May 14, 1957 R. R. GOINS ET AL 2,792,437

REGENERATIVE FURNACE AND CONVERSION OF HYDROCARBONS THEREIN TO ACETYLENE AND ETHYLENE

Filed Oct. 22, 1954 2 Sheets-Sheet 1

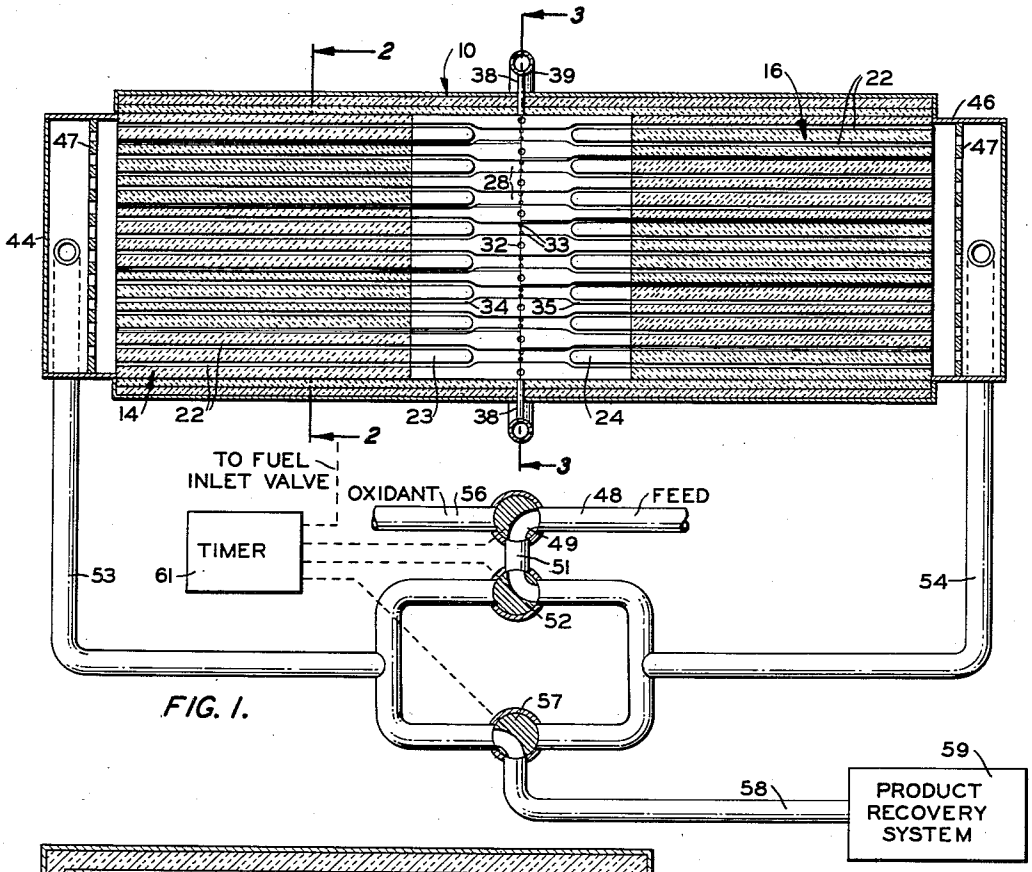


FIG. 1.

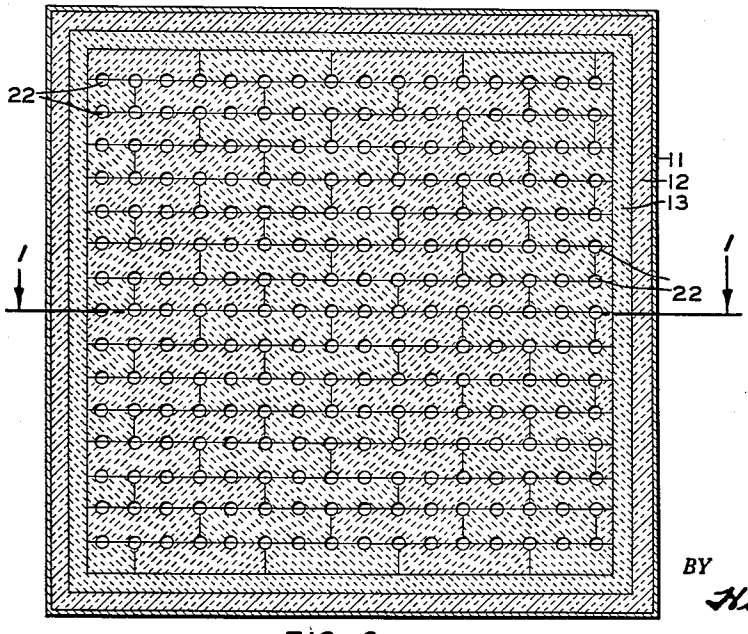


FIG. 2.

