June 9, 1953 V. MEKLER ET AL 2,641,234

HEATER

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Fig. 1.

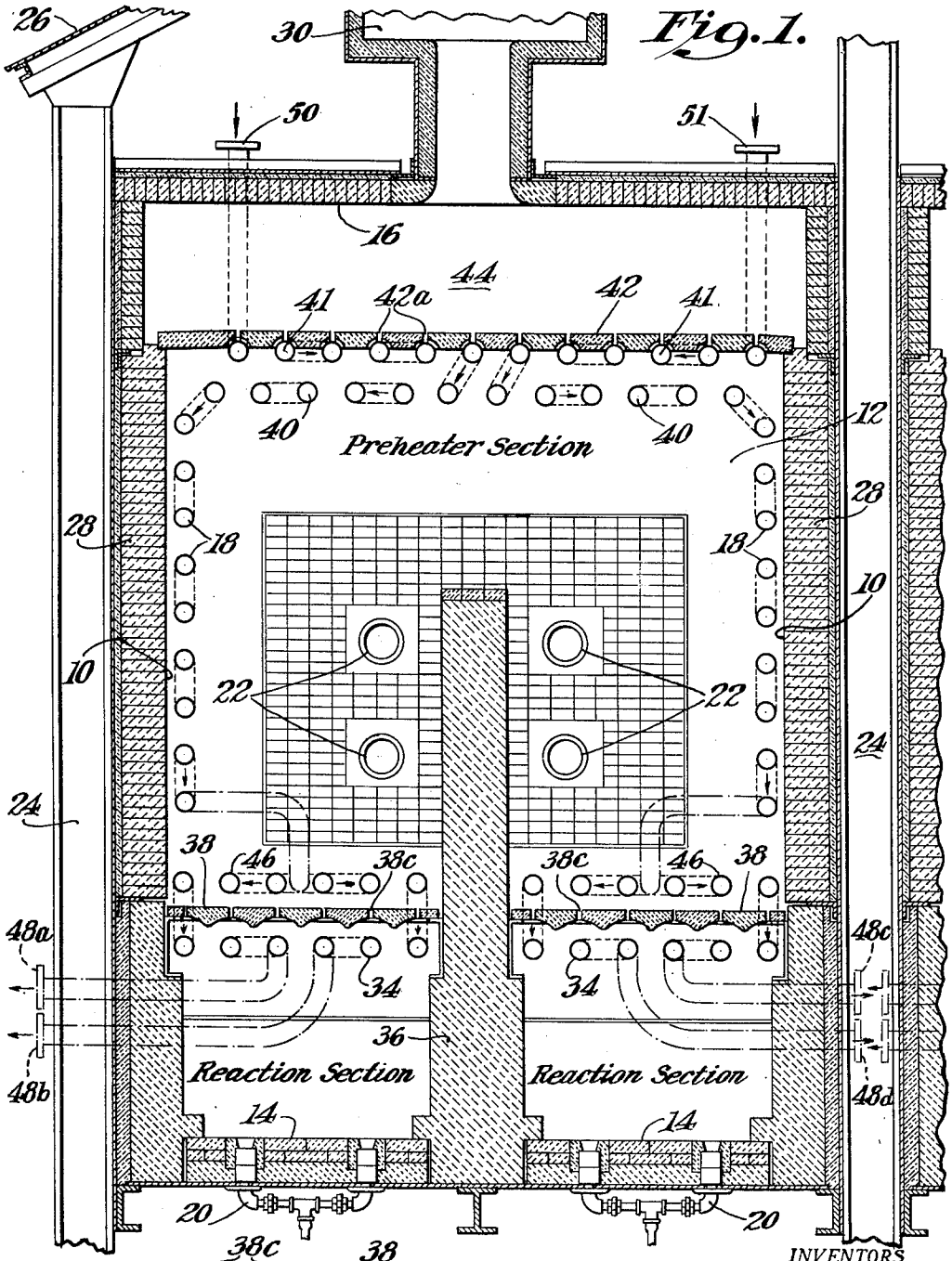
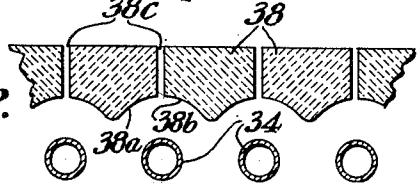


Fig. 2.



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HEATER

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5 Claims. (Cl. 122—356)

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This invention relates to improvements in heaters of the tubular type for the carrying out of chemical reactions by pyrolysis.

The particular object of our invention is to provide a tubular heater having relatively high heat input rates in the reaction zone which are substantially uniform throughout 360° of the tube cross section as well as along the length of a tube section.

