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TUBULAR HEATER

Filed Dec. 14, 1945

2 Sheets-Sheet 1

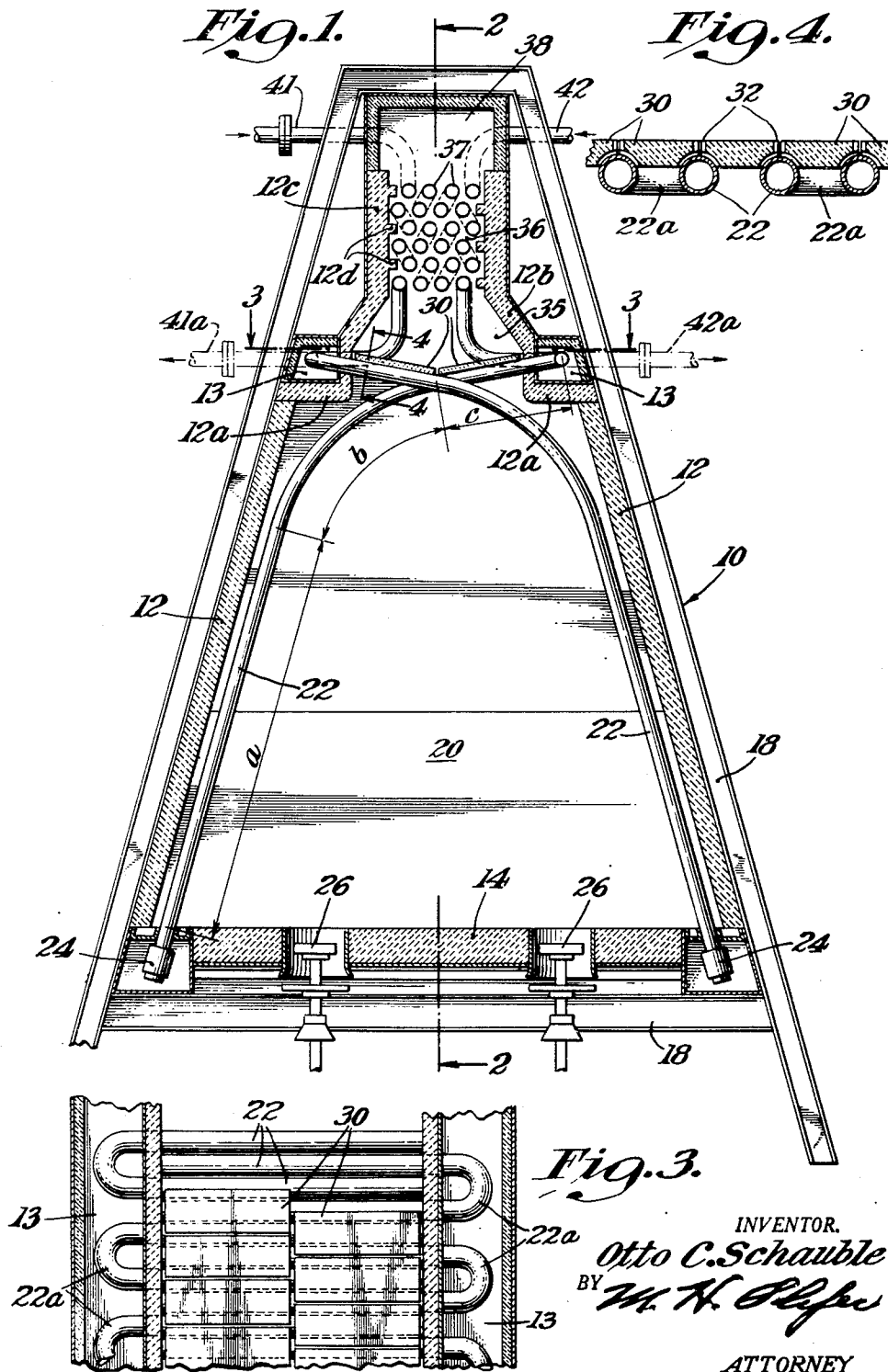


Fig. 3.

