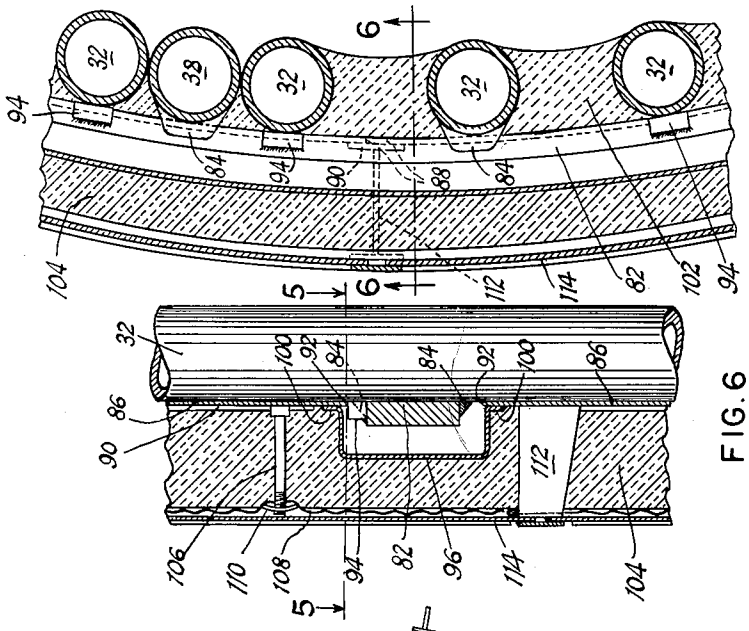


FIG. 5

FIG. 6

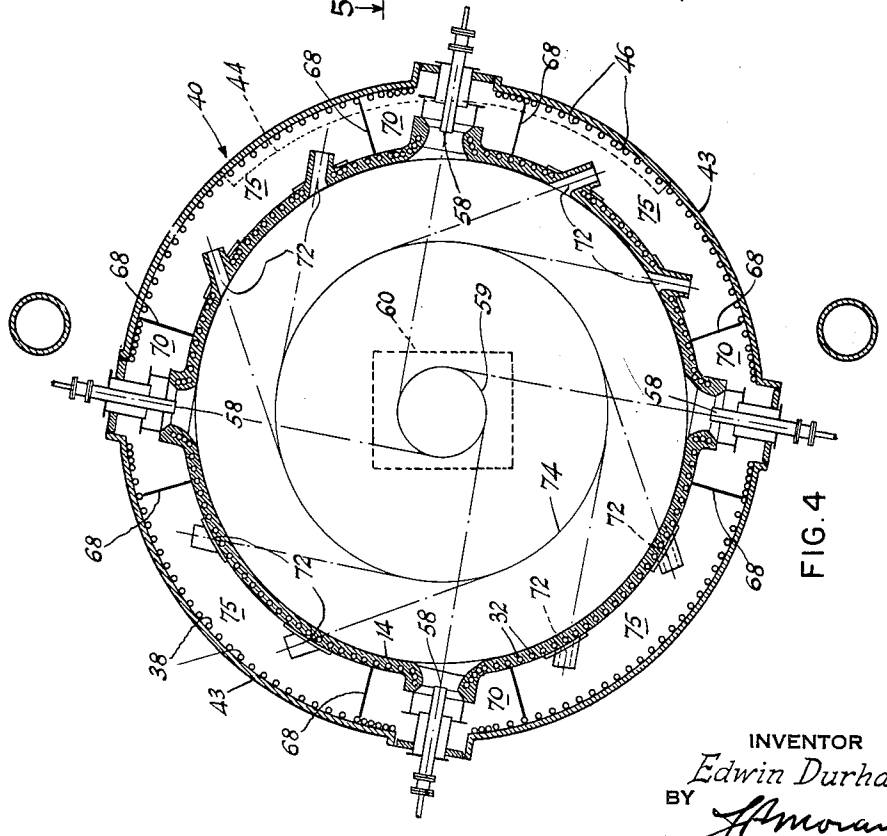


FIG. 4

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United States Patent Office 2,979,039
Patented Apr. 11, 1961

