

United States Patent

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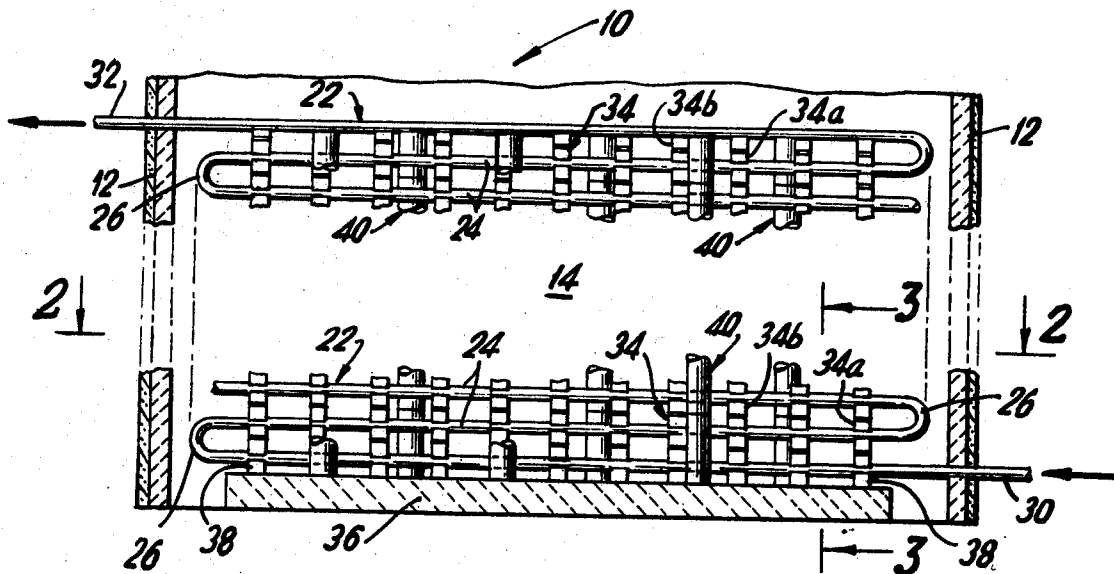
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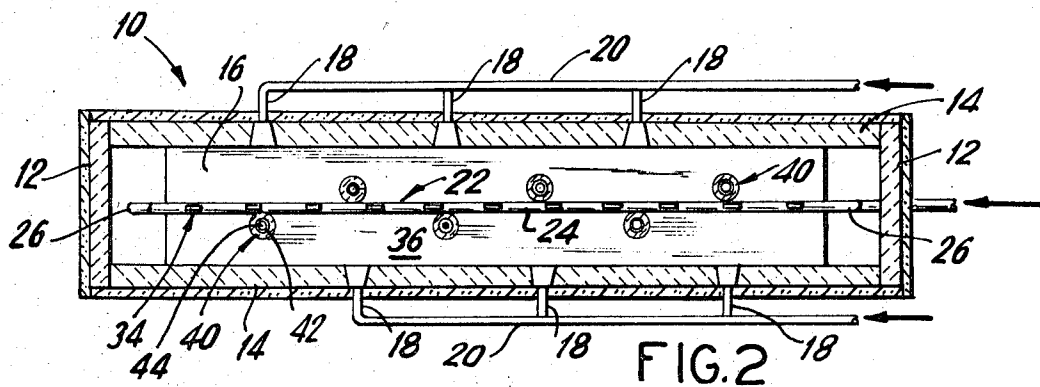
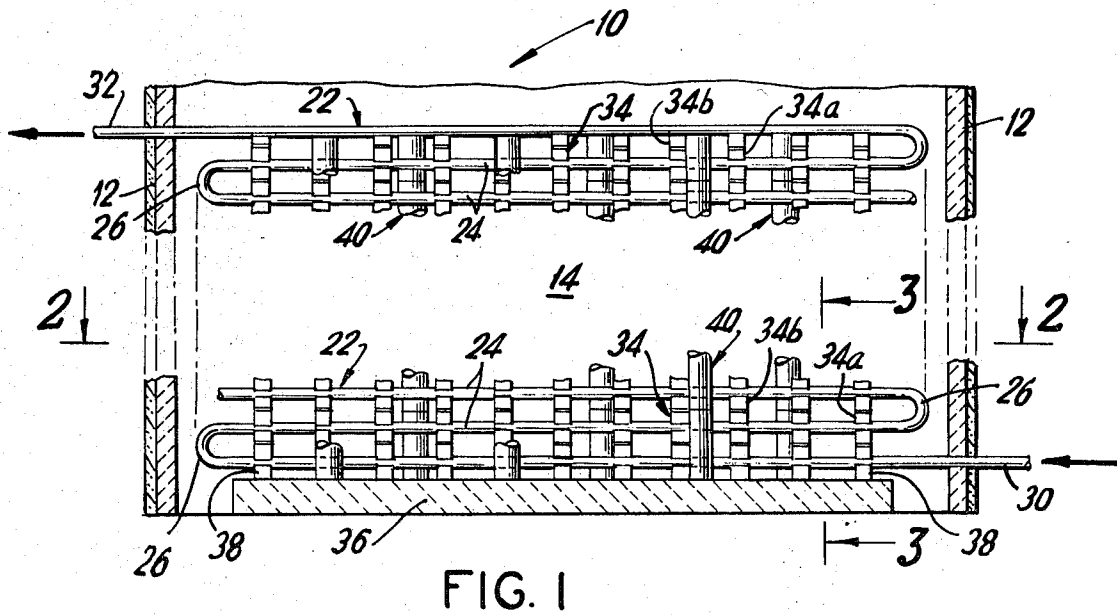
[54] **FURNACE APPARATUS**
1 Claim, 6 Drawing Figs.