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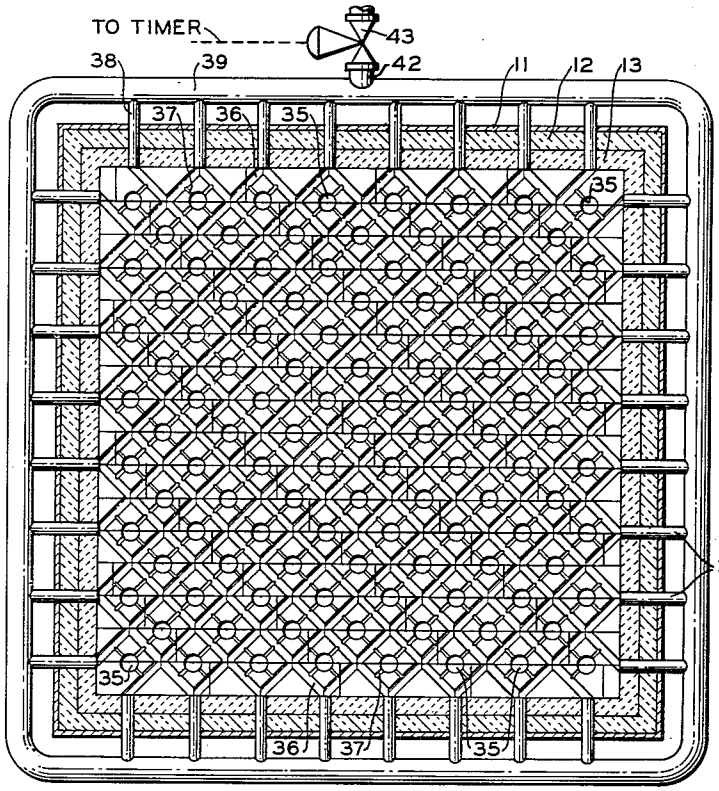


FIG. 3.

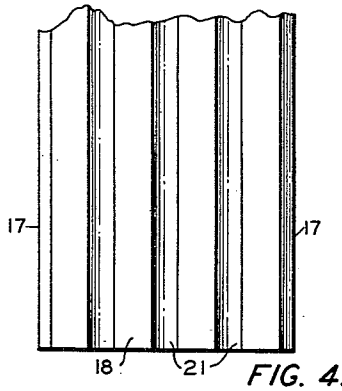


FIG. 4.

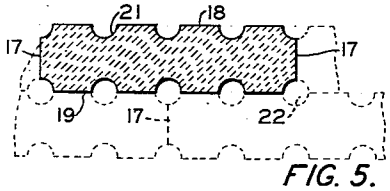


FIG. 5.

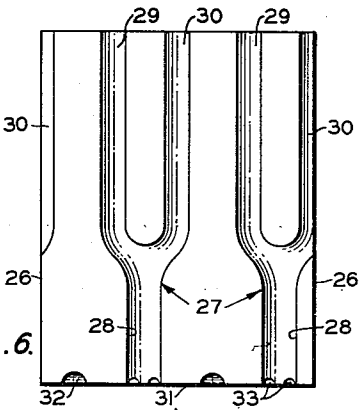


FIG. 6.

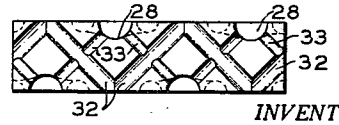


FIG. 7.

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2,792,437

REGENERATIVE FURNACE AND CONVERSION OF HYDROCARBONS THEREIN TO ACETYLENE AND ETHYLENE

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Application October 22, 1954, Serial No. 464,112

10 Claims. (Cl. 260—679)

This invention relates to the conversion of hydrocarbons. In one of its more specific aspects, it relates to a novel regenerative furnace for use in the thermal cracking of hydrocarbons. In another of its more specific aspects, it relates to a regenerative furnace which includes means for assuring even distribution of heat through the refractory checkerworks.

