

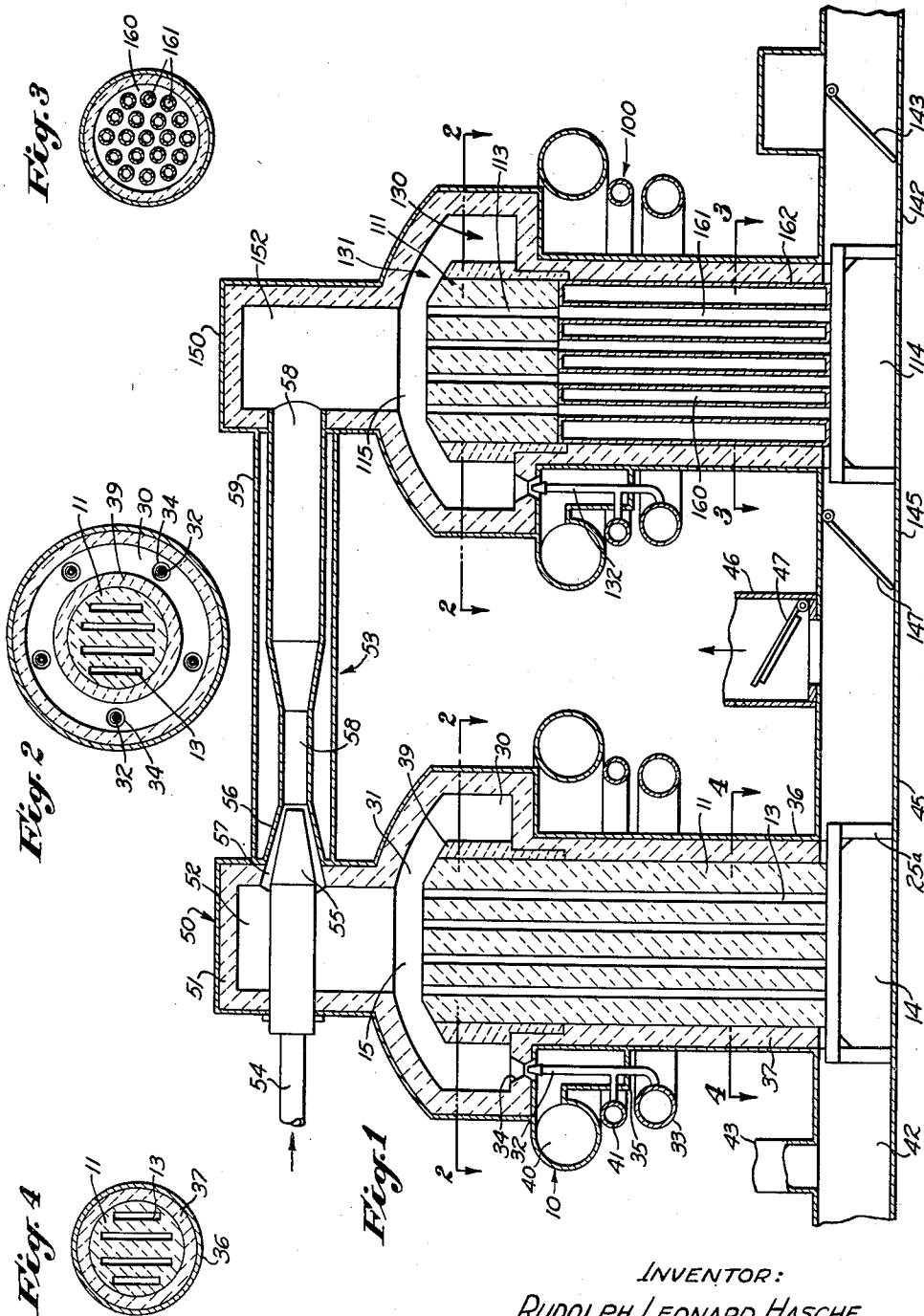
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FURNACE

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FURNACE

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3 Claims. (Cl. 23-277)

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My invention relates to furnaces, the furnaces shown being especially adapted to the production of a mixed gas containing acetylene or ethylene from other hydrocarbons. An object of the invention is to provide furnaces and auxiliaries thereto by which a gas can be quickly heated and quickly cooled. A further object of the invention is to provide furnace structures which are well adapted for use in the practice of the inventions disclosed in my copending application, Serial No. 633,846, filed December 8, 1945, of which this application is a division. The applicant has another case pending which is in the same art, namely, Serial No. 642,452, filed January 21, 1946.