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165/162
[51] Int. Cl. F22b 37/24
[50] Field of Search 122/356,
510; 165/162

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ABSTRACT: A self-supporting conduit comprised of a plurality of horizontal tubes connected by tube bends. The self-supporting conduit is provided with support members which are integrally formed with each horizontal tube and arranged in vertical alignment to provide a continuous tube support from the base of the furnace to the top tube. The individual support members associated with each tube frictionally engage the support members associated with the horizontally adjacent tubes and thereby facilitate sliding therebetween to compensate for expansion. Vertical columns arranged on either side of the composite coil are provided to stabilize the coil.





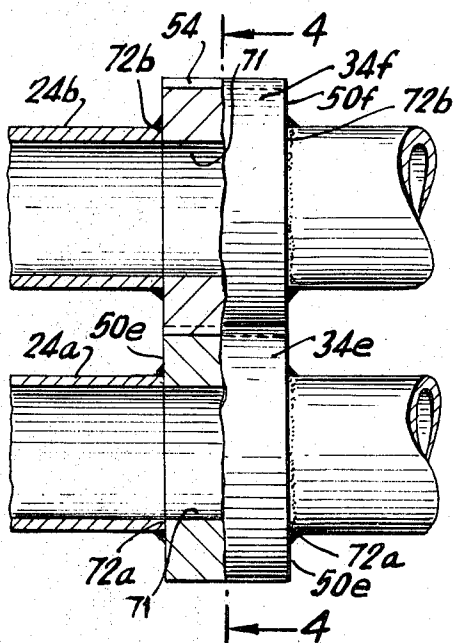


FIG. 3

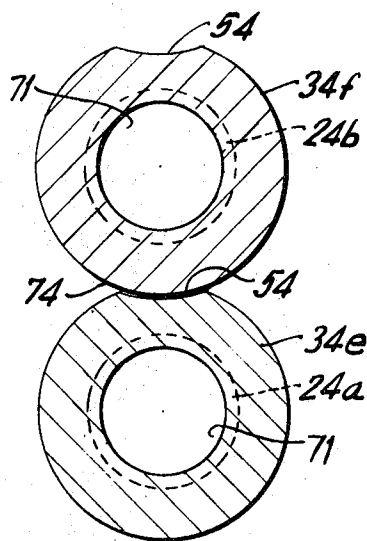


FIG. 4

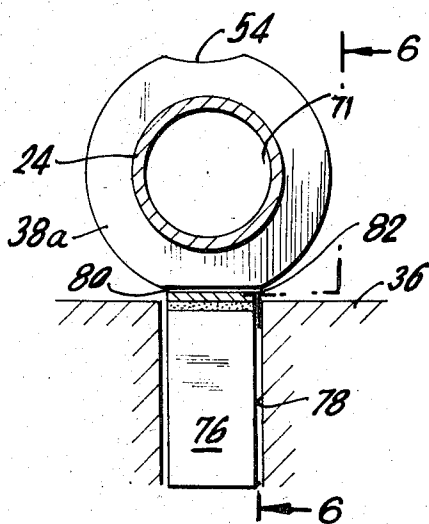


FIG. 5

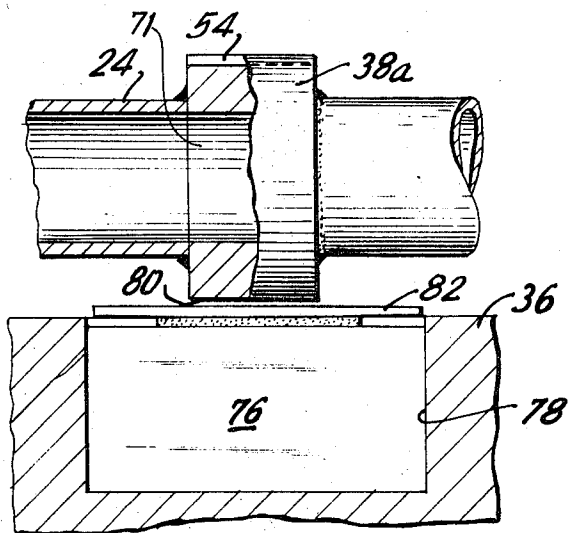


FIG. 6

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FURNACE APPARATUS

This invention relates to a furnace having a self-supporting coil with integral supports therefor operable at processing temperatures without limitation by the physical properties or the structure of the supports. The self-supporting coil of the invention includes a plurality of substantially horizontally disposed, interconnected tubes supported by means disposed along the lengths of and between the adjacent tubes which slidably maintain the adjacent tubes in spaced relationship.

In a furnace having a generally vertical bank of horizontally disposed, interconnected tubes which form a serpentine coil through which fluid flows, an independent structure has heretofore supported the coils. One such support structure includes a vertical post with horizontally extending arms upon which the horizontally disposed tubes rest. Because of the length of the tubes a plurality of such supports have been generally used.