During the early years of the petroleum industry, the possibility of producing unsaturated hydrocarbons by the cracking of low boiling hydrocarbons received comparatively little attention. Because of apparatus limitations imposed by the high reaction temperatures involved and the lack of understanding of the best manner of operation, early developments excluded the cracking of low boiling hydrocarbons. Still another deterrent in the development of successful processes was the availability of vast supplies of heavy naphthas which could be cracked by more easily manageable processes to form easily purifiable products in high yield. Recent advancements made in organic chemistry have resulted in such an increased demand for petro-chemical starting materials, such as acetylene and ethylene, that it is no longer possible to rely on the old sources of supply for these materials. The demand for ethylene has reached such proportions that it cannot be supplied from refinery streams without upsetting the balance in the production of motor and aviation fuels. Furthermore, commercial production of acetylene by reacting calcium carbide with water is too expensive and is limited to amounts far too low to satisfy the demand for acetylene as a chemical synthesis starting material. Accordingly, the development of successful processes for producing unsaturated hydrocarbons by the cracking of low boiling hydrocarbons has in recent years taken on added importance.

Various methods for the pyrolysis of gaseous hydrocarbons have been proposed which involve the use of a variety of heat sources, including externally heated tubes, electrically heated resistance elements, and spark or electrical discharges. The lack of cheap electric power has also drawn attention to other possible methods of heating, such as by the combustion of preheated natural gas with preheated compressed air. In such latter processes when utilizing regenerative furnaces, a stream of air and fuel gas is burned in, or hot combustion products passed through, a refractory checkerwork so as to heat it to a high temperature. After the hot gases have heated the checkerwork to the desired temperature, the flow of combustion gases is terminated, and thereafter the reactant materials to be treated are passed through the heated checkerwork in order to bring the materials to reaction temperature.

In a particularly useful regenerative furnace of this type, utilized for the thermal cracking of hydrocarbons, such as methane, ethane, propane or butane, to produce unsaturated hydrocarbons, such as ethylene or acetylene, an elongated checkerwork of refractory material is provided at either end of a central combustion chamber. Air is passed in one direction through one of the checkerwork structures while a fuel gas is introduced into the central combustion chamber. The fuel gas and air burn in the combustion chamber, and thereafter the resulting combustion gases flow through one of refractory checkerworks. When this checkerwork has reached the desired temperature, the flow of air and fuel is terminated, and the materials to be cracked or otherwise converted are passed in the opposite direction through the heated refractory where the desired cracking or other reaction occurs.

After a timed reaction period, the flow of reactant materials is stopped, and air is passed through the furnace in a direction opposite to that of its first introduction. At the same time, fuel gas is introduced into the central combustion chamber to mix with the air and form a combustible mixture which is burned therein to form hot combustion gases to heat the refractory checkerwork downstream of the combustion chamber. When the checkerwork attains the desired temperature, the materials to be converted are passed through the heated refractory.

When using a regenerative furnace of the type just described, having a central combustion chamber disposed between a pair of similar refractory checkerworks, for cracking light hydrocarbons, difficulty has been encountered in obtaining a uniform distribution of heat in the refractory masses. This unsatisfactory condition arises from the fact that on the regeneration cycle the combustion gases resulting from burning fuel gas and air within the combustion chamber have a tendency to channel through a portion only of the refractory masses, thereby causing certain parts of the refractories to be heated to higher temperatures than other parts. Such uneven heating may result in damage to the refractories and additionally may have a deleterious effect upon the cracking reaction. With regard to the effect of non-uniform heating of the refractories upon the cracking reaction, during the process cycle portions of the hydrocarbon feed are heated to higher temperatures than others, resulting in overcracking and undercracking of the feed. The net result of such a reaction is a low product yield accompanied by the formation of carbonaceous materials which over a period of time may render the furnace inoperative. In accordance with this invention, means are provided for distributing the heat evenly and uniformly throughout the refractory masses, thereby providing for an efficient cracking reaction in which secondary reactions are reduced to a minimum.

Another disadvantage arising from the use of a regenerative furnace comprising a pair of refractory checkerworks separated by a central combustion chamber in the thermal cracking of hydrocarbons is related to the difficulty in controlling the time during which the reaction proceeds. In carrying out processes for the production of unsaturated hydrocarbons, in order to obtain a maximum yield, it is important that the reaction times be closely controlled. This is especially true at the higher reaction temperatures, for it has been found that the higher the reaction temperature employed in the pyrolysis of gaseous hydrocarbons, the shorter the optimum reaction period must be. For example, in the production of acetylene, a very short optimum reaction period is necessary for a maximum yield, and an unduly extended period will result in a low yield of acetylene and the formation of carbonaceous materials in the regenerative furnace. When the reaction products must pass from a cracking section through a large combustion chamber prior to introduction into the quench section of the furnace, it is difficult to control with any degree of accuracy the time during which the products are undergoing reaction before cooling to a temperature at which they are stable. It should be apparent that a certain amount

of stagnation occurs within such a combustion chamber and that different portions of the reaction products will be subjected to varying reaction times. In accordance with this invention, it is possible to accurately control the reaction times by reducing to a minimum the time which elapses between when the gases leave the cracking section and when they enter the quench section.