Another object of our invention is to provide an improved baffle tile and tube construction which will provide for a high degree of reradiation of heat to the tube units.

A further object of our invention is to provide a tubular heater having independently fired and controlled reaction sections and preheater sections in which the relatively cooled products of combustion from the reaction section are passed through baffle floor tile into the preheater section wherein they are further heated by additional hot products of combustion generated in the preheating section for the desired heat transfer to the tubes therein.

A still further object of the invention is to provide an improved method for the pyrolytic treatment of light hydrocarbons or organic compounds in which improved control is provided for the rate of heat input and particularly of the residence time so that optimum yields of desired products may be obtained.

Further objects and advantages of our invention will appear from the following description of a preferred form of embodiment thereof and in which:

Figure 1 is a substantially central vertical section through one unit of a multiple tubular heater.

Figure 2 is a detailed and enlarged vertical cross section showing the baffle tile and tube construction.

The heater or furnace contemplated is a substantially rectangular chamber construction having side walls 10, end walls 12, a floor 14 and a closed roof or top wall 16. The heating tubes 18 are generally disposed within the furnace chamber delineated by these walls and suitable heating means such as gas or oil or similar burners 20 are placed in the floor, and as particularly contemplated herein, are also mounted at 22 in the end walls.

It is well known that heaters of this type may be suitably supported by columns 24 and a rain shed 26 is also provided. The furnace walls may be provided with suitable insulating fire brick indicated at 28 and, if desired, the walls may be of

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separate panel unit construction such as described in the Reed et al. Patent 2,147,609. The products of combustion pass to a stack (not shown) interconnected with the gas discharge outlet 30 in a well-known manner. While the unit shown is complete, it may be one unit of a multiple chamber heater where added chambers are found preferable to the construction of larger chambers.

Our invention is primarily concerned with a heating tube arrangement whereby most effective pyrolysis can be obtained. In designing heaters for preheating or cracking hydrocarbons especially for cracking gases at high temperatures, it is important to have uniform heat transfer rates about the entire circumference of the tube surface. This is particularly true in the zones where the reaction or conversion takes place and it has been customary in the past to use molten metal baths which, of course, have many operating objections.

In the usual types of tubular heaters, especially in the petroleum cracking field, it is found that one side of the tube is relatively colder than the other. With gas cracking, some coke formation is likely to occur on the colder surface of the tube. Furthermore, where the tube skin temperatures vary around the entire periphery of the tube, there is often degradation and decomposition of the heated medium on the side of the tube where the temperature is considerably above the average. If the temperature is below average, then there is a reduction in conversion yields.

Unequal rates of heat transfer on the circumference of the tube also have the undesirable effect of increasing the tube stresses on the hot side particularly when the heat rates at operating temperature levels are of a high order of magnitude.

A further factor enters into the cracking of light hydrocarbons for the production of olefins such as ethylene, propylene, butylene, or in cracking or pyrolysis of organic compounds for production of raw materials for chemicals and that is the control of the residence time at specified temperature and pressure conditions. It is essential that provision be made for the variation of the residence time for different stocks for it is essential that the heaters be arranged to provide optimum residence time and heat rate inputs for the specified product as well as for different charge materials.

In our construction, we provide independently fired reaction and preheater sections so arranged as to give such flexibility of operating conditions that the shape of the temperature curve and the

duration of soaking time may be changed at will to meet the requirements for opimum yields of varied products from a wide range of feed stocks.

In accordance with our invention we have adapted a type of tubular heater having baffle tile and roof tubes with cooperating plenum chamber as shown in the Reed Reissue Patent 21,396 to accomplish a highly efficient pyrolysis of hydrocarbons or organic compounds. As shown in Fig. 1, the preferred heater includes a preheater section and two reaction sections. The reaction sections each have a series of horizontally disposed serially connected bare surface tubes **34** opposite the burners **22**, and to provide independent controlled reaction sections a bridge wall **36** may be provided between them. The reaction sections are completed by a series of horizontal roof tiles **38** which cooperate with the upper tubes **34** as will be hereinafter described.

Referring to Figure 2, it will be noted that the tubes **34** are centered in arcuate substantially parabolic surface sections **38***a* and **38***b* of adjacent tile immediately above the tubes. The arcuate surfaces **38***a* and **38***b* are not only of the desired shape to focus the heat rays on to the upper surface of the tubes **34** and are suitably spaced above the tubes (having a radius from 1.75 to 10 times the tube radius) to accomplish this purpose, but they also serve to direct, uniformly, the combustion products through the openings **39***c* into the preheater section above. These tile thus form a horizontal partition between the two chambers and are made of special refractory material both to establish draft resistance, and to effect a uniform and guided passage of the gases over the heat absorbing surface of the tubes. They thus provide the desired convection, and reradiation heat to the tubular heating surface and make it possible to have substanially uniform heat input throughout the 360° of the tube cross section as well as throughout its length.