The foregoing furnace unit has been commonly used as a heater, for example, in the pyrolysis of a hydrocarbon fluid to make olefins. In such units, generally characterized as pyrolysis furnaces, a serpentine coil comprised of a plurality of interconnected tubes having large total lengths compared to their diameters, is arranged in a furnace to afford means for the passage of hydrocarbon fluid therethrough. Typically, in pyrolysis furnaces, the range of tube lengths is from 300 feet to 700 feet, while the tube diameters generally measure from 3 inches to 6 inches across their inside diameter. Consequently, the ratio of tube length to tube diameter is normally about 1,500 to 1 and can, in some cases, be greater. In passing through the coil, the hydrocarbon fluid is heated to the temperature range at which hydrocarbons are converted to olefins. Generally, it is desirable to fire a pyrolysis furnace to about 2,000° F. to afford sufficient heat to convert the hydrocarbon fluid to olefins. Under this condition the tube wall temperatures will necessarily be between 1,950° and 2,000° F.

Above about 1,600° F., the tensile strength of the metals used in the coil and the supports are adversely affected. However, because the hydrocarbon passing through the coil is at a lower temperature than the surrounding environment it has been found that the coil, unlike the supports, is to some extent cooled. Consequently, the supports are about 100° to 200° F. higher than the coil. The metallurgical limitations of the supports have therefore limited the maximum temperature at which the furnace can be fired. Although attempts have been made to refine the design of the support, including the use of auxiliary cooling systems, these have proved unsatisfactory because of the increase in expense and because of the difficulty in controlling the cooling systems.

Moreover, when the tubes of the furnace coil are subjected to extreme temperatures, their shape and length materially change. Consequently, any rigid support of the coil will militate against the thermal expansion of the tubes and thereby impose a detrimental stress on both the tubes and supports. In a pyrolysis furnace, the heated tubes sag or bow between supports as the thermal growth increases the length of the tubes as much as 6 or 7 inches. As a consequence, the arms of the described fixed supports are subjected to substantially increased forces by the moving and sagging tubes. These forces have frequently caused failure of the support arms.

