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LOW PRESSURE DROP HEATER FOR FLUIDS

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Figure 1

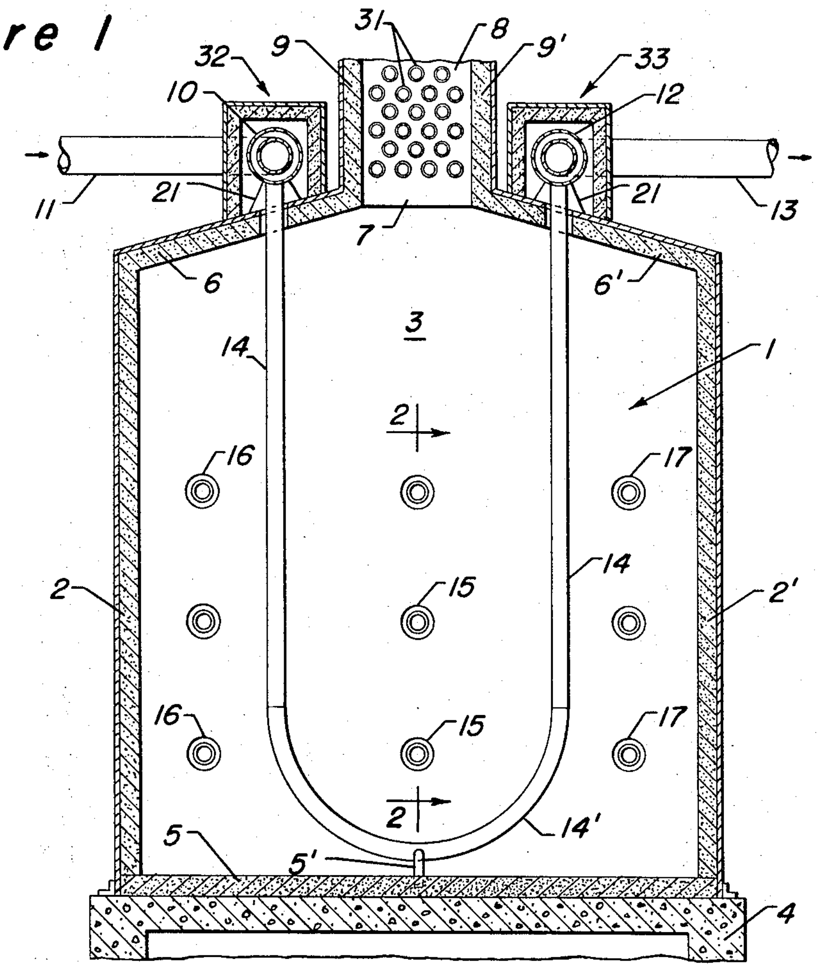
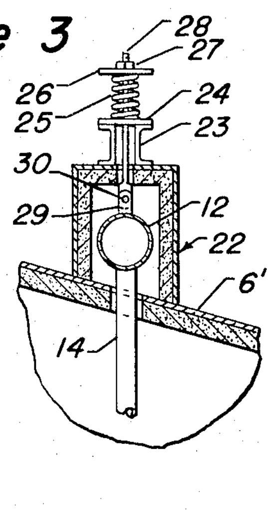



Figure 3



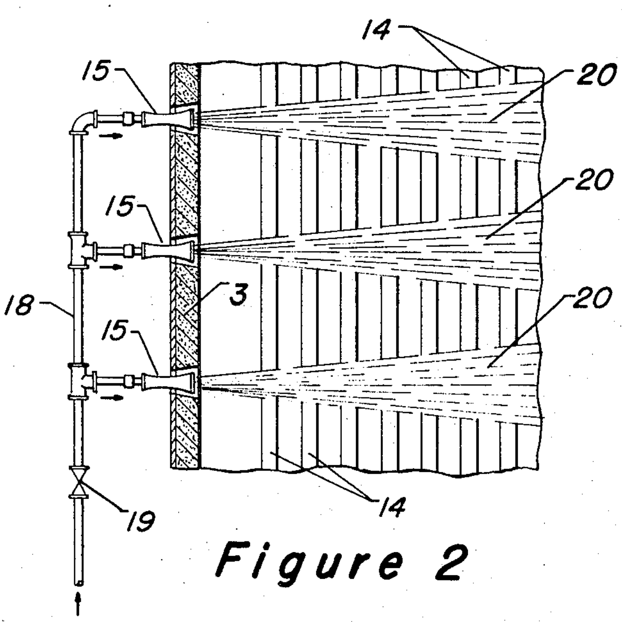




Figure 2

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# LOW PRESSURE DROP HEATER FOR FLUIDS

