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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

(NASA-Case-MSC-15567-1) SELF-CYCLING FLUID HEATER Patent (North American Rockwell Corp.) 9 p CSCL 20M

N73-16918

Unclas
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TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,708,419

Government or Corporate Employee : North American Rockwell Corporation Downey, CA

Supplementary Corporate Source (if applicable) : ______

NASA Patent Case No. : MSC-15567-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [X] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

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Enclosure
Copy of Patent cited above

NASA-HQ

United States Patent [19]

Low et al.

[11] **3,708,419**

[45] **Jan. 2, 1973**

[54] SELF-CYCLING FLUID HEATER

[76] Inventors: **George M. Low**, Deputy Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Walter K. Moen**, Newport Beach, Calif.

[22] Filed: **Nov. 6, 1970**

[21] Appl. No.: **87,551**

[52] **U.S. Cl.** **204/328**, 204/324, 204/325

[51] **Int. Cl.** **C22d 7/08**

[58] **Field of Search**................................204/323–328

[56] **References Cited**

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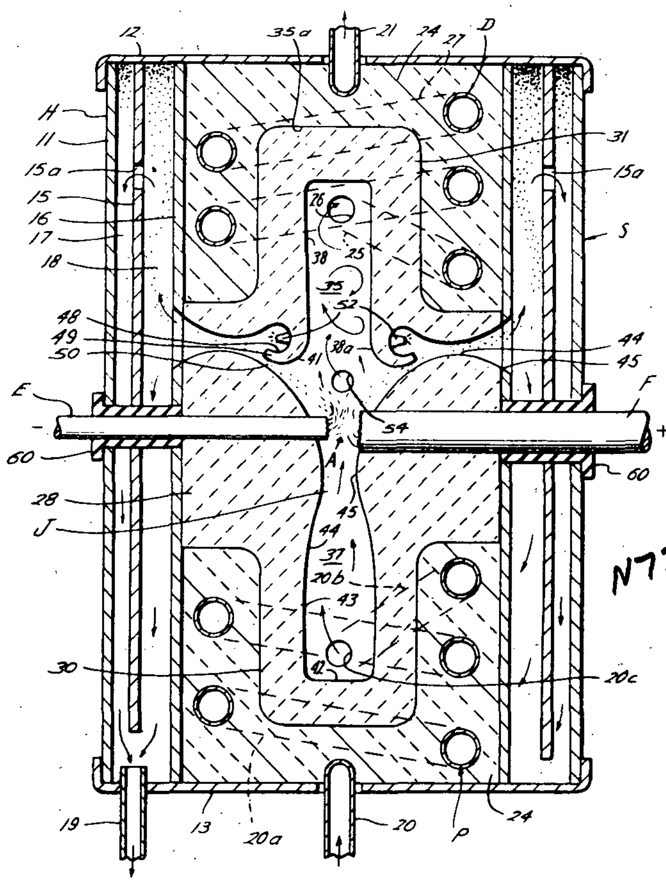
[57] **ABSTRACT**

The specification discloses a self-cycling fluid heater including a high temperature upstream preheater for elevating the stream temperature, a high intensity jet arc heater which heats the preheated fluid stream to ultra high reaction temperatures and discharges said stream into an electric resistance tubular heat exchanger having variations in wall thickness at measured intervals along its length to precisely control the temperature of the fluid passing through such heat exchanger for desired time intervals to provide the specified chemical reactions desired.