In addition, the use of the vertical post to support furnace coils requires that at least two coils be used in a furnace. A coil generally must be placed on each side of the supporting vertical post to help keep it cool and to avoid uneven heating thereacross which could cause bowing of the vertical post. If only one coil is used one side of the post will be directly exposed to the fired furnace walls while the other side will be somewhat shielded by the bank of tubes. The need for two parallel coils increases the maximum to average flux around the circumference of a tube and therefore renders the furnace less flexible than it would otherwise be if there remained the choice of placing one or more banks of tubes in the furnace depending on the requirements of the specific application.

An object of this invention is to provide a furnace with a self-supporting coil which can have longer passes and which can properly function at more extreme temperature levels with improved reliability and at lower costs than theretofore obtained.

Another object of this invention is to provide a furnace with a self-supporting fluid conveying coil having integral supports therefor, wherein the exchange of heat between the fluid passing through the coil and the surrounding environment is not limited by the physical properties of the coil supports, and wherein relative movement between coil sections is permitted without damage to the coil supports.

Another object of this invention is to provide a furnace with a self-supporting serpentine coil through which fluid flows having horizontal tubes and having supports therefor disposed along the lengths of and between adjacent tubes, wherein the fluid flowing through the coil maintains said coil and supports at essentially the same temperature.

A further object of this invention is to provide a furnace with a self-supporting serpentine coil having horizontal tubes and having a plurality of supports disposed along the lengths of and between the adjacent tubes, wherein each support is secured to and moves with one of said adjacent tubes and slidably maintains the other of said adjacent tubes in spaced relationship, and wherein the relative movement between adjacent tubes does not damage such supports.

Still another object of this invention is to provide a furnace with a self-supporting coil which moves on a base of the furnace to, in effect, provide a floating self-supporting coil.

A still further object of this invention is to provide a furnace with a self-supporting coil, and with stabilizers spaced from and along either side of said coil to limit tipping movement of the coil caused by the expansion and contraction of the individual tubes which constitute the coil.

Another object of this invention is to provide a furnace wherein the number of coils used is not limited by the supports therefor.

In accordance with this invention, a furnace is provided with a self-supporting coil having integral supports therefor which afford unimpeded relative movement between the individual tubes of the coil. The coil includes a generally vertical bank of self-supporting substantially horizontally disposed interconnected tubes which form a serpentine coil. A plurality of supports are disposed along the lengths of and between adjacent tubes at spaced intervals, wherein each support is formed with and moves with one of said adjacent tubes and slidably supports the other of said tubes in spaced relationship.

The self-supporting coil of the invention is particularly useful as a coil in a furnace, such as for high temperature cracking or pyrolyzing hydrocarbon oils. With the furnace of the present invention, the supports do not limit the processing temperature because conduction of heat between the fluid passing through the coil and the supports is sufficient to maintain such coil and supports at essentially the same temperature. Furthermore, the thermal growth of the tubes does not adversely affect the process because the distance the supports move is limited to the differential thermal growth between the tubes.

In accordance with the invention, between the lowermost horizontal tube of the coil and the base of the furnace, means are provided which slidably support the coil on said base to thereby, in effect, provide a floating self-supporting coil. Furthermore, the furnace of the invention includes stabilizers placed along each side of the coil at spaced intervals to limit the tipping movement thereof. Where desired each stabilizer can be cooled by providing a passage therefor in each stabilizer for coolant.

Additional objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom or may be learned with practice of the invention, the same being realized and attained by means of the apparatus, steps, combinations and improvements pointed out in the appended claims.

The accompanying drawings referred to herein and constituting a part hereof illustrate several embodiments of the invention and together with the description serve to explain the principles thereof.