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## ABSTRACT OF THE DISCLOSURE

A heater for fluids which provides a low pressure drop for fluid flow by having a plurality of spaced apart U-shaped conduits positioned across the heating zone to connect in a parallel flow manner between spaced, longitudinally extending headers. Preferably, long flame burners provide radiant heating to each side of each leg of the U-shaped conduits by having at least three lines of burners to introduce heating from each end of the heating chamber such that flame and hot gases will provide radiant heat to the opposing inner faces of the U-shaped conduits as well as to the sides facing the side walls of the heater.

The present invention relates to a heater for fluids which is particularly designed and arranged to provide a low pressure drop for the fluid flow through the radiant heating zone. Specifically, the present heater design eliminates extended lengths of conduit and sharp return bends in the fluid flow arrangement by utilizing a plurality of spaced apart U-shaped conduits that are positioned transversely across the entire heater chamber. The lower portion of each U-shaped conduit section has a large radius U-bend that joins together vertical leg portions that in turn connect with headers that extend longitudinally along the top of the heating chamber.

The fluid heating tube banks or coils in most heaters make use of closely spaced tubes and the interconnection of such tubes with short radius U-bends or various types of commercial "return bends" that are adapted to accommodate the close spacing of tubes. As a result, each multiple tube heater coil inherently causes a considerable pressure drop for fluid flow therethrough. On the other hand, there are many processing conditions where it is objectionable to undergo any substantial pressure drop while effecting a heating of the fluid stream. For example, in the reheating of a process stream between reactors or stages in a multi-stage catalytic process, it may be necessary to keep the pressure drop between stages to a minimum.

Thus, it may be considered a principal object of the present invention to provide a heater design where fluid flow undergoes a low pressure drop by reason of having minimum length conduits in the heater.

It is a further object of the present invention to provide a U-shaped conduit with a large radius U-section, as well as burner positioning in the heater that will provide radiant heating to two faces of the fluid conduit in the manner generally referred to as "equiflux" heating.

A still further object of the improved design is to incorporate a spring suspension form of support for the fluid inlet and outlet headers to the heater such that expansion and contraction of such headers, as well as the expansion and contraction of the connecting process



piping in any direction may optimumly be accommodated. This leads to further pressure drop reduction by eliminating the need for expansion loops in the piping with their attendant pressure drop.

Broadly, the present invention provides a heater for fluids, which comprises in combination, a heating chamber with an internal heating zone having a generally rectangular form with respect to horizontal and vertical cross-sections, a fluid inlet header extending longitudinally along the top of said heating chamber, a heated fluid header parallel to and spaced from said inlet header and similarly extending along the top portion of said heating chamber, a plurality of separate and spaced apart U-shaped tubular conduits positioned transversely and depending from said fluid headers down through the top portion of said chamber to thereby be spaced longitudinally throughout said heating zone, burner means projecting into the interior of said heating chamber from each end portion thereof whereby to provide both high temperature radiant flame and hot gases to the walls of said tubular conduits for radiant heating of the fluid streams flowing therethrough and gas outlet means from an upper portion of said chamber.

In a preferred embodiment, the burners are placed in at least three vertical rows within each end of the heating zones such that long flames from each of the burners will pass along side of each side wall of the heater and, in effect behind each outer face of the plurality of leg portions of the U-shaped conduits, as well as have high temperature radiant flame and hot combustion gases within the central portion of the heating zone, whereby both the outer and inner faces of all the conduit sections will be subjected to radiant heating. The length of the heater will, of course, be determined by the capabilities of the burners used through the end wall sections of the heater; however, at the present time, certain high pressure burners are capable of shooting flames and hot combustion gases laterally for a distance of the order of 20 feet. For example, long narrow flames may be obtained by the use of a steam atomizing oil burner having a narrow angular conical tip. As a result, it is possible to construct heaters in accordance with the present design of the order of 40 feet in length as long as burners are provided for each end wall of the heating chamber to shoot longitudinally through substantially a full half length of the heating zone to in turn provide radiant heating to the plurality of U-shaped conduits suspended therein.