The following are objects of the invention.

It is an object of the invention to provide an improved regenerative furnace for use in the thermal cracking of hydrocarbons.

Another object of the invention is to provide an improved method for the thermal conversion of hydrocarbons whereby overcracking and undercracking of the reactant materials are substantially eliminated.

Still another object of the invention is to provide a regenerative furnace having a combustion section comprising a plurality of passageways, each of which is provided with its own fuel supply and each of which communicates directly with a passageway of the main refractory checkerworks of the furnace.

A further object of the invention is to provide a regenerative furnace which includes means for obtaining uniform and even heating of the refractory checkerworks of the furnace by preventing channeling of the gases through any one portion of the checkerworks.

A still further object of the invention is to provide a regenerative furnace which incorporates means for reducing the time interval between when the reaction products undergo reaction and when they are quenched to a minimum.

Still further objects and advantages of the invention will become apparent to one skilled in the art upon consideration of the following disclosure.

Broadly speaking, the present invention resides in a novel regenerative furnace comprising two main refractory checkerworks separated by a combustion section. The combustion section in turn comprises a plurality of passageways, each of which is provided with its own fuel supply and each of which communicates directly with a passageway of the main refractory checkerworks. Fuel gas and heated air are mixed within the passageways of the combustion section, forming a combustible mixture which burns therein. Thereafter, the resulting combustion products are passed directly from the passageways of the combustion section into the passageways of one of the checkerworks in order to heat the refractories for subsequent cracking of the hydrocarbon feed. By employing what in essence amounts to a plurality of separate combustion zones connected to the passageways of the main refractory checkerworks, uniform distribution of the combustion gases through the refractories is assured, and concomitantly even and uniform heating of the refractories occurs. Furthermore, by eliminating the large combustion space commonly employed in conventional furnaces and substituting therefor a plurality of small combustion zones directly connected to passageways of the main refractories, a substantial shortening of the time interval between when the gases undergo reaction and are subsequently quenched is made possible. The net result of this manner of operation is the practical elimination of over- and undercracking of the hydrocarbon feed and the accompanying formation of carbonaceous materials within the regenerative furnace.

A more complete understanding of the invention may be obtained by reference to the following descriptive material and the drawing, in which:

Figure 1 is a plan view, partially in section, of a regenerative furnace in accordance with the present invention;

Figure 2 is a cross-sectional view taken along line 2—2 of Figure 1;

Figure 3 is a cross-sectional view taken along line 3—3 of Figure 1;

Figure 4 is a plan view of a refractory tile suitable for use in forming the main refractory masses of the regenerative furnace of this invention;

Figure 5 is an end view of the refractory tile of Figure 4, and further illustrates by broken lines the manner in which the tiles are placed together;

Figure 6 is a plan view of a refractory tile used in forming the combustion section of the regenerative furnace of this invention; and

Figure 7 is an end view of the refractory tile of Figure 6.

Referring now to the drawing, and in particular to Figures 1 and 2, a regenerative furnace **10** is illustrated which comprises a shell **11** lined with two layers **12** and **13** of insulating material. The inner layer **13** is formed of a more refractory material than outer layer **12**. Disposed in opposite end portions of insulated shell **11** are two refractory masses **14** and **16** which constitute the principal heat exchangers of the furnace. While the furnace as described herein is symmetrical, i. e., having two refractory masses of equal length, it is to be understood that refractory masses of different lengths may be utilized without departing from the scope of the invention. These main refractory masses are built up of refractory tiles similar to tile **17** shown in Figures 4 and 5. Formed in the upper and lower surfaces **18** and **19** of tile **17** are semicircular, longitudinal grooves **21**. When two of the tiles are fitted together and placed one upon the other as illustrated in Figure 5, grooves **21** coincide to form longitudinal openings or passageways **22** as shown in Figure 1.