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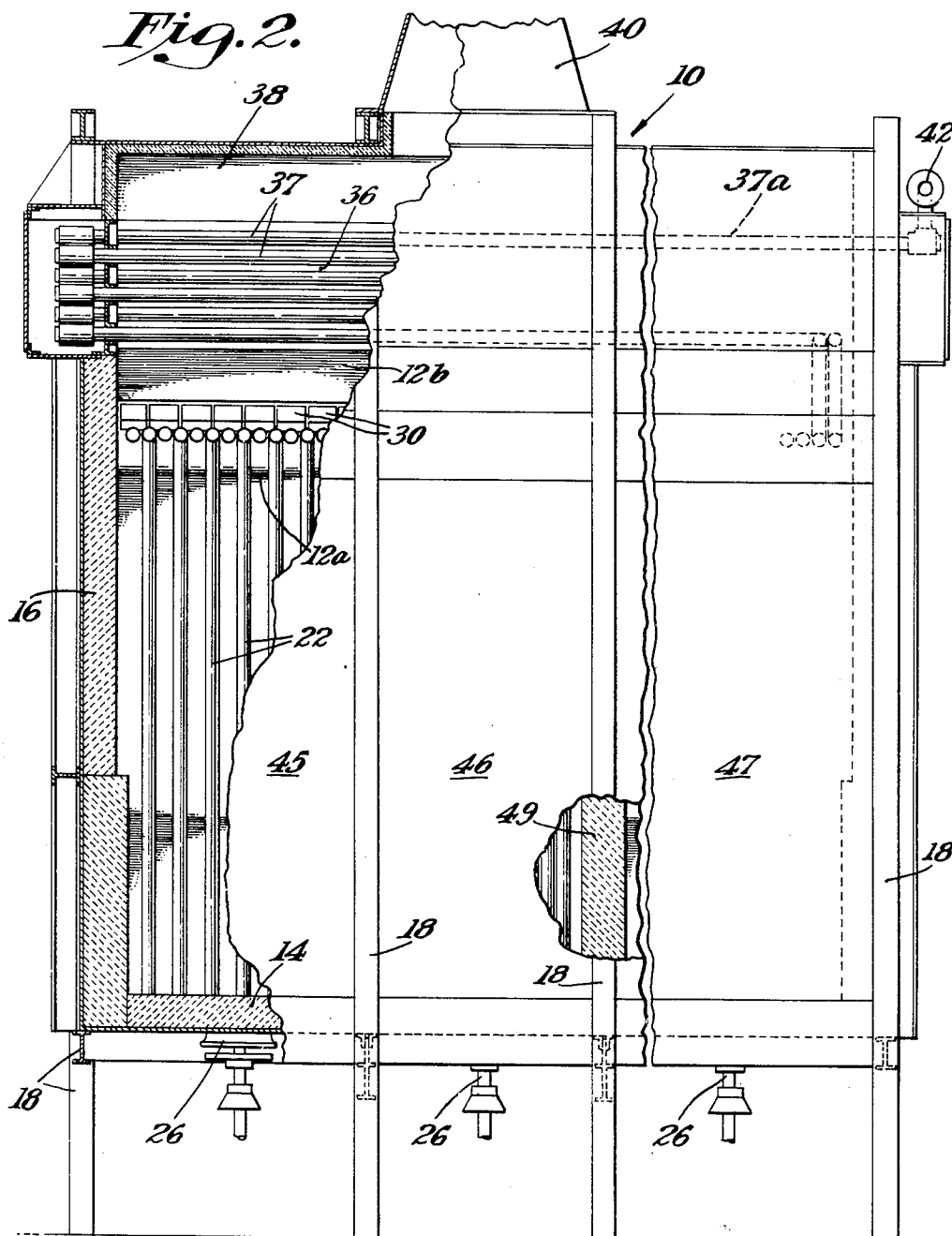
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TUBULAR HEATER

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6 Claims. (Cl. 196—116)

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This invention relates to improvements in fluid heaters and more particularly to the type of tubular heater having a high heat input, such as are used in the chemical and petroleum industries for pyrolytic conversion.

As an example of these heaters, reference is made to the patent to Reed et al. Re. 21,396, dated March 12, 1940, in which a combustion chamber is provided with wall and roof tubes predominantly heated by radiation and the roof tubes are provided with suitable baffle tile, whereby a predetermined and uniform temperature can be maintained throughout the major tube area. Such constructions are of particular need in the petroleum industry, for it is essential that the throughput be not overheated or underheated if efficient operations are to be conducted.