FIG. 1 is a side elevational view, partly sectional and partly schematic, of a portion of a pyrolysis furnace containing a single self-supporting coil and stabilizers therefor of one embodiment of the invention;

FIG. 2 is a cross-sectional plan view of the furnace and self-supporting coil taken along lines 2-2 of FIG. 1;

FIG. 3 is a fragmentary side elevational view of the tubes of the self-supporting coil and supports therefor of a further embodiment of the present invention;

FIG. 4 is a cross-sectional view of the adjacent tubes of the self-supporting coil and supports therefor taken along the lines 4-4 of FIG. 3;

FIG. 5 is an enlarged cross-sectional view illustrating a further embodiment of the support between the lowermost tube of the self-supporting coil and the base of the furnace;

FIG. 6 is a fragmentary side elevational view taken along the lines 6-6 of FIG. 5;

Referring in detail to the drawings, there is shown in FIGS. 1-2 a furnace 10 having end walls 12 and sidewalls 14 each internally faced with a refractory material and externally faced with insulating material. The opposing sidewalls 14 are long relative to the end walls 12 and form therewith an upright chamber or zone 16 that is relatively narrow and substantially rectangular as best shown in FIG. 2.

Each sidewall 14 is provided with a plurality of burners 18 arranged in horizontal rows along the height of each wall 14 in such manner that radiant heat therefrom is uniformly radiated to the central portion of the chamber 16. Each row of burners 18 in each wall 14 is supplied with natural gas or other combustible gas or finely dispersed fuels through a common header 20.

The self-supporting serpentine coil 22 of the invention is positioned within the high temperature radiant heating zone constituted by the combustion chamber 16 so as to obtain conditions of even heat intensity on the heating surface longitudinally and circumferentially of the coil 22. As here preferably embodied, the coil 22 is disposed substantially midway between opposing side walls 14 of the chamber 16.

The self-supporting coil 22 includes a plurality of horizontal tubes 24 disposed lengthwise of the chamber 16 in vertically, uniformly spaced, parallel relation to each other with adjacent tubes 24 connected by 180° bends 26 at the ends thereof. Preferably the coil inlet 30 for fluid to be passed therethrough is at the bottom and the coil outlet 32 is at the top.

The greatest load on the tube support occurs on the bottom row; therefore, it is desirable to keep the metal temperature for this row as low as possible by keeping it in contact with the coolest fluid; i.e., the hydrocarbon fluid entering the furnace.

If desired, the inlet 30 can be connected to standard fluid preheaters (not shown) and the outlet 32 can be connected to a standard fluid quenching device (also not shown).

Between adjacent tubes 24 are a plurality of supports 34 spaced at specific intervals therebetween which are affixed to at least one of said adjacent tubes 24 for slidably supporting the tubes 24 in spaced relation while allowing relative movement therebetween. In the embodiments shown in FIGS. 1-2, supports 34a welded to the upper surface of the lower adjacent tubes 24 extend upwardly therefrom and supports 34b welded to the lower surface of the upper of adjacent tubes 24 depend downwardly therefrom to a point midway between adjacent tubes whereat the supports of each tube frictionally engage one another.

At the bottom of the furnace 10, the self-supporting coil 22 is supported by and movable on a base 36. To permit such movement a plurality of supports 38 are welded to and depend from the lowermost horizontal tube 24 at spaced intervals, and are frictionally supported by the base 36. When the lowermost tube 24 expands or contracts the supports 38 slide on said base 36 to, in effect, provide a floating self-supporting coil 22.

Under operating conditions, the self-supporting coil 22 may laterally tip one way and then the other. To limit such tipping while permitting uniform heating of the tube 24, stabilizers, in the form of columns 40, are staggered on either side of said coil 22 as shown in FIGS. 1-2. During inoperative periods when the furnace is cool, the columns 40 are spaced from the coil 22 but when the coil 22 tips it will come into contact with the columns 40. In tipping the coil 22 will temporarily engage the columns 40 on one side and then on the other side returning to the upright position after each engagement with the columns 40.

Each column 40 comprises an inner duct 42 having a passage 44 therethrough. The duct 42 is, in turn, encased within a cylinder 46 composed of refractory material. To fix each column 40 in place, the duct 42 extends into the base 36 of the furnace and into the top of said furnace (not shown). To maintain the temperature of the columns 40 at a safe level cool air is preferably fed through the duct 42 by natural convection.