Positioned within insulated shell **11** between main refractory masses **14** and **16** and contiguous thereto are two refractory masses **23** and **24** which comprise the combustion section of the regenerative furnace. Each of the refractory masses **23** and **24** are formed of refractory tiles similar to the tile designated by reference numeral **26** in Figures 6 and 7. In the upper and lower surfaces of refractory tile **26**, there are Y or fork shaped grooves **27** comprising a larger groove **28** which branches into a pair of smaller grooves **29** and **30**. The end surface **31** of the tile with which larger grooves **28** intersect, as shown in Figure 7, has diagonal or transverse grooves **32** formed therein which extend between the ends of larger grooves **28**. Smaller radial grooves **33** also formed in end surface **31** connect diagonal grooves **32** with larger grooves **28**.

As previously mentioned, tiles **26** are utilized to form the two refractory masses **23** and **24** comprising the combustion section of the furnace. Referring to Figure 1 as well as to Figures 6 and 7, when the tiles are placed one upon the other, Y shaped grooves **27** coincide to form forked passageways **34** and **35** within the combustion section. In forming the two refractory masses **23** and **24**, the tiles are so positioned that the smaller grooves **29** and **30** are placed contiguous to passageways **22** of the main refractory masses so as to form a continuation of these latter passageways in either end of refractory masses **23** and **24** adjacent main refractory masses **14** and **16**. The ends of larger grooves **28** of tiles **26** meet in the center of the combustion section with the result that each of the refractory masses of the combustion section have formed therein Y shaped passageways **34** and **35** which meet at the center of the combutsion section.

The end surfaces **31** of refractory tiles **26**, which are in contact in the central portion of the combustion section have, as noted above, diagonal and radial grooves formed therein. Placement of refractory tiles **26** so that their end surfaces meet results in the formation of a series of diagonal or transverse tubes **36** and radial tubes **37** connecting the diagonal tubes to the larger passageway of the fork shaped passageways as shown in Figure 3. When the tiles are placed as described, each of the forked passageways is provided with four oppositely positioned radial inlets. Still referring to Figure 3, diagonal passageways **36** are connected by lines **38** to a header mem-

ber 39 which has a fuel inlet line 42 containing a valve 43 connected thereto.

Plenum chambers 44 and 46, connected to the ends of regenerative furnace 10, provide means for introducing reactant materials into the furnace. Each of the plenum chambers may be provided with a perforated distributor plate 47 to facilitate even distribution of the reactant materials through the refractory masses.

Conduit 48, through which hydrocarbon feed material is introduced, is connected by a three-way valve 49 to a conduit 51. Conduit 51 in turn is connected through a three-way valve 52 to a conduit 53 which communicates with plenum chamber 44 or, alternatively, to a conduit 54 which communicates with plenum chamber 46. Valve 49 is also adapted to attach oxidant conduit 56 to conduit 51 and, thence, to conduits 53 and 54, as determined by the setting of valve 52. Conduits 53 and 54 are also selectively connected by a three-way valve 57 to an effluent conduit 58 which leads to a product recovery system 59 or other disposal, as desired. Timer 61 is operatively connected to valve 43 in fuel inlet line 42 (Figure 3) and to three-way valves 49, 52 and 57 to provide alternate regeneration and process cycles.

The regenerative furnace of this invention is especially adapted for carrying out processes for the production of unsaturated hydrocarbons, such as acetylene, ethylene, and mixtures of acetylene and ethylene. The reaction temperatures for such processes will vary in the approximate range of 1250° F. to 2700° F. More specifically, in the acetylene process, the reaction temperature is preferably maintained between about 2200° F. and 2700° F., in the process for the production of acetylene and ethylene, between about 1700° F. and 2200° F., and in the ethylene process, between about 1250° F. and 1700° F. The reaction times for the several processes are in the following approximate ranges: for acetylene, between 0.0001 and 0.2 second; for a mixture of acetylene and ethylene, between 0.01 and 0.2 second; and for ethylene, between 0.01 and 2 seconds. From this consideration of reaction temperatures and reaction times, it is apparent that the reaction times vary inversely with the reaction temperatures, i. e., the higher the reaction temperature, the shorter the reaction time.

A wide variety of hydrocarbon feed stocks can be used in the practice of the processes of this invention. Those which can be suitably used include methane, ethane, propane, butane and mixtures of these hydrocarbons and/or their corresponding olefins. It is to be understood, however, that any vaporizable or gaseous hydrocarbons can be advantageously employed as the feed. It is also within the contemplation of the invention to use a diluent such as steam with the hydrocarbon feed in order to reduce the deposition of carbonaceous materials within the furnace.