In the process described in said application, Serial No. 633,846, a charging stock or first gas is first converted into a second gas containing intermediate hydrocarbons, for example, propylene and ethylene, which, upon being heated, readily form acetylene, this first conversion being accomplished in a first regenerative mass, and in which these intermediate hydrocarbons are then converted into a gas containing substantial amounts of acetylene in a second regenerative mass, the masses being each independently heated to that degree necessary to enable each to perform its desired function. The partial pressure of the intermediate hydrocarbons is reduced by dilution of the second gas with an inert diluent to form a third gas before said third gas is delivered to the second regenerative mass. The conversion of stock hydrocarbons to intermediate hydrocarbons may be accomplished under different conditions as to time of reaction, heat, and pressure than the conversion of these intermediate hydrocarbons to acetylene, and thus it is desirable to use two independent regenerative masses in which time of reaction, heat, and pressure may be independently controlled.

Further objects and advantages will be made evident hereinafter, as will be obvious to a man skilled in the art after he has read and understood this specification.

In the drawings, which are solely for illustrative purposes, I show an apparatus in which my process may be conducted. In these drawings:

Fig. 1 is an elevation, partly in section, certain instrumentalities readily supplied by a man skilled in the art being omitted to simplify the drawings and description;

Fig. 2 is a section on a plane represented by

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the line 2-2 of Fig. 1, this section being the same for each of the regenerative furnaces;

Fig. 3 is a section on a plane represented by the line 3-3 of Fig. 1; and

Fig. 4 is a section on a plane represented by the line 4-4 of Fig. 1.

The intermediate hydrocarbons are formed in a first furnace 10 which contains a regenerative mass 11. The regenerative mass 11 may be formed of loose carborundum bricks so placed as to provide vertical, substantially straight, and open primary passages 13 which extend through the mass 11 and connect a primary space 14 below the mass with a secondary space 15 above the mass.

The regenerative mass is so constructed that it can be supported wholly on a steel structure 25a in the primary space 14. This space 14, as will be understood from the description appearing later herein, never contains gas at a temperature which will substantially impair the strength of steel, and the lower end of the regenerative mass 11 never reaches such a destructive temperature.

Surrounding the upper end of the regenerative mass 11 is an annular combustion chamber 30, which is in communication with the secondary space 15 through an uninterrupted annular throat 31. Combustion in this space is provided by five equally spaced burners 32, each fed with gas from a fuel gas manifold 33. The combustion products in the space 15 may have a temperature of 3200° F. to 3400° F. The burners 32 discharge through openings 34 in the lower wall of the combustion space 30, these openings connecting the combustion space 30 with pipes 35 forming part of each burner. A steel shell 36 surrounds the mass 11 and the combustion chamber 30. Surrounding the mass 11 inside the shell 36 is an annular layer of heat insulating material 37. Surrounding the upper end of the regenerative mass 11 is a ring of carborundum 39. Various pipes may also be heat insulated externally by heat insulating material, not shown. Air is supplied to the pipes 35 from an air manifold 40, and steam is admitted into the burners 32 from a steam manifold 41.

I prefer to line the inside of the combustion chamber 30 with carborundum brick, but it should be understood that carborundum is merely a preferred refractory material and wherever I have specified its use any refractory material having satisfactory characteristics may be used. In fact, in actual furnace construction

I do not use carborundum as the material for the annular layer 37, in which a low thermal conductivity is desirable.

The primary space 14 is provided with an inlet pipe 42 through which the gas to be processed may be supplied to the space 14, and steam or other inert diluent gas may be supplied to the primary space 14 through a pipe 43. The pipes 42 and 43 are provided with valves, as are the pipes that supply fuel gas to the pipes 35, and as is the pipe supplying steam to the burners 32, these valves also not being shown. The primary space 14 also has an outlet pipe 45 through which combustion gases are conducted to a stack 46 through a valve 47.

Both the first furnace above described and the second furnace to be later described are operated in a recurring cycle which consists of a heating period, a purging period, and a treating period, each period in the second furnace occurring at the same time that a similar period occurs in the first furnace. The operation of the first furnace is as follows:

At the beginning of the heating period, the valve 47 into the stack 46 is open, and during the heating period no gas is supplied to the primary space 14 through the pipe 42. Fuel gas is supplied to the burners 32 from the manifold 33, and air for combustion is supplied to the pipes 35 from the manifold 49. It is important to so regulate the flow of air and gas that each of the burners will produce combustion products of about the same volume and at about the same temperature. In the drawings, I show five burners 32, but in large furnaces more than five burners are desirable. The burners may be inserted through the side walls of the combustion chamber 30, their exact location being somewhat a matter of convenience. If the burners are properly operated, the combustion chamber 30 is filled with an annular ring of combustion gases at a fairly uniform temperature of 3200° F. to 3400° F. I have found that in a properly designed furnace a heat liberation of 750,000 to 1,000,000 B. t. u. per hour for each cubic foot of combustion space is possible. This ring of combustion products surrounds the upper end of the ring 39 and tends to heat it. The combustion products flow evenly through the throat 31, which is constricted to an area perpendicular to the gas flow of at least one-third of the area on a horizontal plane of the combustion space 30. This constriction tends to promote an even flow of combustion products through the throat 31. Combustion products flow through the throat at a rather uniform velocity and temperature all around the throat, and this velocity is lowered in the space 15 before the gases change direction and flow downwardly through the primary passages 13. The changes in velocity and direction of the combustion gases in passing from the combustion chamber 30 to the space 15 tend to mix the gases and produce a very uniform temperature of the gases entering each of the passages 13, which is highly desirable.