It should be particularly noted that the use of a plurality of U-tube conduits with the large radius bend essentially provides a minimum of lineal feet of heater tube to effect the passage of a fluid medium from an inlet header down through the heating zone and upwardly into an outlet header. Thus, there is a minimum of pressure drop as compared with serpentine fluid flows and other reverse flow path arrangements utilizing a plurality of conventional "return fittings." Still further, it may be pointed out that the present design eliminates all pipe racks, beams, or other supporting arms that are typically used in fluid heaters to support horizontally positioned conduits and horizontal tube banks. The elimination of tube supports in turn reduces the "first-cost" for the heating chamber as well as maintenance expense, particularly with respect to tube support repairs and the replacement of deformed or sagging conduits when they are in the horizontal position. The U-tube sections themselves will generally be formed by bending long tubular sections with a long radius bent U-portion and there is no need to weld such U-portions to straight pipe leg sections.

In still another aspect, the present simplified design permits the longitudinal headers to be placed above the heater roof or ceiling and in turn be suspended from springs or counterweight means such that all types of expansion and contraction may be readily accommodated with respect to the inlet and outlet piping that connects with the headers, as well as with respect to the headers themselves and the multiplicity of depending U-shaped conduit sections spaced throughout the radiant zone of the heating chamber.

Reference to the accompanying drawing and the following description thereof will serve to show one embodiment of the improved low pressure drop heater design, as well as point out certain mechanical advantages obtained in connection therewith.

## DESCRIPTION OF THE DRAWING

FIG. 1 of the drawing is a sectional elevational view through a rectangular form heater indicating the rise of a plurality of transversely positioned U-shaped conduit sections.

FIG. 2 is a partial sectional view through an end portion of the heating chamber, as indicated by the line 2—2 in FIG. 1.

FIG. 3 of the drawing indicates diagrammatically one means of effecting the resilient spring supporting of the longitudinal headers above the roof portion of the heating chamber.

Referring now particularly to FIGS. 1 and 2 of the drawing, there is indicated a large unobstructed radiant heating chamber **1** defined by refractory side walls **2** and **2′** as well as end walls **3**. The heating chamber is also indicated as being supported by a foundation **4** and having a refractory lower floor section **5** as well as refractory roof sections **6** and **6′**. The latter may be flat or may slope in a manner similar to that indicated in the present drawing toward the center of the heating chamber where a longitudinal opening **7** provides a longitudinal convection heating section **8** between spaced walls **9** and **9′**. Convection section **8** will in turn lead into and connect with a suitable stack means, not shown in the drawing, whereby the flue gases from the burner means may be exhausted from the entire heating chamber.

In accordance with the present invention, longitudinally positioned inlet and outlet headers are provided along the roof portions of the heating chamber such as in the manner of the inlet header **10**, having fluid supplied thereto by way of line **11**, and the outlet header **12** which has a heated fluid removed therefrom by way of outlet conduit **13**. The longitudinal headers **10** and **12** are spaced apart horizontally in a manner to provide for the connection of a plurality of long radius U-shaped conduit sections **14**, which may be spaced relatively close to one another throughout the entire length of the heating zone. In other words, the vertical leg portions of the U-shaped sections **14** will connect to and depend from the respective lower wall portions of each of the headers **10** and **12** so that the conduits will provide for the radiant heating of a multiplicity of fluid streams passing in a parallel manner from the inlet header **10** to the outlet header **12**.

It should also be noted that each of the U-shaped sections **14** has a large radius U-bend section **14′** which shall be positioned in a manner to clear the floor portion **5** within the heating chamber after each U-shaped section has been subjected to heating and expansion. Where desired, vertical guide members **5′** may project vertically upwardly from the floor portion **5** in a manner to hold or guide each side of the U-shaped sections **14** in a proper vertical alignment and maintain substantially equal spacing between the adjacent tubular sections **14** throughout the entire length of the heating zone. As best shown in FIG. 2, the plurality of conduit sections **14** will normally be spaced relatively close together, as for example, on 3″ to 6″ centers. The spacing between conduits in any one heater or portion of a heater will of course depend upon the diameter of the tubing being used for each conduit section.