Oxidants which can be used in the process of this invention include oxygen, air, and oxygen-enriched air. Any suitable fuel, preferably a clean burning fuel, can be used in the practice of this invention. Gaseous or liquid hydrocarbons are preferably utilized as fuels, and process off-gases from the process of this invention or other processes can be advantageously employed. When using a liquid hydrocarbon, the fuel is introduced into the furnace in vaporized form.

In the operation of the regenerative furnace of Figure 1, during the regeneration cycle, three-way valves 49 and 52 are in such a position that an oxidant, such as air, is forced by a blower (not shown) through conduits 56, 51 and 53 into plenum chamber 44 from which it passes into passageways 22 of refractory mass 14. Plenum chamber 44 and perforated distributor plate 47 disposed therein provide for even distribution of air across the face of refractory mass 14 and facilitate even flow of air therethrough. It is assumed that the furnace has been previously brought to operating temperature by utilizing an outside source of preheated air.

The air in passing through refractory mass 14 is heated to a temperature at least as high as the ignition temperature of a fuel gas to be introduced into the forked passageways of the combustion section. The heated air issuing from refractory mass 14 immediately enters forked passageways 34 of refractory mass 23. Since the smaller passageways of forked passageways 34 are continuations of passageways 22 of refractory mass 14, the air is evenly and uniformly distributed among the passageways of the combustion section. The fuel gas, which may be preheated, is introduced into the forked passageways of the combustion section through fuel inlet line 42, header member 39, lines 38, diagonal tubes 36 and radial inlets 37. The air and fuel are thoroughly mixed within each of the forked passageways, forming a combustible mixture which burns therein. The resulting combustion products leave the combustion section through the smaller passageways of forked passageways 35 and immediately enter passageways 22 of refractory mass 16. Since each of the passageways of refractory mass 16 are directly connected to one of the smaller passageways of forked passageway 35 and are thereby in effect each provided with a separate combustion chamber, even distribution of combustion gases through refractory mass 16 is assured. By operating in this manner, channeling of the combustion gases through one portion only of refractory mass 16 is prevented, and substantially no differential in temperature exists across any cross section of the refractory mass. In flowing through refractory mass 16, the combustion gases heat the refractories to the desired temperature. The combustion products thereafter flow into plenum chamber 46 and, thence, through conduits 54 and 58 into product recovery system 59 where they may be used for heating or other purposes.

At the conclusion of a predetermined time interval, as determined by the setting of timer 61, valve 49 is actuated by timer 61 to transfer conduit 51 from its connection with conduit 56 to a connection with conduit 48. The timer also operates to close valve 43 in fuel inlet line 42 and to reverse the settings of valves 52 and 57 so that conduit 51 is connected to conduit 54 and conduit 53 is connected to conduit 58. An interval of one minute is a suitable reaction period and regeneration period for the cracking of propane to form acetylene. In general, the time interval will depend upon the particular process being practiced and the specific hydrocarbon feed being converted.

As a result of the movement of valves 49 and 52, the process cycle commences and hydrocarbon feed and steam, if desired, now pass through conduits 48, 51 and 54 into plenum chambers 46. As previously pointed out, the combination of the plenum chamber and perforated distributor plate 47 provides for even flow of gases through refractory mass 16. On contacting hot refractory mass 16, the hydrocarbon feed is raised to the desired cracking temperature and undergoes reaction. The cracked hydrocarbon feed thereafter passes through forked passageways 35 and 34 and immediately enters passageways 22 of refractory mass 14 which has been previously cooled on the regeneration cycle by passage of air therethrough. In flowing through refractory mass 14, the reaction products are rapidly quenched to a temperature at which they are stable, e. g., to a temperature in the range of about 400 F. to 1000° F. By providing a combustion section comprising a plurality of passageways directly connected to the passageways of the main refractory masses, the reaction products leave the cracking section and enter the quench section with a minimum period of delay. The provision of a plurality of small combustion zones as contrasted with a single large combustion chamber does not subject the reaction products to

a period of stagnation during which portions of the reaction products undergo further reaction prior to quenching. After passing through refractory mass **16**, the reaction products flow into plenum chamber **44** and are subsequently passed through conduits **53** and **58** to product recovery systems **59** for separation of the product gas from the reaction products.