In some cases, I find that furnaces of this type, which are of extremely large size, cannot be economically reduced in scale for lower throughput due to the relatively high cost of the wall areas necessary to secure the required combustion chamber volume.

It has heretofore been proposed that an A-frame heater would be of especial benefit due to its stability of construction, absence of unheated corners and generally reduced wall area as compared with combustion chamber volume. The A-frame heater, however, has been difficult to construct with the desired characteristics of uniform temperature and heat input to the various tubes, and it has been necessary either to use longitudinal partitions for radiant reaction firing, or to use a series of burners with unequal spacing or unequal firing.

In accordance with my invention, however, I have been able to construct an A-type heater which has all of the advantages of stability, economy and comparatively small size, with a standard form of burner with the resulting high input efficiency of heat to the tubes and without compromise in amount of heat input.

It is one of the objects of my invention to provide a low cost A-type of heater with the above characteristics and more particularly to provide such a heater with upwardly and inwardly inclined radiant heating tubes which may be connected to form a continuous heat-receiving conduit along each of the side walls of the heater.

Another object of my invention is to provide a unique system of crossed or interlocked or arched, generally vertically extending, tubes for a heater in which the arched portion not only constitutes the roof but also permits the use of baffle tile whereby controlled combustion discharge is afforded.

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Another and more specific object of my invention is to provide an A-type heater having floor firing with one or more longitudinal series of tube banks which will permit independent or zone firing of different sections of the tubular heater so that one or more sections may be fired for varied rates of heat input or may be cut in or out without materially reducing the efficiency of the heater and, particularly, so that independent temperature control as well as product streams may be maintained in one setting.

Further objects and advantages of my invention will appear from the following description of a preferred form of embodiment thereof taken in connection with the attached drawings, which are illustrative thereof, and in which:

Fig. 1 is a vertical, substantially central, transverse, cross section through the heater;

Fig. 2 is a central, vertical, longitudinal section taken partially along the line 2—2 of Fig. 1 with parts of the heater shown in elevation;

Fig. 3 is a horizontal section substantially along the line 3—3 of Fig. 1;

Fig. 4 is a transverse, cross section, taken substantially along the line 4—4 of Fig. 1.

For the purpose of distinguishing the present heater from former types, I have designated the heater 10, as illustrated, as of the A-type in that it is constructed with a vertical trapezoidal cross section with the side walls 12 upwardly and inwardly inclined from the bottom wall or hearth 14 so that the upper part is of smaller cross sectional area than the lower part. The end walls are shown at 16 and while there is technically a top or roof, this will be described later.

The walls 12 are preferably of a suitable refractory material which is of relatively light weight and low heat storage capacity to safeguard the main structure not only against loss of heat, but also against retained heat which might be injurious in case of a tube failure or desired changes in operating temperatures. Walls of this type are generally fabricated as, for example, in accordance with the patents to Reed et al., 2,144,597, and 2,144,598, of January 17, 1939.

The walls 12 are conveniently supported from I-beam framework generally designated at 18, which will consist of the necessary side legs, transverse floor beams, and closing beam for the top of the A-frame structure. The structural part of the heater, however, is not a fundamental part of the invention other than that it makes possible a convenient formation of a desired combustion chamber generally indicated at 20.

Heating tubes 22 are provided within the combustion chamber and extend along the side walls

12 in a substantially vertical or upwardly and inwardly inclined position. Specifically, they extend from the lowermost edge of the hearth 14 on one side of the combustion chamber to the uppermost ridge of the combustion chamber on the other side. This provides a crossed tube shield construction, which is a fundamental part of my invention since the tubes thus form a screen of combined radiant and convection heat absorbing surfaces, which becomes the roof of the combustion chamber 20.

The tube bundle or tube support is comprised of individual tubes connected in series, the lower ends being connected as by return bends 24 to the adjacent tube. The tubes along one wall are conveniently made continuous and at the top they may also be joined by return bends or by welding U-bends 22a as shown in Fig. 3. It will thus appear that the side wall tubes are a series of U-tubes of substantial length which are preferably arched or bent in a vertical plane and, as will further be apparent from Fig. 3, the tubes on one side are interlaced within the tubes of the adjacent side to make a substantially continuous arch or screen at the top.