2,979,039

FLUID HEATING UNIT

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Original application May 20, 1954, Ser. No. 431,123, now Patent No. 2,840,049, dated June 24, 1958. Divided and this application Apr. 7, 1958, Ser. No. 726,860

2 Claims. (Cl. 122—6)

This invention relates in general to the construction of fluid heating units particularly adapted and especially useful for furnace operation under superatmospheric pressures. More particularly, the invention is directed to the construction of fluid heating units of the character described having an elongated setting of circular cross-section including an elongated furnace chamber of circular cross-section in communication with a lateral gas pass in which are positioned fluid heating tubes. The present application is a division of my copending application, Serial No. 431,123, filed May 20, 1954, now Patent No. 2,840,049, granted June 24, 1658.

In recent years there has been a trend towards the superatmospheric pressure combustion of fuels. These combustion pressures have ranged from 1 p.s.i. to over 100 p.s.i. Positive gas pressures in fluid heating units have created many mechanical design difficulties when the heating gas is confined in essentially rectangular settings of conventional fluid heaters.

The large flat walls of these rectangular units must be reinforced with heavy structural members in order to withstand the positive pressures. From a mechanical standpoint, a rectangular cross-section is inherently not adapted for the use of minimum size structural parts. Therefore, superatmospheric pressure gas units of this type have become more complicated and expensive with increases in fluid heating capacity and combustion pressure. It has become increasingly apparent that there is an economic limit of design pressures for rectangular units.

This invention provides a large capacity fluid heating unit of circular cross-section having a general arrangement of heating surface and pressure-containing walls which is advantageously applicable to high heating gas pressure operation. The adaptation of this type of unit for various combustion pressures entails merely a change in the thickness of the gas pressure-containing parts without a major rearrangement of the fluid heating surface. This is made possible by utilizing pressure-carrying members formed in a cylindrical shape, which members are able to contain any particular pressure with a maximum efficiency of material utilization.

More specifically, this invention provides an arrangement of fluid heating surface within a vertically elongated setting of circular cross-section including a vertically elongated furnace chamber of circular cross-section within said setting, a lateral convection heating gas pass in communication with said furnace and convection heated fluid heating tubes disposed in said gas pass transversely to the heating gas flow.

The invention also presents an improved gas-tight casing for a circular fluid heating unit which is composed of long rectangular metallic casing sheets circumferentially disposed around the periphery of the circular setting and joined at their short ends to form pressure carrying bands.

Another feature of this invention is the provision of water cooled annular wind box circumferentially enclosing the furnace chamber of the unit to provide a plenum chamber for combustion air.

Another feature of this invention is the provision of a fluid heating unit of the type described which is capable of burning a low heating value fuel in conjunction with a high heating value fuel in the furnace thereof and having a fluid cooled annular type wind box circumferentially enclosing the furnace chamber which is segmentally divided into chambers, some of which are for combustion air and the others for a low heating value gaseous fuel.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a vertical section of a pressure-fired steam generating unit constructed according to the invention;

Figs. 2, 3 and 4 are horizontal sections taken on the lines 2—2, 3—3 and 4—4 respectively of Fig. 1;

Fig. 5 is a fragmentary enlarged view of the setting shown in Fig. 2 at position A; and

Fig. 6 is a vertical section taken on the line 6—6 of Fig. 5.

The steam generating unit illustrated in the drawings is composed of a vertically elongated setting of a circular cross-section throughout its height. The setting includes an elongated furnace chamber 10 of a circular cross-section in the lower part of the setting and a lateral heating gas pass 12 in communication with the furnace chamber 10 in the upper part of the setting. The furnace chamber is defined by cylindrical wall portions 14, 14B, circular refractory floor 16, and a wing baffle 18. The baffle 18 cooperates with the upper circular setting wall portion 14A and roof 20 to form the lateral convection gas pass 12. A steam and water drum 22 is arranged to extend along the transverse centerline of the top of the setting and directly below, across the bottom of the gas pass 12, is an elongated water drum 24 with banks of upright steam generating tubes 26 connected between the drums. A steam superheater 25 is disposed in the pass 12 ahead of the tube banks 26.