The combustion products pass from the space 14 through the valve 47 to the stack 46. The regenerative mass 11 is raised to a sufficient temperature to heat the gas flowing through the passages 13 to form a second gas containing intermediate products, and when the mass is sufficiently heated the heating period terminates, combustion is stopped, and the valve 47 is closed.

The heating period may be from 1 to 2 minutes.

The purging period follows the heating period, steam being admitted to the primary space 14 from the pipe 42 and flowing upwardly through the passages 13 and the space 15, clearing these spaces of combustion gases. Steam, at the same time, is admitted to the burners 32 from the manifold 41 to purge the combustion chamber 30 of combustion products, and the flow of steam into the combustion chamber 30 from the burners 32 is maintained until the end of the treating period to keep treated or second gas out of the combustion space 30.

The treating period follows the purging period and completes the cycle. During the treating period the first gas flows upwardly from the primary space 14 to the secondary space 15 through the passages 13, and second gas containing the desired intermediate products is formed. First gas is supplied to the primary space 14 through the pipe 42.

Situated inside a continuation of the shell 36 is a dome 50, which is lined with carborundum brick 51 and which forms a space 52 which is a continuation of the space 15. An injector 53 draws the second gas from the first furnace, this gas containing the desired intermediate products, such, for example, as ethylene. This injector 53 is actuated by a motive gas delivered thereto by a pipe 54. This motive gas may be steam, but I prefer to use natural gas. The injector 53 delivers the motive gas to a nozzle 55, which delivers the motive gas into the throat 56 of the injector, thus drawing the second gas from the space 52 through a space 57 and delivering it to a pipe 58. In the pipe 58 the motive gas is mixed with the second gas to form a third gas, which is delivered to a dome 150 on the second furnace 100. The injector 53 and the nozzle 55 are provided with water jackets to enable them to withstand the heat of the second gas, the water jacket of the injector being shown at 59.

The first furnace containing the regenerative mass 11 is shown and described in my copending application, Serial No. 633,839, filed December 8, 1945, issued as U. S. Patent No. 2,432,885, December 16, 1947, and no specific claims to this first furnace are included in this application except in combination with the second furnace.

The second furnace 100 has a regenerative mass 111, which is similar to the mass 11 of the first furnace 10 except that it has less axial height. The upper portion of the furnace 100 is quite similar to the furnace 10, the furnace 100 having a combustion space 130 in which combustion occurs just as it does in the space 30, the combustion gases passing through a throat 131 into a space 115 which is an extension of a space 152 inside the dome 150. This combustion is fed and controlled during the cycle synchronously, as to each period of the cycle, as in the combustion space 30. The regenerative mass 111 of the second furnace 100, however, is placed on a steam boiler 160 having tubes 161 which are so placed that they communicate with and serve as extensions of the passages 113 through the regenerative mass 111. The space inside a shell 162 of the boiler 160 and around the tubes 161 is at all times kept filled with water under superatmospheric pressure, the boiler being kept full of water at all times by means common in the boiler art and therefore not shown. The tubes 161 deliver gas to a space 114 below the boiler. The space 114 communicates through a pipe 145 and a valve 147 and the valve 47 with the stack 46,

to provide an outlet for the products of combustion used to heat the mass 111. The space 114 also communicates with a pipe 142 having a valve 143 therein. The final product or fourth gas is delivered to the pipe 142.

The furnace 100 also operates on the recurring cycle of the first furnace 10, the two furnaces being heated, purged, and treating gas at the same time. The furnace 100, however, operates differently from the furnace 10 in that, although both furnaces are heated by products of combustion passing downwardly, the second furnace is purged by a downward flow of steam from the burners and the third gas from the space 152 passes downwardly through the passages 113, whereas in the first furnace the purging and treating flow is upward. During the heating period gases of combustion are cooled in the passages 113, their heat producing steam in the boiler.

The method of operation of the apparatus described is as follows:

The regenerative masses 11 and 111 are heated to the desired temperature during the heating period by passing products of combustion from the combustion spaces 30 and 130 downwardly through the passages 13 and 113, the combustion products from both furnaces passing off through the stack 46. The furnaces are then purged to the stack 46, as previously described. The operation of all of the valves is automatically controlled by a timing device (not shown).