Heating of the tubes 22 is accomplished by burners 26 which may be mounted in the end walls or in the floor, and are preferably mounted in a manner such that there will be substantially uniform heating of the tubes 22. It is to be noted that the tubes 22 are predominantly heated by radiation through the zone *a* which extends from the hearth to the point of departure of the curved portion. There is no material gas velocity across the tubes in this zone, so that they are predominantly radiantly heated tubes.

For convenience, it is desirable to consider a second zone of the tubes 22 as extending from the point of departure from the side wall 12 to the point of crossing or zone *b*. In this zone, the tubes are also largely heated by radiation but there is some convection heating due to the transfer of the gases from the combustion chamber. Due to the distance from the center of the combustion zone, and due to lowered gas mass temperature by reason of radiant heat absorbed by the lower portions of the tubes, the radiation effect will be somewhat diminished and thus the total heat input will be balanced by this convection effect.

The third part of the tubes is the remainder or zone *c*, which extends beyond the cross section and, although this is partly heated by radiation by its view of the hot gas mass through the tube interstices, this section of the tubes is heated largely by convection effect as will be hereinafter described.

In accordance with a further feature of my invention, I place on the crossed portions of the tubes 22 a series of baffle tile 30, more generally shown in Fig. 4. These tile are of the general type shown in Zimmerman Patent 2,147,610, dated February 14, 1939, and as shown in Fig. 4, the tile 30 are so mounted as to provide relatively small but uniform passages 32 around the tubes.

The primary function of the diffusion baffle in the converged path of the exit gases from the combustion chamber is to effect uniform and low velocity gas flow over the tubes or tube portions exposed to direct radiation and to prevent channeling of the gases which would be the result of an unguided low velocity flow. The free openings through the baffle tile, by restricting the flow, distribute the gases over the entire tube

surface to produce a low uniform velocity over the entire area and to eliminate localized overheating. The baffle tile are so designed as to produce high velocity gas flow over the uppermost and shielded portion of the tubes, with a consequent high convection heat transfer rate and to further complete the screen of combined radiant and convection heat absorbing surface at the gas exit from the combustion chamber 20.

The size of the passages 32 is predetermined to have a combustion gas flow out of the combustion chamber which will so blanket the flow of gases as to obtain a substantially perfect, uniform heat input to the tubes 22 throughout the length of the tubes. In addition, the convection effect resulting from the wiping of the tube surfaces by the gas discharge through the passages 32 affords convection heating on the tubes in the crossed zones *c* so that they are likewise substantially uniformly heated as is the rest of the tube in zones *a* and *b*.

The top of the heater preferably has a plenum chamber 35 and convection section or chamber 36, in which is mounted a series of horizontal tubes generally indicated at 37. As will appear from Fig. 2, these tubes extend across one or more combustion chamber portions or sections and are heated by the products of combustion from one or more burners 26.

The products of combustion from the convection chamber 36 are discharged through the duct 38 to the stack 40.

The side walls 12 may be inwardly stepped at 12a to form the desired area of throat for the passage of the combustion gases across the crossed portions of the tubes and these stepped portions 12a may form suitable unfired portions or boxes 13 for the tube ends 22a.

Above the tubes 22 and in the plenum chamber 35, the tube walls 12b may be further inwardly projected to form a further restricted portion into the convection chamber 36. The walls 12c of the convection chamber may also be provided with staggered projecting portions 12d to prevent channeling of the gases up the walls of the convection chamber.

A heater of the type 10 is especially adapted to multiple fluid flow and, as indicated in Fig. 1, separate inlets 41 and 42 may be conducted to separate portions of the convection tubes 37 with the respective tubes then communicating with the different side wall tubes. For convenience, it may be desirable to have the discharge from the side wall tubes also at an elevation as at 41a and 42a respectively. It is, of course, to be understood that, if desired, the streams 41 and 42 may be part of a single flow divided for the uniform heating through the heater.

A heater of this type is particularly flexible in that the number of tubes in the side walls can be separated into sections generally indicated at 45, 46, and 47 in Fig. 2. Considering the section 45, for example, there is a fixed length of tubes in this section and they are heated by one or more burners 26. If, in the construction of the heater, the tubes in section 45 are joined to the section 46, then it will be considered that the sections 45 and 46 are a common section. It is possible, however, to put one flow of material through the section 45 and a separate flow of material through the tubes in section 46 by merely rearranging the tube connections. Alternatively, it may be desirable to increase the heater by adding a complete additional section 47 with its independent burners 26 and the tubes in section

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47 may be connected to the tubes in sections 45 and 46, or to the section 46, or may be independent. If independent, it is preferable to have a central, transverse, vertical baffle generally indicated at 49, so that there will be a bridge or partition wall between the respective sections for the desired independent temperature control.