In operation, the hydrocarbon fluid is fed into the coil 22 through inlet 30 at about 900-1,200° F. and heated in the furnace 10 to the reaction temperatures of 1,300-1,700° F. as it passes through the coil 22 to produce the desired olefins at the coil outlet 32. Consequently, the passage of the relatively cooler hydrocarbon fluid through the coil 22 effectively maintains both the coil 22 and the support 34 at a lower temperature than the fired furnace. This convection cooling by the hydrocarbon fluid of both the coil 22 and the supports 34 tends to equalize the temperature of the tube wall and the supports 34. In practice, it has been found that the temperature of the supports 34 is only slightly higher than the temperature of the tube wall of the coil 22. Therefore, unlike the prior art supports which are not arranged to be cooled by the fluid passing through the furnace coil 22, the supports 34 of the present invention will normally be kept at temperatures 100-200° F. below the uncooled supports. This result permits the operation of the process at temperatures 100-200° F. higher than heretofore possible, which results in material processing gains.

During operation, the thermal growth of the tubes 24 is easily handled because the supports 34 move with the tubes 24. Thus, the supports 34 merely have to move the differential growth of adjacent tubes 24 which normally is a fraction of the movement of tubes relative to the heretofore used stationary support, i.e. about one-tenth or one-twentieth the thermal growth of the tubes relative to a fixed support.

Simultaneously, the supports 38 permit the lowermost tube 24 and the coil 22, in general, to move relative to and on the base 36 to, in effect, provide a floating coil 22.

In addition, the conduit 22 is restrained from excessive tipping by the columns 40 located on either side thereof which limit said tipping of the coil 22 and maintain it in an upright position.

FIGS. 10-11, 12 and 13 illustrate an embodiment of the supports 34 which can be used to make the serpentine coil 22 self-supporting. For simplicity, only a portion of two adjacent tubes 24 and a single support 34 therebetween are shown. It is to be understood, however, that a plurality of such supports 34 are provided between adjacent tubes 24 of the coil 22, such as illustrated in FIGS. 1-2.

The present invention as depicted in FIGS. 3 and 4 is comprised of supports 34e and 34f integrally formed with the coil tubes 24a and 24b, respectively. For illustrative purposes, the supports 34e and 34f are shown as being annular in shape with a centrally disposed opening 71 having an inside diameter substantially equal to the inside diameter of the tubes 24a and 24b. Each of the supports 34e and 34f have parallel end surfaces 50e and 50f and a concave longitudinal exterior recess 54 at the top. In practice, it has been found that sections of cast tubing having the same inside diameter as the coil but having an outside diameter large enough to provide support between the tubes, serves as a suitable support for this embodiment. The cast tubing, as shown in FIGS. 3 and 4 is solid,

however, it is possible to make the support of plate material thereby effecting a hollow configuration for the supports.

As seen in FIG. 3, the opening of each of the tubes 24a and 24b is aligned with the opening 71 in the supports 34e and 34f. The ends 72a and 72b of each length of the tubes 24a and 24b are welded to the end surfaces 50e and 50f of the supports 34e and 34f. Consequently, the inner surface of each support opening 71 becomes a part of the wall of the passage through which the hydrocarbon fluid is conveyed.

The longitudinal concave recess 54 formed in the top of each support has the same radius of curvature as the surface of the bottom of the mating adjacent support. Therefore, the bottom 74 of each support rests in the recess 54 of the support located directly below it. As in all the other embodiments of the present invention, the mating surfaces of the adjacent supports are frictionally engaged to facilitate coincident movement thereof when the adjacent tubes expand identically and sliding movements therebetween when subjected to differential expansion.

The bottom tube 24 of the coil used in the installation employing the annular supports 34e and 34f is shown in FIGS. 5 and 6. Basically, the support 38a for the bottom tube 24 is similar to the supports 34e and 34f, to the extent that it is annular and has a central opening 71 sized for alignment with the opening of the tube 24. Similarly, a concave external recess 54 is also formed in the top of the support 34a as in the supports for the other tubes of the embodiment. The function of the recess 54 is to accommodate and support the support member directly above it.

However, the support 38a has a flattened lower surface 80 which mates with a plate 82 mounted on the floor of the furnace 36 to facilitate sliding movements thereon. The plate 82 is welded to a metal block 76 which is embedded in the floor of the furnace. In operation, as the tube 24 expands and forces the support 38a to move longitudinally with it, the surface 80 of the support 38a slides on plate 82 in response to the thermal expansion of the tube 24.