15 Claims, 8 Drawing Figures



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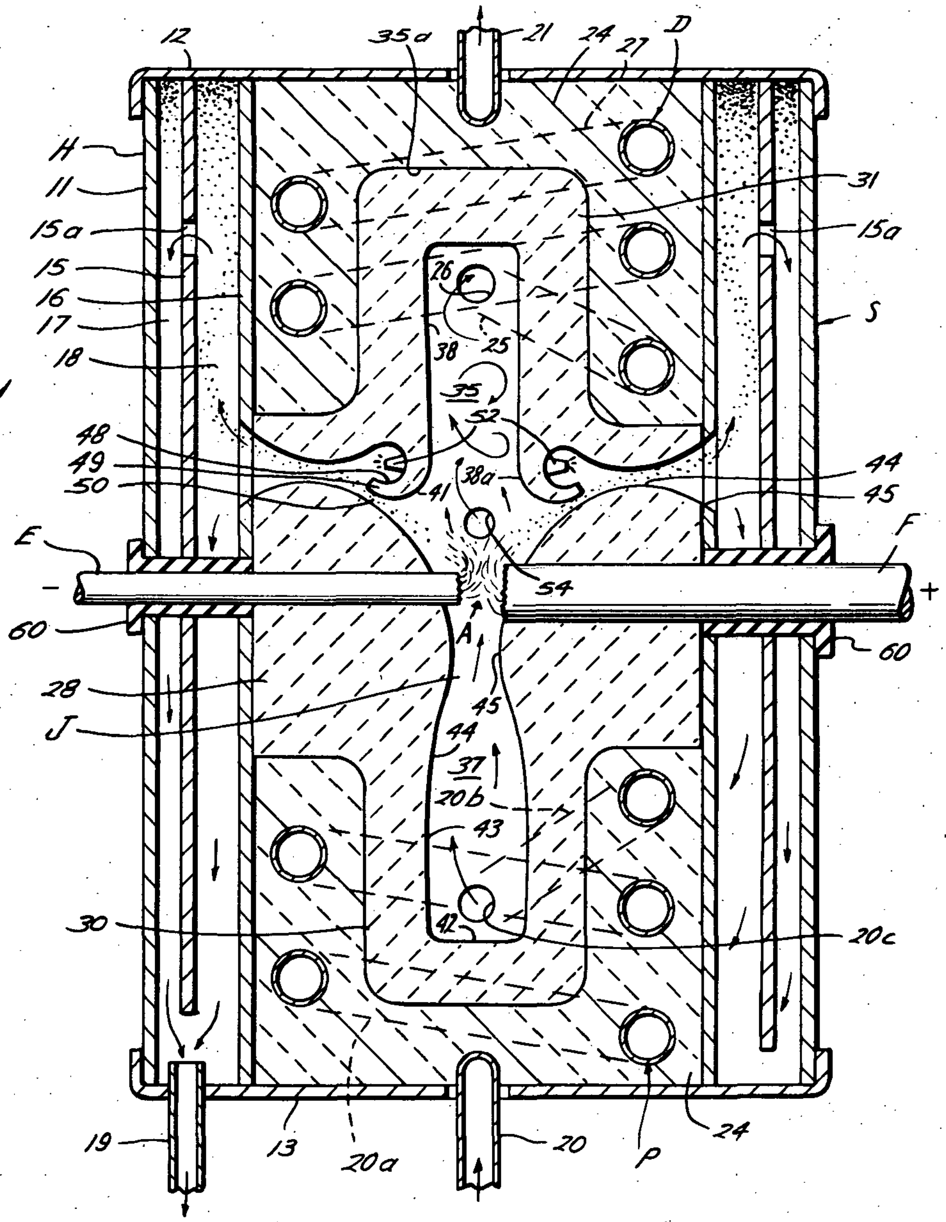

Fig. 1

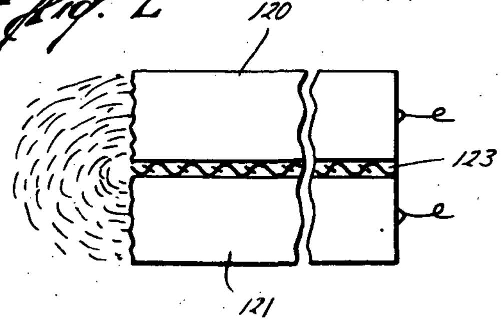

Fig. 2

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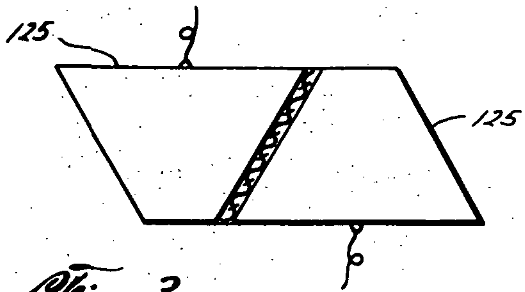