In the lower end of the setting there is a toroidal distributing header 28 which receives water from downcomers 30. Leading upwardly from the toroidal header 28 are wall tubes 32 arranged in a circular pattern. These tubes define the furnace chamber wall portions 14, 14B and the convection gas pass defining wall portion 14A and are connected to an upper toroidal header 36. Also leading upwardly from the lower header 28 in spaced relationship throughout approximately three quarters of the periphery of the setting are tubes 38 which are first directed radially outwardly and are then bent upwardly parallel to the furnace wall along the outer circular wall 43 of an annular wind box 40. The tubes are then bent radially inwardly passing through the furnace wall and forming in conjunction with refractory an orifice type baffle 42. The tubes 38 are then bent back into the plane of the wall portion 14B and continue up to the upper toroidal header 36.

In Fig. 3 there is more clearly shown the tube pattern of the orifice baffle 42 showing how the tubes 38 are bent inwardly out of the plane of the outer wall 43 of the annular wind box 40, through the furnace wall portion 14 and thence back into the wall portion 14B, wherein the steam generating tubes are in tangent relationship to each other and form a tube to tube circular pattern.

The roof tubes 45 are risers carrying a vapor-liquid

mixture from the upper header 36 to the drum 22. Separately connected to the downcomer 30 is a segmental header 44 which passes around about one fourth of the periphery of the circular setting. The tubes 46 rise from the header 44 vertically along the wall 43 parallel to the furnace wall portion 14 then bend inwardly to form, in conjunction with refractory, the orifice baffle 42, a portion of the wall 14B of the furnace chamber, and then are bent inwardly in a parallel relationship at a slight incline to extend along the wing baffle 18. The upper ends of the tubes 46 are then connected to the lower drum 24.

In Fig. 2 there is more particularly shown the tube pattern of the wing baffle 18 wherein the tubes 46 bend out of the plane of the wall of the setting in substantially parallel relationship before turning in and being attached to the lower drum 24. There is also shown the tube pattern of the fluid heating tube bank 26, the tubes of which connect the drums 22 and 24. This figure also shows that the tubes are in an aligned relationship, filling the entire transverse width of the lateral gas pass 12. In addition there is shown the aligned tube pattern of the superheater 25, which is disposed gas flow-wise ahead of the generating bank 26.

The entire circular setting and steam pressure parts are top supported from the structural steel 48 by upper drum U-bolts 50, thus the thermal expansion of the setting is downward. Also hung from the steel work 48 is the pendent type superheater 25 which is composed of a plurality of tubes which are sinuously bent to form a tube bank extending across the entire width of the lateral gas pass 12. To prevent gas by-pass around the tube bank 26 the roof tubes 45 cooperate with refractory to form a gas-tight closure thus defining the roof 20 of the lateral gas pass on the upstream side of the tube bank 26. On the downstream side of the tube banks 26 the risers 45 have inter-tube openings which allow the heating gases to enter the flue 52.

The unit is particularly adapted for the burning of low heating value fuel gas, such as formed, for example, during the regeneration of a catalyst used in a hydrocarbon cracking process. The low heating value gas is composed of carbon dioxide, carbon monoxide, nitrogen, oxygen, water vapor and hydrocarbon vapor. The carbon monoxide and hydrocarbon vapors can be oxidized to CO_2 and H_2O in an exothermic process by the addition of an oxidizing medium such as air with a release of about 20 B.t.u./cu. ft. The amount of heat released is small and is not sufficient to maintain combustion when mixed with relatively cool air but if a furnace temperature of approximately 1500° F. or higher is maintained the gas will burn in the presence of air. As large amounts of this gas are discharged from a catalystic cracking unit it is desirable in the interest of an efficient cracking process to utilize the heat from these gases. Accordingly, in this invention the gas is burned in a combustion atmosphere of high heating value fuel oil and air wherein the combustion temperature is in excess of 1500° F. As hereinafter described the low heating value gas and high heating value fuel are separately introduced into the furnace 10 in a manner for efficient heat release. Afterward, the products of combustion are passed through the setting of a fluid for the generation and superheating of steam.