It will be apparent that the flexibility of such an arrangement is substantial inasmuch as it is only necessary to change return bend arrangements and the physical limitations of horizontal tubes are eliminated.

It is to be considered that flexibility is not only a function of original design, which may require changes for different stocks, but is also a function of after-thoughts of increased capacity where it is more economical to add a section to a heater than to build an entirely new installation.

As shown in Fig. 2, the convection section of tubes 37 may extend over the entire series of burners, but it is preferably arranged to extend only over the original burners with a separate section 37a to be added if additional burners and sections of heaters are added. As previously mentioned, the burners 26 can be mounted in the end walls 16 where fixed size heaters are constructed, but if mounted in the floor, a greater range of flexibility of the heater will be possible.

While I have shown and described a preferred form of embodiment of my invention, I am aware that modifications may be made thereto and I, therefore, desire a broad interpretation of my invention within the scope and spirit of the disclosure herewith and of the claims appended hereinafter.

I claim:

1. A heater for hydrocarbon fluid, comprising a combustion chamber having a floor wall, end walls, opposite side walls extending upwardly from said floor wall and an outlet for combustion gases at the top of the chamber and on a vertical center line substantially midway between said side walls, a pair of tube banks overlying the inner face of said side walls respectively and each comprising a series of substantially parallel horizontally spaced tubes extending upwardly along the respective side wall, said tubes of the two banks having intermediate length portions thereof inwardly curved and converging upwardly and interlacing substantially in a vertical plane midway between said side walls, and upper end portions of substantial length extending laterally from opposite sides of said plane and providing each bank with a substantially flat lateral portion at said outlet and overlying and diverging outwardly from the portion of the other bank containing said curved tube portions, return bend connections at the upper and lower ends of each bank connecting the tubes of the bank for passage of a fluid to be heated therethrough in series, and means for conducting combustion between the banks, below said curved portions of the tubes, said intermediate portions and said upper end portions of the tubes being disposed across the path of the gases of such combustion to said outlet, and the width of the outlet, between said side walls, being substantially less than the maximum distance between said curved portions of the tubes of the two banks.

2. A fluid heater as claimed in claim 1 and including tile assemblies borne respectively by

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said substantially flat upper portions of the tube banks and forming gas diffusion baffles.

3. A fluid heater as claimed in claim 1 wherein the lower ends of said tubes of both banks extend outwardly through the floor wall and have their return bends located outside of the combustion chamber.

4. A fluid heater as claimed in claim 1 wherein the upper and lower extremities of said tubes of both banks extend outwardly through the adjacent walls of the combustion chamber and have their return bend connections located outside of the chamber.

5. A fluid heater as claimed in claim 1 wherein the side walls, together with the tube banks overlying them, slope and converge upwardly and the combustion chamber is substantially trapezoidal in vertical section transverse to the said vertical plane.

6. A heater for hydrocarbon fluid, comprising a combustion chamber having a floor wall, end walls, opposite side walls extending upwardly from said floor wall and an outlet for combustion gases at the top of the chamber and on a vertical center line substantially midway between said side walls, a pair of tube banks overlying the inner face of said side walls respectively and each comprising a series of substantially parallel horizontally spaced tubes extending upwardly along the respective side wall, said tubes of the two banks having at least intermediate length portions thereof converging upwardly and interlacing substantially in a vertical plane midway between said side walls, and upper end portions of substantial length extending laterally from opposite sides of said plane and providing each bank with a substantially flat lateral portion at said outlet and overlying and diverging outwardly from the portion of the other bank containing said intermediate portions, return bend connections at the upper and lower ends of each bank connecting the tubes of the bank for passage of a fluid to be heated therethrough in series, and means for conducting combustion between the banks, below said intermediate portions of the tubes, said intermediate portions and said upper end portions of the tubes being disposed across the path of the gases of such combustion to said outlet, and the width of the outlet, between said side walls, being substantially less than the maximum distance between said converging intermediate portions of the tubes of the two banks.

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