Fig. 3

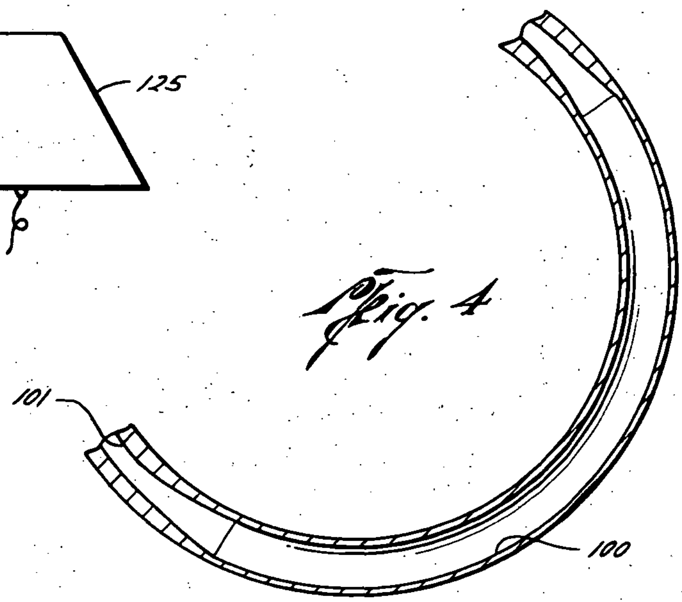


Fig. 4

Fig. 5

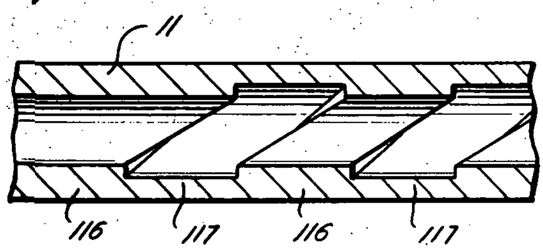
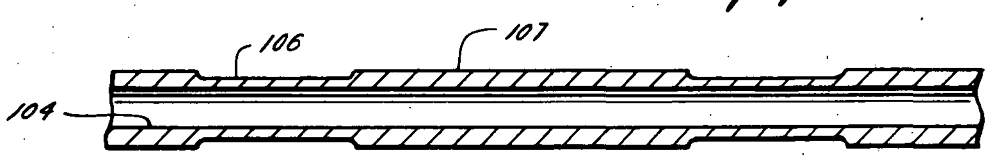


Fig. 6



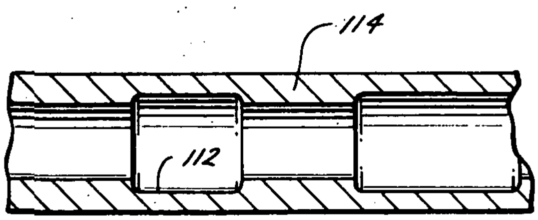


Fig. 7

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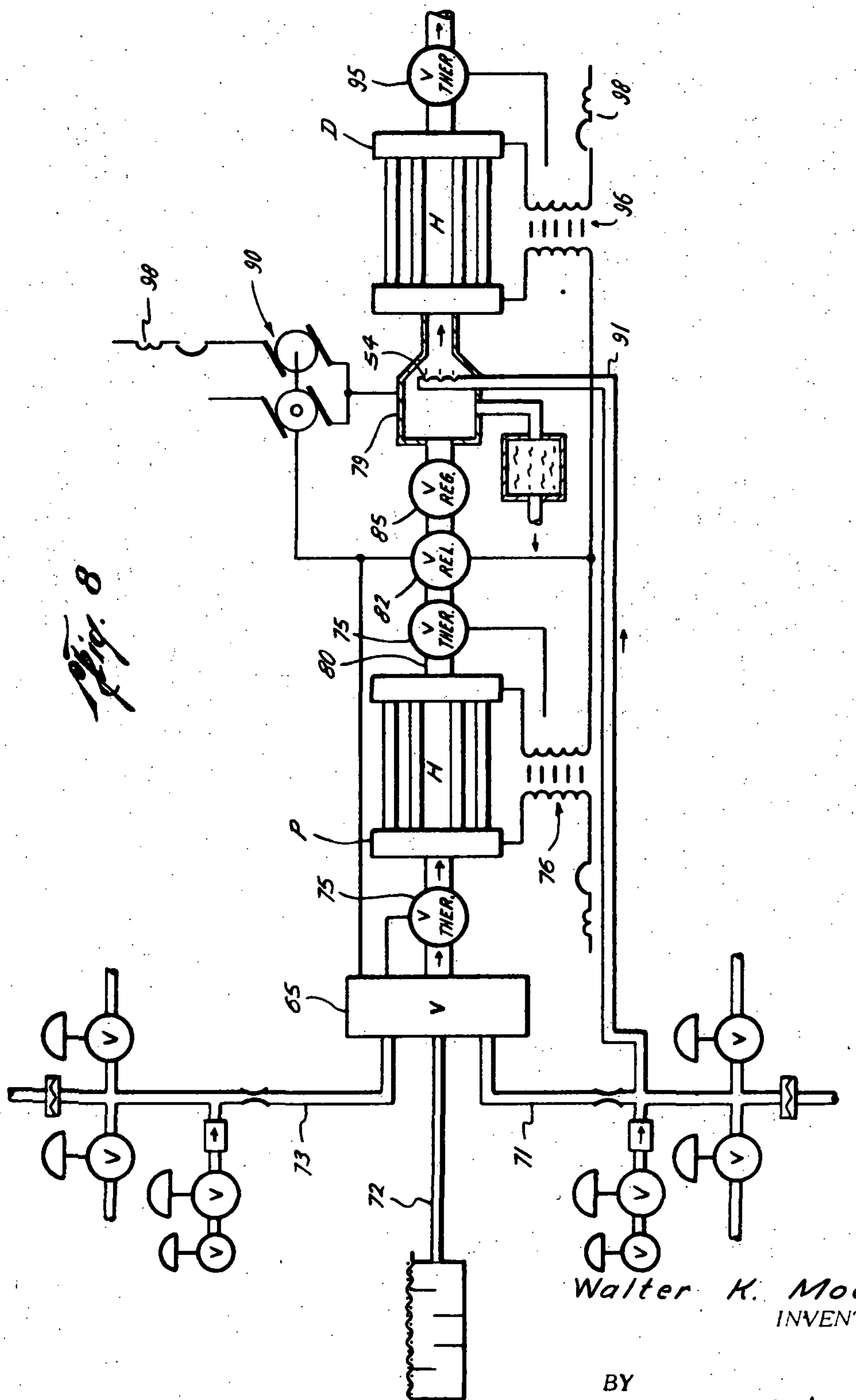
Fig. 8