The furnace 10 is divided into a lower combustion zone 54 and an upper radiation zone 56 by the orifice type baffle 42. Disposed in the fluid cooled wind box 40 and passing through the wall portion 14 of the furnace 10 there is a plurality of high heating value fuel burners 58 arranged in vertically spaced rows with each row containing four burners and each burner having its centerline tangent to an imaginary circle 59 (Fig. 4), which circle preferably has its center on the longitudinal axis of the furnace 10. Combustion air is furnished to the burners from an air duct 60, the air being discharged to a plenum chamber 62 below the floor 16. This plenum chamber is formed by a lower circular casing 64 and a downward extension 66 of the vertical side wall 43. The air is distributed radially from the plenum chamber past the fluid heating tubes 32 and flows upwardly into the fluid cooled wind box 40. The wind box 40 is segmentally divided by the longitudinal baffles 68 so that, for example, secondary air for the burners 58 passes into wind box segments, or segmental chambers 70 formed between successive baffles 68.

Arranged in the wall portion 14 of the furnace combustion zone 54 are two rows of low heating value gas ports 72 which are vertically spaced at alternate levels below the high heating value burners 58. Each row contains eight gas ports with each port 72 being circumferentially spaced from the position of the high heating value burners 58 and with the ports having their longitudinal centerlines tangent to an imaginary circle 74 concentric with the longitudinal axis of the furnace. This latter circle being concentric with the tangent circle 59 of the high heat value burners but having a greater radius. Furthermore, the tangential gas port rows are spaced vertically from the high heating value fuel burner rows. The low heating value gas enters an extension 40A of the annular wind box 40 from the supply duct 71 and, by virtue of the segmental division of the annular wind box by the baffles 68, flows downwardly in the gas chambers 75 and thence through the ports 72. The combustion air for the gas will normally be obtained from the excess air introduced through the high heat value burners 58 but by opening dampers 78, air from the air chambers 70 will mix with the gas before going into the furnace 10.

The wall portion 14 of the combustion zone 54 includes the steam generating tubes 32 associated with refractory, which covers the tubes and fills the spaces therebetween. This refractory covering also extends up to and is included in the orifice baffle 42. As can be seen from Fig. 4 the fluid cooled wind box 40 is annular in shape and shares with the furnace, the common wall 14. Its outer circular wall 43 includes the upright parallel fluid heating tubes 38, 46.

Throughout the entire vertical height of the steam generating unit the setting wall is enclosed in an insulated fluid-tight casing such as illustrated in Figs. 5 and 6. The fluid heating tubes 32, 38 of the setting walls are arranged upright and parallel in a circular pattern. A buckstay band, made, for example, of ¾" by 3" steel bar, encompasses, in tangent relationship, all of the fluid heating tubes of the wall and is connected by welds 84 to the tubes alternately on the top and the bottom of the band so as to maintain the tubes in the circular pattern. These bands 82 are placed on the tubes at spaced vertical positions of the setting wall as shown in Fig. 1 so as to give support to the fluid heating tubes. Placed between the buckstay bands are long rectangularly shaped thin metal casing sheets 86 which also encompass all of the fluid heating tubes in a tangent relationship. These casing sheets 86 are pulled tight against the tubes and the short edges 88 of the sheets are joined by welding to upright butt straps 90 in such a manner that the joint is pressure tight. The long edges 92 of the casing sheets are adjacent the buck-stay bands 82 and the lower edges of each sheet rest on a small support block 94 which are in turn welded to the buck-stay bands 82. Thus the casing sheets 86 are supported from the buck-stay bands without being secured thereto. This arrangement allows the thin metallic casing to thermally expand independently of the fluid heating tubes. To complete the casing and to make it pressure tight, there is a flexible flanged channel member 96 enclosing each buck-stay band and placed with their recessed portions over the buck bands 82 and having the flanges 100 overlapping the long edges 92 of the casing sheets 86. Each of the flanged channel members 96 is also constructed of thin metal and is formed with its longitudinal centerline as a circle. Thus by welding the two ends of each channel member together and by welding their flanges to the casing sheets

there is completed a pressure-tight casing structure external of the fluid heating tubes.