As hereinbefore noted, the radiant heating for the U-shaped tubular conduits is provided by long flame emission from burners positioned at each end of the heating chamber in the end wall portions **3**. Generally, a plurality of vertically spaced burners such as **15** will be provided along the center line of each end wall whereby long hot flames will provide radiant heat and hot combustion gases to the inner faces of the U-shaped conduit sections. In certain instances for low heating services, it may be sufficient to provide burners only along the center portion of each end wall in order to project flame into the interior faces of each U-tube section. On the other hand, where it is desired to impart a high heat input to the fluid medium passing through the heating chamber then it is preferable to provide at least three vertical rows of burners, such as indicated in FIG. 1 of the drawing. In this instance, additional burner means **16** will pass flame and hot combustion gases between side wall section **2** and the outer faces of the plurality U-shaped conduit sections **14** along one portion of the heating chamber and additional burner means **17** will provide radiant heating to the opposing exterior faces of the plurality of U-shaped sections **14** and along the opposing side wall portion **2′**. As a result, there may be accomplished a high intensity rapid heating of the fluid stream passing through each conduit section **14** in a typical "equiflux" manner.

In FIG. 2 of the drawing there is indicated fuel supply piping means **18**, with valve means **19**, connecting to the plurality of vertical spaced burner means **15** which are of a type providing long lateral flames **20** to carry inwardly for approximately a full half length of the entire heating chamber. In a similar manner, long narrow flames will be provided from each of the burners **16** and **17** such that there is high temperature radiant heating to the exterior faces of each of the U-shaped conduit faces throughout the entire length of the heating zone. It is, of course, not intended to limit the heater design and arrangement to any given number of burners or to any particular spacing of burner means. In certain instances, it may be desirable to have double vertical rows of burners to supply high temperature flame and gases to the central portion of the heating zone **1** so as to provide radiant heating to the inlet opposing faces of the U-shaped sections. Also, where it is desired to have long U-shaped sections within a heating zone of considerable height, then it will, of course, be necessary to provide more than three burners within each vertical row as to insure adequate heat input into the entire heating zone and effect the desired radiant heating to the upper vertical leg portions of each U-shaped section **14**.

In FIG. 1 of the drawing, each of the longitudinal header sections **10** and **12** are indicated as being supported on spaced cradle members **21** which in turn are supported from the upper roof portions **6** and **6′** of the heating chamber. In this case, the longitudinal and vertical expansions due to temperature changes for each U-shaped section **14** will take place downwardly from support positions **21** while each of the header sections **10** and **12** will undergo a certain amount of sliding across the spaced supports **21**. However, as noted hereinbefore, expansion and contraction movement due to temperature changes in the conduit system may well be accommodated by the spring suspension of each of the headers **10** and **12**, whereby the entire system may be freely floating and minimizing of stresses from connecting pipe runs as well as in the headers and conduit sections. As best shown in

FIG. 3, there is indicated one form of spring support system for a longitudinal header section, such as **12**, whereby the latter may be free to move and readily accommodate temperature expansion and contraction effects. Although not to be considered limiting, the present embodiment indicates a housing **22** around header **12** as being supported from roof section **6'** and the housing **22** holding longitudinal channel members **23** which in turn supports a plate member **24** and a compression spring means **25** with a superposed bearing plate **26** holding a threaded nut **27** that is attached to an adjustable length threaded rod means **28**. The latter connects to lug means **29** and the header **12** through pin connection means **30**. By this arrangement a plurality of spaced rod means **28** and spring means **25** result in the spring suspension for the entire length of the header **12** so as to readily accommodate all expansion movements without undue stress at any particular portion of the piping system.

Where desired, suitable tension springs may be connected at spaced distances to the top portion of each header and the spring means in turn hung from overhead beam means in lieu of the compression spring arrangement, as set forth in connection with FIG. 3 of the drawing.

It should be still further pointed out in connection with a modified fluid heating system that there may be more than one longitudinal header along each roof section of a single radiant heating zone. In other words, a plurality of U-shaped sections, such as **14**, may connect between a less than full length longitudinal inlet header and accompany an opposing fluid outlet header. Such shortened headers may be at one end or along a central portion of the radiant heating zone, while at the same time one or more additional longitudinal header sections may be provided to accommodate separate fluid streams through an additional plurality of U-shaped conduit sections. In other words, more than one fluid stream may be introduced into a single rectangular form heating zone for low pressure drop radiant heating in such zone. Still further, where more than one set or bank of tubular headers is utilized, there may be varying diameters of conduits for the different groups of transverse U-shaped conduit sections, the size of the conduits being determined by the quantity of fluid to be handled and the amount of heat input required for the particular fluid stream.