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SELF-CYCLING FLUID HEATER

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to a self-cycling fluid heater for heating a continuous fluid stream having a jet arc heater for heating fluids and gases to ultra high temperatures, such as 3,000° to 5,000° in an arc crater which discharges into a tubular heat exchanger precisely controlled to specific temperatures for desired resident times to facilitate the desired petro-chemical or other chemical reactions in the flowing stream.

2. Description of the Prior Art

The prior art includes patents to Rouy U.S. Pat. No. 2,684,329 issued July 20, 1954 for a Method and Apparatus for Promoting Chemical Reaction, and U.S. Pat. No. 3,003,939 issued Oct. 10, 1961 for a Method and Apparatus for Producing and Enhancing Chemical Reaction in Flowable Reactant Material. The first of such patents discloses an apparatus for promoting chemical reaction wherein a heated fluid travels through a pipe and is subjected to an electric field, and particularly through an alternating electric field producing a wide range of graduated intensities to provide a zone of optimum electron velocity. Whereas, the second Rouy patent discloses an apparatus and method for effecting chemical reaction in a reacting zone positioned in an electric field in conjunction with a venturi nozzle to control the pressure, temperature, and velocity of a flowable reaction material to favor a particular desired reaction.

There has long been recognized the need for improved high temperature processing tools and the advantages to be derived from high-intensity arc heaters and their ability to activate a solid phase for reaction. For example, the following publications recognize the need for such devices:

"Development and Possible Application of Plasma and Related High-Temperature Generating Devices" Report MAB–167–M Division of Engineering and Industrial Research, National Academy of Sciences, National Research Council, Washington, D. C. (August 30, 1960).

"Trends in High-Temperature Chemical Processing" Part 1 Chemical Engineering March 14, 1966.

Also, there is a recognized need for precise control of the duration and intensity of heat applied to a reaction stream for controlling or providing a desired chemical reaction. The present invention presents a novel means for reclamation of chemicals from polluted surface water, particularly hydrocarbon waste. By heating a continuous flowing stream of polluted water to a high reaction temperature, as made possible by the apparatus of the present invention, hydrocarbon waste may be extracted from the polluted stream.

SUMMARY OF THE INVENTION

Briefly, the present invention provides a self-cycling fluid heater comprising a tubular pre-heater, a high intensity direct arc-jet heater, and a downstream reaction heat exchanger in which the temperature of the reaction fluid is precisely controlled. It is an object of the present invention to provide a new and improved self-cycling fluid heater incorporating a high intensity arc-jet with a pre-heater and a downstream reaction heat exchanger wherein the high intensity arc-jet includes carbon electrodes which provide an arc for heating a fluid stream to the range of 3,000° to 5,000° F. and discharging the fluid into the tubular heat exchanger for a controlled reaction of such heated fluid. The pre-heater tube as well as the control reaction heat exchanger tube is chemically milled internally to facilitate self-cycling of fluids in the system.

Another object of the present invention is to provide a new and improved self-cycling heater in which heat from the high intensity arc-jet heats the fluid in a shaped container to cause the fluid to flow through the pre-heater and also the downstream reaction heat exchanger. Such invention also includes means for injecting gas into the arc crater to effect the desired reaction.