Preheating of the charge is accomplished in the preheater section which not only has the side wall tubes **18** but preferably has two rows of roof tubes **40** and **41** the upper of which is provided with roof tile **42** to form a diffusion baffle for the discharge of the products of combustion to the plenum chamber **44**. These tiles may be of the type shown in the Zimmerman Patent 2,147,610.

To avoid local overheating of the tubes **18** due to laning or channelling of the low velocity heating gases relative thereto, this diffusion baffle is arranged at the outer side of the row of tubes **41** with the gas flow passages **42***a* therein uniformly distributed and of less aggregate flow area than the aggregate intertube area of the subjacent portions of the row of tubes **41**, thereby providing a pressure drop between opposite sides of the baffle which will cause the low velocity heating gases to flow uniformly past all of the tubes in both rows.

This baffle performs two functions—it presents a restricted area for the outlet of the hot gases which insures slow travel of the combustion gases through the furnace proper particularly past the roof tubes; it also distributes the openings uniformly over the entire baffle surface, thus providing a uniform flow of heating gases across the roof tubes.

It will thus appear that the primary products of combustion leaving the reaction section below the horizontal partition **38** will pass up into the preheater section above and be further heated by the burners **22** and, by use of the baffle tile **42** and plenum chamber **44**, a blanketing effect will be obtained which will provide substantially uniform heat input to all of the tubes in the side and roof of the preheater section.

In the construction which has been described the transfer of heat to the tubes **18** in the preheater section takes place substantially entirely by radiation. The travel of the combustion gases takes place at such a rate that very little convection effect results. The tubes in the roof of the furnace (or in the exit side, where the gases do not leave the furnace at the roof) are spaced at sufficient intervals to prevent a rapid flow of gases past the lower row of tubes. The restricted exit areas in the diffusion baffle above the roof tubes are such as to prevent rapid passage of gases past these tubes, and also such as to insure a uniform distribution of the gases across the roof tubes. The result is a heat transfer wherein convection plays a very slight part except in the second row of roof tubes as explained above. The upper row of tubes **41**, of course, will be heated both by radiation and by reradiation and by convection effect.

It is also possible to include floor tubes **46** which will be heated by radiation from the burners **22** as well as by the convection effect of the gases passing up through the tile **38**.

It will be obvious that this form of heater lends itself easily to a two-stream parallel flow of fluid through the heater, the heating in the two streams being at a substantially uniform and equal rate and to the same final temperature throughout. Thus one stream may flow serially through half the tubes **41**, half of the tubes **40**, and one group of wall tubes **18** and half of the floor tubes **46**, and thence through half the reaction tubes **34** while the other stream flows through the remaining half of the heating surface. At the floor tubes **46**, the flow may be split and thence into four groups of tubes **34** in the reaction section and thence out the outlets **48***a*, **48***b* and **48***c* and **48***d*.

The time of reaction for pyrolysis of hydrocarbon gases and organic chemicals is frequently very short and may be in the order of a fraction of a second. The pressures are also quite low, the discharge pressure being substantially atmospheric and the inlet pressure is as low as possible to accomplish the movement of the products through the heater. Temperatures on the other hand are frequently in the high range of 1350 to 1450° F. and heat input rates may vary from 5000 to 15,000 B. t. u. per square foot per hour.

Specific examples of important uses for a heater of this type include the pyrolysis of propane, ethane, propylene and other light hydrocarbons to produce lighter olefins and it may also be used in the organic chemical field as, for example, in the pyrolysis of acetone to ketene. As will be appreciated such applications depend upon very precise control and time-temperature relations to obtain optimum yields of the desired end products.

While we have shown and described a preferred form of embodiment of our invention, we are aware that modifications may be made thereto and we therefore contemplate that such modifications as come within the scope and spirit of the description herein and the claims appended hereinafter are within the contemplation of our invention.

Features disclosed in this application but not claimed are claimed in our divisional application Serial No. 326,976, filed December 19, 1952.