At the end of the predetermined time interval, timer **61** operates to change the setting of valve **49** so that air is now introduced into the regenerative furnace through conduit **54** to start the regeneration cycle. The timer functions also to open fuel valve **43** contained in fuel inlet line **42** of header member **39**, thereby allowing fuel to flow into the forked passageways of the combustion section. The regeneration cycle is now carried out in the same manner as previously described except that the burning of the fuel and air occurs in forked passageways **34** of the combustion section rather than passageways **35**. After the regeneration cycle is completed, the process cycle is begun by timer **61** operating to close fuel valve **43** and to change the settings of valve **49**, **52**, and **57**, thereby permitting hydrocarbon feed to enter the furnace through conduit **53** and the effluent to pass to product recovery system **59** through conduits **54** and **58**. The regeneration and process cycles are thereafter repeated at the predetermined time intervals to produce the desired product.

As previously mentioned, the regenerative furnace of Figure 1 may be non-symmetrical, i. e., one of the main refractory masses may be longer than the other. When opearting with a furnace of this type, the longer refractory mass is the reaction section while the shorter refractory mass serves as the quench section. During the regeneration cycle air is introduced only into the shorter refractory mass, and during the process cycle hydrocarbon feed is passed only into the longer refractory mass. Thus, the air and hydrocarbon feed are always introduced into the same end of the furnace.

It will be apparent that by employing the regenerative furnace of this invention in the thermal cracking of hydrocarbons, it is possible to obtain a more efficient cracking reaction. Accordingly, by utilizing a regenerative furnace having a combustion section comprising a plurality of passageways, each provided with its own fuel supply and each directly connected to one of the passageways of the main refractory checkerworks, it is possible to obtain uniform and even heating of the refractory checkerworks. Furthermore, because of the form of the combustion section it is possible to reduce to a minimum the time between the end of the reaction period and the cooling of the reaction products to a temperature at which they are stable. By operating in this manner, over- and undercracking of the hydrocarbon feed is prevented, thereby substantially eliminating secondary reactions which tend to form carbonaceous materials and substantially reduce the product yield.

As will be evident to those skilled in the art, various modifications of this invention can be made or followed without departing from the spirit or scope of the disclosure.

We claim:

1. In a regenerative furnace comprising refractory checkerworks spaced apart so as to provide a combustion section therebetween, the improvement which comprises at least one refractory mass positioned within said combustion section and having its outer faces in contact with the inner faces of said refractory checkerworks; a plurality of combustion chambers formed within said refractory mass, each of said combustion chambers communicating with one of the openings in each of said refractory checkerworks; means for introducing fuel laterally into each said combustion chamber; and means for passing air and material to be converted into and through said refractory checkerworks.

2. In a regenerative furnace comprising at least two main refractory masses disposed in longitudinal alignment and spaced apart so as to provide for a combustion section therebetween and having parallel passageways therethrough parallel to the axis of said furnace, the improvement which comprises at least one refractory mass positioned within said combustion section and having its outer faces in contact with the inner faces of said main refractory masses; tubes extending inwardly a substantial distance into said refractory mass from its outer faces, said tubes being extensions of said parallel passageways and each pair of said tubes thereafter merging into a single enlarged tube disposed in an intermediate portion of said refractory mass; means for introducing fuel laterally into said enlarged tubes; and means for passing air and material to be converted into and through said main refractory masses.

3. In a regenerative furnace comprising at least two main refractory masses disposed in longitudinal alignment and spaced apart so as to provide for a combustion section therebetween and having passageways therethrough parallel to the axis of said furnace, the improvement which comprises at least one refractory mass positioned within said combustion section and having its outer faces in contact with the inner faces of said main refractory masses; tubes extending into but not completely through said refractory mass from its outer faces, said tubes being extensions of said parallel passageways; enlarged tubes in an intermediate portion of said refractory mass, at least two of said first mentioned tubes converging into said enlarged tubes; means for introducing fuel laterally into said enlarged tubes, and means for passing air and material to be converted into and through said refractory masses.

4. A regenerative furnace which comprises, in combination, an elongated, closed shell; a first refractory mass disposed in one end portion of said shell; a second refractory mass disposed in the other end portion of said shell, said refractory masses having parallel passageways extending therethrough substantially parallel to the longitudinal axis of said shell; third and fourth refractory masses having their inner faces in contact disposed within said shell between said first and second refractory masses, the outer faces of said third and fourth refractory masses being in contact with the inner faces of said first and second refractory masses; fork-shaped passageways each comprising a pair of smaller passageways converging into a single enlarged passageway extending through each said third and fourth refractory masses, said smaller passageways being extensions of said parallel passageways of said first and second refractory masses and said enlarged passageways coinciding with one another at said inner faces of said third and fourth refractory masses; means for introducing fuel laterally into said enlarged passageways; and means for passing air and material to be converted into and through said refractory masses.