It is also an object of the present invention to provide a high intensity jet arc heater having means to separate particles from spent carbon electrodes from the fluid stream and also having a tubular reaction heat exchanger wherein such tubes are loosely supported intermediate their extreme ends to facilitate expansion and vibration of such tubular elements during operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a cylindrical heater housing showing the pre-heater coil, the jet-arc crater, and the downstream reaction heat exchanger of the present invention;

FIG. 2 is a sectional view showing a sandwich-type electrode for use in the jet-arc heater of the present invention;

FIG. 3 shows truncated electrodes;

FIG. 4 is a view of a portion of a typical coil showing the internal construction thereof;

FIG. 5 is a sectional view of a straight heater tube having a helical internal configuration;

FIG. 6 is a sectional view of another straight heater tube having hot control zones;

FIG. 7 is a sectional view showing a straight heater tube having graduated internal sections for controlling the heat of fluid thereto and causing turbulence in the flow of such fluids;

FIG. 8 is a schematic view of a self-cycling fluid heater of the present invention shown in conjunction with a petro-chemical production reclamation facility.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The self-cycling fluid heater apparatus of the present invention is designated generally as S in FIG. 1 of the drawings. Such heater S includes a housing H having a pre-heater coil P for pre-heating the reacting fluid, a jet-arc reaction chamber J in which a high intensity arc-jet heats such pre-heated fluid to ultra high reaction temperatures such as 3,000° to 5,000° F. and discharges such superheated fluids into a downstream control reaction heat exchanger D where the desired chemical reaction is controlled. The ultra high temperature is created by the arc crater designated generally A which spans the gap between the ends of two carbon electrodes E and F, respectively, which are positioned in the reaction chamber J. The reaction fluid is circulated through the pre-heater P where its temperature is elevated to a desired temperature and thereafter it is injected into the reaction chamber J and subjected to the ultra high intensity arc-jet and thereafter such fluid and gas resulting from the high temperature is conducted through the control reaction heat exchanger D where the controlled chemical reactions are produced.

In the preferred form of the present invention, as shown in FIG. 1 of the drawings, the housing H includes an outer cylindrical wall **11** having end closure members **12** and **13**, respectively. As shown, a pair of radially inwardly spaced cylindrical walls **15** and **16** which are disposed concentrically inwardly relative to the outer cylindrical wall **11** are provided in the housing H and form annular chambers **17** and **18**, respectively. The inner cylindrical wall **16** connects both ends **12** and **13**, respectively, and the intermediate cylindrical wall **15** connects the end **12** but is spaced laterally from the end **13** to provide a passage for circulating fluid therethrough which will be described in detail hereinafter. Also, as shown, a plurality of openings or passages **15a** are provided in the intermediate wall **15** to afford communication between the inner annular chamber **17** and the outer annular chamber **18**.

As shown, an inlet conduit **20** is connected to the pre-heater coil, P which comprises a plurality of turns of tubular conduit which is made of corrosion resistant steel, nickel, platinum, tantalum, rhodium, silver, brass, aluminum, copper, wrought-iron, lead, or alloys of a wide variety. Also, it will be appreciated that the pre-heater could consist of a bank of coiled or straight tube heaters manifolded together to increase flow capacity.

The reaction control heat exchanger D is formed similarly to the pre-heater P and is provided with an outlet **21** for discharging fluids and gases from such heat exchanger after the desired chemical reactions have accrued. The tubular heater P as well as the reaction heat exchanger D are shown surrounded by super-X high temperature insulation **24** which is preferably a loose insulation material that does not restrict the motion of the tubular heater P or heat exchanger D under pressure and permits vibration of such tubular sections to thereby increase the heat transfer coefficient thereof. The inlet **20** is shown connected to the first turn **20*a*** of the tubular heater P and the last turn **20*b*** is connected to a port **20c** formed in the reaction chamber J as will be described in detail hereinafter. Similarly, the control reaction heat exchanger D has its innermost turn **25** connected to the port **26** in the reaction chamber J and the outermost turn **27** is connected to the discharge conduit **21**.

The body of the high intensity reaction chamber J is preferably formed of a high temperature (3,300°F) castable refractory, graphite (ATJ, JTA or prolytic) or a water cooled reaction chamber is provided for higher temperatures. Such reaction chamber body is preferably formed of a generally cylindrical outer central portion **28** of substantially the same diameter as the inner diameter of the innermost wall **16** and having restricted diameter axial end portions **30** and **31**, respectively, which project axially of the coil tubular heater P heat exchanger D, respectively. It will be appreciated that the material from which the body of the reaction chamber is formed, in addition to being a high temperature castable, material, may also assist the reaction of the fluids therein by proper material selection of the chamber walls which may be expendable to the overall operation of the heater.