In still another aspect, there is indicated in FIG. 1 a flow pattern into and out of the headers **10** and **12** such that the fluid inlet pipe **11** connects to header **10** at one end thereof and the heated fluid outlet conduit **13** connects to the end of outlet header **12** at the same end of the heater unit. This flow pattern provides that fluid pressure is high at the opposing closed ends of each of the headers even though velocity head has decreased at the downstream end of the inlet header **10** and is also low at the laterally opposing upstream end of the outlet header **12**. However, it is not intended to limit fluid flow into and out of the headers to any one fixed flow pattern within the scope of the present invention.

With respect to flue gas flow, the present illustrated embodiment indicates a central flue gas outlet through the convection heating section **8** such that the hot combustion gases from all of the end wall burners will flow uniformly into and upwardly through the entire central heating zone **1**. However, where non-uniform flow of combustion flue gases may be desired then the convection heating section **8** and the flue gas outlet means may be positioned in an off-center manner. Generally, a plurality of conduits, such as shown in tube bank **31**, will be provided in the convection heating zone **8**, although it is not intended to limit the present improved heater design to any one type of tube bank or waste heat boiler arrangement with respect to the removal of heat in the convection heating section, or within outlet duct work from the heating chamber **1**.

FIG. 1 still further indicates diagrammatically the use of generally rectangular, or box-like, refractory wall enclosures **32** and **33** for encompassing the fluid header means **10** and **12**; however, again it is not intended to limit the present invention to any one type of header enclosure or limit the design to the exterior placement of the headers **10** and **12** above the heater roof means **6** and **6'**. Actually, it is to be noted that the drawing is merely diagrammatic with respect to the method of construction for the heater walls, roof and floor sections, in that all such sections may be fabricated in any conventional manner in order to provide a high temperature resistant refractory wall and inner surface. For example, the refractory walls may compirse temperature resistant tile members, or of fire brick, or of a castable refractory material. Still further, the wall sections may be prefabricated in a manner where a refractory material is connected directly to metal panel sections sized to form the wall and roof sections of a heating chamber. Still other modifications with respect to the structural details for the heating chamber construction and erection will be obvious to those familiar with the heater arts and be within the scope of the present invention which is primarily directed to the design and arrangement for a fluid heating system embodying the U-shaped conduits in a manner providing for a low pressure drop fluid flow and a suspension system for accommodating expansion and contraction movements.



We claim as our invention:

**1.** A heater for fluids, which comprises in combination, a heating chamber with an internal heating zone having a generally rectangular form with respect to horizontal and vertical cross-sections, a fluid inlet header extending longitudinally along the top of said heating chamber, a heated fluid header parallel to and spaced from said inlet header and similarly extending along the top portion of said heating chamber, a plurality of separate and spaced apart U-shaped tubular conduits positioned transversely and depending from said fluid headers down through the top portion of said chamber to thereby be spaced longitudinally throughout said heating zone, burner means projecting into the interior of said heating chamber from each end portion thereof whereby to provide both high temperature radiant flame and hot gases to the walls of said tubular conduits, and gas outlet means from an upper portion of said chamber.

**2.** The heater of claim **1** further characterized in that said burner means are mounted centrally within each end portion of the heating chamber whereby to provide long lateral flame and hot combustion gases into the central portion of the heating zone between the inner opposing face of the U-shaped tubular conduits.

**3.** The heater of claim **1** further characterized in that at least three vertical rows of burners are used in each end wall portion of the heating chamber in a manner to provide resulting flame and hot combustion gases to the center portion of the heating chamber and to portions along each interior wall of the heating chamber and externally along the exterior faces of each U-shaped conduit, whereby there is resulting radiant heating through to both the inner and outer faces of the vertical portions of the U-shaped tubular conduits.

**4.** The heater of claim **1** further characterized in that a flue gas outlet is provided longitudinally along the central top portion of the heating chamber between the spaced longitudinally extending fluid inlet and fluid outlet headers.

**5.** The heater of claim **4** further characterized in that said longitudinal flue gas outlet is provided with at least one bank of tubular fluid conduits whereby there may be heat recovery from the hot combustion gases passing through said flue gas outlet.

**6.** The heater of claim **1** further characterized in that both the fluid inlet and fluid outlet headers are provided with spring support means whereby said headers and the depending plurality of U-shaped tubular conduits can better accommodate expansion and contraction movement from temperature changes in connecting piping to the heater.

7. The heater of claim **1** further characterized in that the inlet to the fluid inlet header is from one end thereof and the outlet from the heated fluid header is from the end thereof which is adjacent the same end of the heater, whereby to provide for optimum flow of fluids through the plurality of U-shaped conduits.



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