The fluid heating tubes are shown in Fig. 5 with some in tube to tube relationship and others in spaced relationship. This is indicative of the various constructions required in the fluid heating unit of the invention. In order to protect the casing from excessive temperature, a refractory material **102** such as plastic chrome ore or castible refractory cement is placed behind the tubes in the tube to tube pattern and behind and between the spaced tubes with the refractory always covering at least half of the outer circumference of the heating tubes. Externally of the casing structure and attached thereto is thermal insulation **104** which, in turn, is attached to the studs **106** which are welded to the casing **86**. In order to hold the lightweight thermal insulation **104** in operative position there are a number of strands of wire **108** secured by the washers **110** fixed to the studs. In this example there is shown an external protective insulation casing **114** which is composed of thin circumferentially disposed metallic sheets welded to and supported by a multiplicity of spacer bars **112**. The spacer bars in turn are welded to the pressure-tight casing sheets **86**. The protective means may alternatively include a plastic insulation coating and in that event the external metallic casing and supporting means would not be required.

The fluid heater of this invention has certain desirable characteristics. The walls are formed in a circular shape such that they will efficiently withstand high gas pressures of superatmospheric pressure fired fluid heaters. This circular arrangement also provides an arrangement of fluid heating surface which makes possible the efficient combustion of a wide range of fluid fuels and the subsequent efficient removal of heat from the ensuing heating gases. It is further to be noted that this general arrangement may be used with most any combustion gas pressure by increasing the thickness of the gas pressure casing materials without any change to the basic fluid heating pressure part arrangement.

There is provided a unique fluid cooled wind box arrangement which materially reduced differential thermal expansion casing problems.

Attendant with and an inherent part of this fluid heater is a unique, simplified, and inexpensive fluid-tight casing which has eliminated the problems of supporting pressure walls of conventional rectangular shaped fluid heaters.

While in accordance with the provisions of the statutes I have illustrated and described herein a specific form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that

certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:

1. Fluid heat exchange apparatus comprising, in combination, circular wall means forming an elongated setting of circular cross-section, said circular wall means including a plurality of parallel fluid heating tubes extending longitudinally of said elongated setting, buckstay band means encompassing and contacting said tubes at at least two positions spaced longitudinally of said setting, each of said band means being welded to each of said tubes in said circular wall means, rectangularly shaped metallic casing sheets having their short edges welded together in fluid-tight joints to form a ring encompassing said tubes in tangent and touching relationship, said ring of sheets being between and having its edges adjacent said longitudinally spaced band means, means supporting one edge of said ring of sheets adjacent one of said band means, and flexible flanged channel members each encircling and having its recessed portion fitting over one of said band means with the flanges of each channel member welded in a fluid-tight joint to an edge portion of a ring of sheets adjacent each of the opposite edges of said band means.

2. Fluid heat exchange apparatus comprising, in combination, circular wall means forming an upright elonagted setting of circular horizontal cross-section, said circular wall means including a plurality of parallel fluid heating tubes extending longitudinally of said elongated setting, buckstay band means encompassing and contacting said tubes at at least two positions spaced longitudinally of said setting, each of said band means welded to each of said tubes in said circular wall means, rectangularly shaped metallic casing sheets having their short edges welded together in fluid-tight joints to form a ring encompassing said tubes in tangent and touching relationship, said ring of sheets being between and having its upper and lower edges adjacent said longitudinally spaced band means, means supporting the lower edge of said ring of sheets from an adjacent one of said band means, and flexible flanged channel members each encircling and having its recessed portion fitting over one of said band means with the flanges of each channel member welded in a fluid-tight joint to an edge portion of a ring of sheets adjacent each of the opposite edges of said band means.

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