Holes can be drilled in the supports 34e, 34f and 38a to reduce the weight thereof. Similarly, other modifications in the configuration of the supports 34e, 34f and 38a such as trimmed flat sides can be made to effect weight reduction.

The number of supports between adjacent tubes of the coil and between the furnace base and the lowermost tube, is a function of the height, length and weight of the coil 22, as well as the environment in which the coil 22 is used. A sufficient number of supports should be used to provide for the efficient operation of the coil without adding undue weight.

Typically, a pyrolysis furnace could consist of a bank of six coils in the form of two adjacent sets of three coils in vertical alignment. With each coil comprised of six horizontally disposed, interconnected tubes, each tube being 50 feet long, 4 inches in inside diameter, and spaced apart from each other 6 to 7 inches, the total height of the furnace would be 20 feet. For such coils in such environment five supports are provided between each adjacent tube and between the base and the lowermost tube. Each support is 3 inches in length, 4 inches in width and spaced about 5 feet apart at regular intervals along the lengths of each adjacent tube and along the length of the lowermost tube.

The supports 34 and 38 and the conduit 22 are generally made of metallic materials which provide the efficient exchange of heat together with the necessary structural strength even at extreme temperatures. For a pyrolysis furnace the supports and conduit can be made from 25-20 Cr-Ni steel.

When stabilizers are used, a sufficient number are positioned on either side of the coil to prevent the coil from tipping to such an extent as to damage the coil or supports or in the extreme, topple over. The columns are spaced from the coil so as not to adversely affect the exchange of heat between the fluids flowing through and about the coil while satisfactorily limiting the tipping of the coil.

In the typical example of a coil in a pyrolysis furnace, three columns are staggered at intervals of 10 feet along either side of the coil. When the furnace is cool, the columns are spaced one-half to 1 inch from the coil. Each column is cooled by air passing therethrough from the atmosphere outside the furnace to the lower pressure zone maintained within the furnace by a stack or an induced draft fan.

Furthermore, while a single coil 22 has been illustrated in FIGS. 1-2 to emphasize that the number of coils is not dependent on the supports therefor, a plurality of coils 22 can be used for a given application. A pair of self-supporting coils 22 can be juxtaposed alongside one another midway in the combustion chamber 16 of the pyrolysis furnace 10.

If two coils are arranged in a furnace between the vertical supports, the tubes 24 of each coil 22 are vertically offset from each other so that for each tube there is presented a substantially unshielded heating surface to both emission surfaces of the chamber 16. The operation of the furnace pertaining to the pair of self-supporting coils is the same as the operation for the single self-supporting coil.

However, the columns 40 are spaced from and placed alongside the outer sides of the coils 22. Undue tipping of one coil of the pair of coils toward the other is prevented by the tube supports 34 of the respective coils coming into contact with each other.

The furnace of the invention has been particularly described with respect to a pyrolysis furnace but it is understood that said structure of the invention can be used for other applications such as the polymerization of light hydrocarbon oils, hydrogenation of oils, decomposition of ethylene dichloride to vinyl chloride, tetramer decomposition, methane reforming and dehydrogenation.

The subject invention in its broader aspects is not limited to the specific described embodiments and departures may be made therefrom within the scope of the accompanying claims without departing from the principal of the invention and without sacrificing the chief advantages.

I claim:

1. In a furnace for cracking hydrocarbons to produce olefins having a plurality of horizontally disposed thin walled furnace tubes arranged in vertical alignment, the improvement comprising substantially vertically aligned short tubular support sections each having inside surface dimensions substantially the same as the inside surface dimensions of the furnace tubes and outer surface dimensions greater than the outer surface dimension of the furnace tubes, which tubular support sections are welded to the furnace tubes to form a portion of each furnace tube wherein the lower portion of the outer surface of the tubular support sections rest on the upper portion of the support surface below to form a support structure; a longitudinally extending recess in the upper surface of each tubular support section configured to conform to the contour of the lower surface of the tubular support section directly above; a plate arranged in the floor of the furnace directly below each of the tubular support sections in the lowermost furnace tube; and vertical columns arranged adjacent to each side of the horizontally disposed tubes.