The reaction chamber J is preferably formed by using a pre-formed wax or glass container which may be melted or cracked out for shaping the chamber with the desired internal configuration. As shown, such reaction chamber is formed with a discharge chamber **35** positioned in the end **31** and an inlet chamber **37** is axially aligned with the inlet chamber and positioned in the opposite end **30**. Such discharge chamber **35** has a substantially flat end portion **35*a*** with a generally circular wall **38** extending longitudinally toward the center of such reaction chamber J. The walls **38** of the reaction chamber J flare or curve radially outwardly from adjacent their inner end **38*a*** toward the inner cylindrical wall **16** to form a curved or flared surface indicated at **41**.

As shown, the inlet chamber **37** adjacent the reaction chamber J is provided with a substantially flat end **42** and a cylindrical wall **43** which curves or tapers inwardly at **44** to form a throat or restricted neck **45**. Thereafter, such side wall flares upwardly and outwardly toward the opposite curved walls **41** to provide a circumferentially extending restricted, outer throat or passage extending circumferentially of the chamber J and outwardly to a circumferentially extending slit or port **45** in the wall **16** so as to communicate the chamber J with the outer annular chambers **17** and **18**. As shown, a circular recess **48** surrounds the cylindrical chamber **38** adjacent the curved end portion **44** to form a circumferentially extending tubular lip or flange **49** that forms an inner throat of passage **50** which is disposed between the arc crater area A and the outer throat **44**.

A plurality of circumferentially spaced jets **52** are positioned in the annular recess **48** for discharging steam or gas into the narrowed restricted throat or passage **44** for urging gas and particles formed in the arc-jet crater A outwardly through the ports **45**. A suitable gas injection port **54** is preferably formed in the reaction chamber housing adjacent the arc-jet crater A for injecting gas or a catalyst adjacent the temperature in such arc-jet crater.

As shown, the arc-jet crater is positioned adjacent the facing ends of the electrodes E and F which are carried in the housing H in suitable electric bushings **60** that extend through openings in the wall **11** as well as the inner and intermediate walls **16** and **15**, respectively. Preferably, the positive electrode F is a consumable electrode which is mechanically advanced into the arc crater. Such electrodes are operated preferably by a motor generator using direct current so that the consumable electrode F receives more heat by electron bombardment. Such consumable electrode normally operates in the area of 3,000°F. to 5,000°F. and above where it vaporizes. Carbon particles are ejected from the arc crater by the influence of the passage 44 provided by the steam injector nozzles 52 which inject steam through the passage 44 to draw particles through the passage 50. Such carbon particles are separated from the reaction gas and collected in the concentric chambers 17 and 18 and such gas is filtered and exits the chambers through the passage 19.

In operation, fluid is introduced into the tubular preheater P via the inlet 20 where such fluid is heated to a desired amount as will be described in detail hereinafter. Such fluid is discharged from the preheaters through the port 20c into the reaction chamber J. Such preheated fluid flows through the throat 45 to the arc crater area A where such fluid or gas is heated to an ultra high temperature and thereafter such heated fluid passes into the chamber 35 and is discharged through the port 26 into the controlled reaction heat exchanger D. There the temperature of such superheated fluid is maintained at a desired temperature for a desired period of time to provide the necessary reaction of the heated fluid or gas. Steam is injected through the lateral ports 52 adjacent the arc crater area A for causing the carbon particles from the electrodes to pass laterally outwardly into the concentric chambers 17 and 18 where they settle out or are filtered out from the gas and bypass gas carrying such particles is then discharged through the outlet port 19. Other gases or desired elements may be introduced into the arc crater via the inlet port 54 for combining with the fluid or gas in such arc crater for subsequent processing in the controlled reaction heat exchanger.

In operation, the current to the arc crater A is increased to a point where vaporization of the consumable electrode F reaches a heat balance most desirable for the particular chemical reaction. When operating the high intensity arc, the consumable electrode F is mechanically advanced into the arc crater A where the energy transfer occurs at high energy transfer efficiencies. This condition is ideal for chemical synthesis when assisted by downstream reaction heater D to maintain a desirable reaction temperature of a constant flowing end product useful gas.