5. The regenerative furnace of claim 4 in which said means for passing air and material to be converted into and through said refractory masses comprises a first plenum chamber having a conduit attached thereto connected to and enclosing one end of said shell and a second plenum chamber having a conduit attached thereto connected to and enclosing the other end of said shell.

6. A regenerative furnace which comprises, in combination, an elongated shell; a first refractory mass disposed in one end portion of said shell; a second refractory mass disposed in the other end portion of said shell, said refractory masses having parallel passageways extending therethrough substantially parallel to the longitudinal axis of said shell; third and fourth refractory masses having their inner faces in contact disposed within said shell between said first and second refractory masses, the outer faces of said third and fourth refractory masses being in contact with the inner faces of said first and second refractory masses; fork-shaped passageways each comprising a pair of smaller passageways converging into a single enlarged passageway extending through each said third

and fourth refractory masses, said smaller passageways being extensions of said parallel passageways of said first and second refractory masses and said enlarged passageways coinciding with one another at said inner faces of said third and fourth refractory masses; diagonal passageways formed in said inner faces of said third and fourth refractory masses and extending between said enlarged passageways to the exterior surfaces of said third and fourth refractory masses; conduits formed in said inner faces of said third and fourth refractory masses communicating said enlarged passageways with said diagonal passageways; means for introducing fuel into said diagonal passageways; and means for passing air and material to be converted into and through said refractory masses.

7. The regenerative furnace of claim 6 in which said conduits communicate with said enlarged passageways at points diametrically opposite one another.

8. The regenerative furnace of claim 6 in which said means for introducing fuel into said diagonal passageways comprises a header member connected to the ends of said diagonal passageways and said means for passing air and material to be converted into and through said refractory masses comprises a first plenum chamber having a conduit attached thereto connected to and enclosing one end of said shell and a second plenum chamber having a conduit attached thereto connected to and enclosing the other end of said shell.

9. A process for converting hydrocarbons which comprises heating air in a first refractory checkerwork; passing said heated air into a plurality of separate combustion zones; introducing fuel gas laterally into each of said combustion zones, thereby forming a combustible mixture within each said zones; burning said combustible mixtures within said combustion zones; passing the resulting combustion products from said combustion zones into a second refractory checkerwork so as to heat same to a desired temperature; terminating the supply of air and fuel gas; introducing hydrocarbon feed into said second refractory checkerwork; transferring heat from said second refractory checkerwork to said hydrocarbon feed so as to crack said feed; passing the resulting reaction products into said first refractory checkerwork; cooling said reaction products within said first refractory checkerwork to a temperature at which they are comparatively stable; and removing said cooled reaction products from said first refractory checkerwork.

10. A process for converting hydrocarbons which comprises introducing air into a first refractory checkerwork so as to heat same; passing said heated air into a plurality of separate combustion zones; introducing fuel gas laterally into each of said combustion zones, thereby forming a combustible mixture within each of said zones; burning said combustible mixtures within said combustion zones; passing the resulting combustion products from said combustion zones directly into a second refractory checkerwork so as to heat same to a desired temperature; terminating the supply of air and fuel gas; introducing hydrocarbon feed into said second refractory checkerwork; transferring heat from said second refractory checkerwork to said hydrocarbon feed so as to crack said feed; passing the resulting reaction products through said combustion zones and into said first refractory checkerwork; cooling said reaction products within said first refractory checkerwork to a temperature at which they are comparatively stable; removing said cooled reaction products from said first refractory checkerwork; terminating the supply of hydrocarbon feed to said second refractory checkerwork; introducing air into said second refractory checkerwork so as to heat same; passing said heated air into said plurality of combustion zones; introducing fuel gas laterally into each of said combustion zones, thereby forming a combustible mixture within each of said zones; burning said combustible mixtures within said combustion zones; passing the resulting combustion products from said combustion zones directly into said first refractory checkerwork so as to heat same to a desired temperature; terminating the supply of air and fuel gas; introducing hydrocarbon feed into said first refractory checkerwork; transferring heat from said first refractory checkerwork to said hydrocarbon feed so as to crack said feed; passing the resulting reaction products through said combustion zones into said second refractory checkerwork, cooling said reaction products within said second refractory checkerwork to a temperature at which they are comparatively stable; and removing said reaction products from said second refractory checkerwork.

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