We claim:

1. A fluid heater comprising a housing, vertically spaced, horizontally extending partitions dividing the interior of said housing into superposed chambers including an upper chamber, an intermediate chamber and a lower chamber, each of said partitions forming the roof of the chamber therebelow and the floor of the chamber thereabove and having gas exit apertures distributed over the area thereof, burner means to conduct combustion in said lower chamber, burner means to conduct combustion in said intermediate chamber, and rows of fluid heating roof tubes within the lower and intermediate chambers respectively, beneath the respective partitions and distributed across the area thereof, said tubes being exposed for radiant heating by said combustion within the respective chambers and having inlet and outlet means and being connected for flow of a fluid to be heated first through the tubes of one of the chambers and subsequently through the tubes of the other chamber, said gas exit apertures enabling diffused flow of combustion gas from the lower chamber through the other chambers in succession said partitions being formed of rows of tiles, said gas exit apertures being formed by spaces between the tiles, and the tiles of the partition which forms the roof of the intermediate chamber being supported on the adjacent roof tubes.

2. A fluid heater comprising a housing, vertically spaced, horizontally extending partitions dividing the interior of said housing into superposed chambers including an upper chamber, an intermediate chamber and a lower chamber, each of said partitions forming the roof of the chamber therebelow and the floor of the chamber thereabove, burner means to conduct combustion in said lower chamber, burner means to conduct combustion in said intermediate chamber, rows of fluid heating roof tubes within the lower and intermediate chambers respectively, disposed beneath the respective partitions and distributed across the area thereof, and a row of floor tubes within the intermediate chamber, said partitions having gas exit apertures distributed across the area thereof and enabling a diffused flow of combustion gas from the lower chamber through the other chambers in succession, said gas exit apertures being located directly over the respectively adjacent roof tubes and being narrower than the latter to cause the escaping gas to flow around the upper side of the tubes, and said floor tubes being disposed directly over the gas exit apertures respectively of the partition therebeneath, with clearance for flow of combustion gas around the under side of the tubes from said apertures to the intermediate chamber, the tubes of all of said rows being exposed for radiant heating by said combustion within the respective chambers and having inlet and outlet means and being connected for flow of fluid to be heated through the roof tubes of the intermediate chamber and subsequently through said floor tubes and the roof tubes of the lower chamber, in succession, whereby the fluid may be preheated by the heat in the intermediate chamber and converted by the heat in the lower chamber.

3. The heater of claim 2 wherein the intermediate chamber has side wall tubes connected to the roof tubes of the intermediate chamber to receive the fluid therefrom and connected to said floor tubes to deliver the fluid thereto.

4. A fluid heater comprising a housing having a lower wall, a vertical dividing wall extending upward from the lower wall of said housing, horizontally extending partitions dividing the interior of the housing into a plenum chamber, a preheater chamber directly therebeneath and a pair of reaction chambers directly beneath said preheating chamber at opposite sides of said dividing wall, said wall extending into the preheater chamber and terminating below the top thereof, burner means for conducting combustion at opposite sides of said wall within the preheater chamber and the reaction chambers, said partitions each forming the roof of the chamber therebeneath and the floor of the chamber thereabove and each having gas exit apertures distributed over its area, roof tubes within each of said reaction chambers and distributed across the roof area and exposed to radiant heating by the combustion within the reaction chambers, two groups of roof tubes in the preheater chamber distributed across different portions of the roof area, tubes at the side walls of the preheater chamber opposed to said dividing wall and exposed to radiant heating by the combustion within the preheater chamber, each of said groups of roof tubes having inlet means for fluid to be heated and the roof tubes of each reaction chamber having outlet means for said fluid, and connections for passing the fluid from one of said groups of tubes through the tubes at one of said side walls and through the tubes of one of the reaction chambers, in succession, and for passing the fluid from the tubes of the other of said groups through the tubes at the opposite side wall and the tubes of the other reaction chamber, in succession.

5. A fluid heater comprising a housing, a horizontally extending partition dividing the interior of said housing into superposed chambers, said partition forming the roof of the chamber thereabove and the floor of the chamber therebelow and having gas exit apertures distributed over the area thereof, a row of fluid heating roof tubes within the chamber below said partition and distributed across the area of the partition, the tubes of said row being located respectively beneath said gas exit apertures, a row of fluid heating floor tubes within the chamber above the partition and distributed across the area thereof and located respectively over said gas exit apertures, burner means for conducting combustion within the chamber below the partition, burner means for conducting combustion within the chamber above the partition, said tubes being exposed for radiant heating by said combustion within the respective chambers and having inlet and outlet means and being connected for flow of a fluid to be heated first through the tubes of one of said chambers and subsequently through the tubes of the other chamber, and combustion gas outlet means for the chamber above the partition, said gas exit apertures being narrower than the tubes thereabove and therebelow and there being spaces between the partition and said tubes for flow of combustion gas around the tubes from the chamber below the partition to the chamber above the partition.

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