FIG. 8 presents a schematic of a typical self-cycling fluid heater arrangement shown associated with conventional processing components. A three-way valve 65 controls the flow through a steam inlet line 71, a material inlet line 72, and a reactant gas inlet line 73 into the pre-heater P through a thermal valve 75. Such fluids are mixed at an elevated temperature in the preheater P as monitored by the thermal valve 75 which controls the alternating current supply to the saturable core reactor controller 76 that provides heat to the preheater P. The flow of fluids out of the pre-heater P to the jet-arc crater in the housing 79 is through a suitable conduit 80 having a regulator valve 82 therein which functions as a pressure valve associated with the electrical equipment as described hereinafter to provide a safety shut-off apparatus in the event of malfunction of the system. A constant pressure regulator 85 is associated with the conduit 80 for controlling the flow of gas to the high intensity arc in the crater chamber 79. Motor generator 90 supplies current to the electrodes in the jet-arc crater 79. Steam or other gases may also be supplied to the crater by means of the conduit 91 which introduces fluid into the jet-arc crater through a port or opening 54. The reacting gases leave the arc crater 79 where further mixing occurs at the downstream port prior to entrance to the downstream reaction control heat exchanger designated generally D which provides a precise control to the final product gas passing outwardly or discharged through the thermal valve 95 which is operably connected to the saturable core reactor 96 providing alternating current to the downstream controlled heat exchanger D.

Circuit breaker control devices 98 provide means for interrupting power to electrical power inputs and such circuit breaker devices are connected for actuation by the safety control valve 82.

FIG. 4 of the drawing illustrates a portion of a coil tube section of the pre-heater P or the reaction heat exchanger D showing in section the chemically milled internal configuration of such tubular device. In this arrangement the tube is provided with a relatively large internal diameter thin wall portion designated generally 100 which is positioned intermediate adjacent relatively thick wall and small internal diameter sections 101 which, when included as an electric resistance heater, provide different temperatures for heating the fluid in such tubular devices. It will be appreciated that the thinner wall sections will be heated more than the thicker wall sections. Another example shown in FIG. 6 of the drawings has a straight section of tube provided with a substantially uniform internal diameter opening or passage 104 with relieved or reduced thickness external wall sections 106 providing hotter zones than the thicker wall portions 107 so that longitudinally spaced "hot zones" may be provided in the tubular devices D and P for heating the reactant chemicals passing therethrough to various temperatures. It will be appreciated that the various wall portions of such tubes may be made of a specific thickness to provide the specific temperature desired in the tube, and each of the various sections is made a particular length so as to provide a flow time for subjecting the chemicals passing therethrough to be exposed to the desired temperature for the desired time.

Similarly, in FIGS. 5 and 7 there are shown various alternate embodiments of chemically milled heating tubes having varying internal diameters for providing varying heats for different controlled periods of time for controlling the temperature of fluids flowing therethrough. For instance, the tube shown in FIG. 7 includes reduced wall thickness sections 112 of a desired length and alternate thickened wall sections 114 disposed therebetween. Such wall sections each having a different heat or temperature produced therein as a result of passing electrical current therethrough to provide differing temperatures for each of the sections to enable each section to heat the fluid passing therethrough a desired amount. The length of the particular section of tubing will determine the period of time fluid flowing through the tube will be subjected to the temperature of any given section. Also, the configuration shown in FIG. 7 provides turbulence in the flow of fluid therethrough.

The other alternate embodiment, shown in FIG. 5 of the drawings, provides a helical arrangement for inducing turbulence of a particular pattern into the stream of fluid flowing therethrough and also provides an alternate means for subjecting such fluid to differing temperatures in the portions of the tube having differing temperatures in the portions of the tube having different wall thicknesses, such as the thickened wall sections 116 as compared to the thinner wall sections 117. It will be further appreciated that the wall thickness of any particular section may be determined in accordance with the desired amount of temperature to be applied to the fluid at that point in the flow pattern, and that the length of such section may be determined according to the period of time the fluid is to be subjected to that desired temperature. Thus, it would be appreciated that the internally milled or externally milled tubes illustrated in FIGS. 4, 5, 6, and 7 provide means for controlling the temperature applied to fluid as it flows through a section of tubular conduit.

Such milled tubular sections in a coiled heater or heat exchanger are positioned to accomplish self-cycling action by virtue of the unequal heating of the liquid or fluid in a coil tube wherein convection currents are set up in either liquids or gases, the heat being transmitted by molecules in the moving currents. The tubular conduit may be reduced in wall thickness at long or short intervals within the heater or heat exchanger to provide hot zones for a desired resident period of time. The tubular conduit outer wall, or inner wall for that matter, may be chemically etched so as to provide operation thereof with a known temperature profile for a given electrical energy input. With this arrangement, specific heated zone sections may be provided that will accomplish precise reaction zone heat conditions in such tubular heaters heat exchangers.

In chemically milling the tubes, they may be formed in a coil section, turned on a horizontal axis and partially filled with etching acid. With the coils so filled, the tube is heated by passing an electrical current therethrough or other means to provide the proper etching temperature which will permit etching of the acid filled portion of the tube to reduce its thickness for providing higher resistivity and thereby produce a higher operating temperature and self-cycling action of fluids being heated as they pass therethrough.

FIGS. 2 and 3 illustrate alternate embodiments of the electrodes E and F of the present invention wherein FIG. 2 shows flat plate electrodes 120 and 121 which are separated by glass cloth 123 that electrically insulates one from the other. In a preferred embodiment of this invention these electrodes operate on alternating current and permit an extremely long electrode arc with an arc crater of greater effective area. Similarly, cylindrical discs or truncated cones 125 such as shown in FIG. 3, may be used to provide a uniform electrode erosion and air gap when heavy sludge is in the arc crater. These electrodes can be arranged side by side to provide a linear arc and can be rotated to provide uniform wear. Also, these electrodes can withstand moderate stresses at high temperatures which can produce crushing actions desirable for waste materials and feed mechanisms. The circumferences may be formed with teeth, grooves, and other shapes which permit automatic feed. Using ATJ graphite, these electrodes may be machined so that the arc may pass through porous waste material while in rotation.

It will be appreciated that the self-cycling fluid heater of the present invention may be applied to present processing systems or, it may be made portable and operated as an oil skimmer picking up floating oil and processing it into useful products while providing a solution to pollution problems.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

I claim:

1. A self-cycling heater for heating liquids to ultra high temperatures comprising:

a. a housing having a high temperature refractory body forming a reaction chamber therein,
b. a liquid inlet chamber in said refractory body communicating said reaction chamber,
c. a liquid discharge chamber in said refractory body communicating said reaction chamber,
d. positive and negative electrodes in said reaction chamber for forming an electric arc therein for heating liquid flowing therethrough,
e. preheater means connected to said liquid inlet chamber for heating the liquid prior to introduction into said reaction chamber, and
f. downstream reaction heat exchanger means connected to said liquid discharge chamber for controlling the temperature of said liquid during a controlled reaction.

2. The invention of claim 1 wherein said preheater and said downstream reaction heat exchanger comprise tubular electrical resistance heaters.

3. The invention of claim 2 wherein said tubular electrical resistance heaters are provided with walls whose thickness varies according to the temperature desired in each portion of the tubular heater.

4. The invention of claim 2 in which the length of the various portions of the tube of a given wall thickness varies according to the resident time of the liquid flowing therethrough.

5. The invention of claim 2 wherein said tubular electric resistance pre-heater is coiled around said inlet chamber and said downstream control heat exchanger coiled around said discharge chamber.

6. The invention of claim 1 including a restricted throat in said fluid inlet chamber for increasing the velocity of liquid entering said reaction chamber.

7. The invention of claim 1 including conduit means extending radially outwardly from adjacent said reaction chamber to the exterior of said refractory body and means for injecting fluid into said conduit means for removing particles of the electrodes from said fluid stream.

8. The invention of claim 7 wherein said high temperature refractory body is surrounded by annular chambers and said conduit means communicates with said annular chambers.

9. The invention of claim 7 including a pair of concentric annular chambers around said body, with said conduit means connecting the innermost of said annular chambers with said reaction chamber; passages connecting the inner and outer annular chambers; and exhaust means in said outer annular chamber for discharging fluid therefrom.

10. The invention of claim 1 including port means in said refractory body adjacent said reaction chamber for injecting catalyst into said reaction chamber for mixture with liquids entering said reaction chamber from said inlet chamber.

11. The invention of claim 1 wherein the electrodes are truncated cones aligned side by side to provide maximum linear contact.

12. The invention of claim 1 wherein said electrodes comprise flat plates which are stacked one on top the other with insulating means therebetween and which are operated by alternating current to provide a long electrode arc.

13. The invention of claim 1 wherein said electrodes have rounded sides and are arranged side by side to provide a linear arc.

14. The invention of claim 1 wherein said refractory body is formed of aluminum oxide.

15. The invention of claim 1 wherein said refractory body comprises a material suitable for combustion as an element in the desired chemical reaction and which is expendable in the chemical reaction.

* * * * *