During the treating period the gases to be treated first pass through the regenerative mass 11, then through the injector 53, and then through the regenerative mass 111. The first gas, or charging stock, enters the space 14 from the pipe 42. This first gas contains the stock hydrocarbons, and in passing through the passages 13 of the first regenerative mass 11 this first gas is converted to a second gas containing desirable intermediate hydrocarbons. The second gas may be at a temperature below 2000° F. when it is delivered to the space 52 in the dome 50. The principal intermediate hydrocarbon usually found in this gas is ethylene. This second gas is drawn into the injector 53 sufficiently below atmospheric pressure to insure a good gas flow through the passages 13, and in the injector 53 the gas pressure is increased sufficiently above atmospheric pressure to insure a good gas flow through the passages 113 and the tubes 161. The pressure on the third gas in the space 152 is therefore slightly higher than the gas pressure in the space 52. The third gas entering the space 152 differs from the second gas in that the third gas is considerably diluted by motive gas, such, for example, as hydrogen, methane, natural gas, or steam. This reduces the partial pressure on the intermediate hydrocarbons, which promotes their conversion to acetylene. This third gas flows through the passages 113 of the second regenerative mass 111 at high velocity and is in these passages for a very short time, preferably less than $\frac{1}{10}$ of a second. The mass 111 is preferably at a temperature close to 3000° F., and, due to the fact that treating and heating are produced by gas flows in a downward direction, the mass 111 is uniformly heated. In the passages 113 the third gas is changed to a fourth gas that contains a substantial amount of acetylene.

Acetylene is, however, a transient product at the temperatures above 2800° F. at which the fourth gas may be delivered from the passages 113 into the tubes 161 in the boiler, and at that

temperature the acetylene tends to break down into hydrogen and carbon. The fourth gas flowing at high velocity enters the tubes 161 as soon as it leaves the passages 113 and is quickly cooled in the tubes 161 to a temperature at which acetylene is stable, for example, to a temperature of 1200° F. or below.

The fourth gas containing substantial amounts of acetylene passes through the pipe 142 and valve 143 to suitable separation apparatus (not shown), in which the acetylene is separated from the fourth gas. This fourth gas from which acetylene has been separated is a valuable fuel gas and may be burned in the combustion chambers 30 and 130 to supply the combustion gases that heat the regenerative masses.

While the first gas may conveniently be at or near atmospheric pressure during the time it is being heated, it is possible that when using some charging stocks it is desirable to operate the first furnace under a partial vacuum, and experience shows that the formation of desirable intermediate products at any temperature is promoted by lowering the partial pressure on the stock hydrocarbon. The partial pressure may be produced by lowering the pressure of the first gas or reducing the proportion of stock hydrocarbon therein.

My process produces a very high yield of the desired hydrocarbons, which is in part due to the use of the short regenerative mass 111 which is maintained at a high temperature which is fairly uniform throughout. Good results have been attained in making acetylene in the electric arc, although the yields have been much lower than in my process and the cost per pound of the acetylene produced has been high. In electric arc processes the gas is not uniformly heated, as the arc itself consists of a very hot and small core surrounded by gases of lower temperature. In my process the treating zone, that is, the space in the passages 113, is uniformly heated so that all the gas is subjected to a uniformly high temperature. Also, in any arc process the heat of reaction, that is, the heat necessary to cause the formation of acetylene, is provided by the conversion of electrical energy to heat. In my process this heat is provided by burning the waste gases from the process, and the energy so released costs only a small fraction of the cost of electrical energy.

My process has, however, some of the advantages of the arc processes in that the contact time of the reaction to acetylene is very short. In other words, the gases are very quickly and uniformly heated in the passages 113 and are immediately passed to the tubes 161 of the boiler 160, where they are very quickly cooled to a temperature at which acetylene is stable. The speed of heat transfer from the regenerative mass 111 to the gas flowing through the passages 113 is very high, being proportional to the difference in temperature between the mass 111 and the gases flowing therethrough. The whole mass is at a substantially uniform temperature because the gases of combustion used to heat it flow in the same direction as the gas to be treated, and a very high rate of heat transfer is maintained throughout the whole length of the passages 113. Due to this high rate of heat transfer, the time during which the gases are subjected to high temperature is very short. The acetylene is very quickly formed, and, after being formed, it is not given time to decompose to hydrogen and carbon.

In any such process some decomposition will, however, occur, and some carbon will appear in the tubes 161. This carbon is, however, burned out by the hot gases of combustion that flow through these tubes during the heating period. The heat in the gases of combustion and in the treated gas flowing through the tubes 113 is, however, not lost, as it is utilized to form steam in the boiler 160.

The invention sought to be patented in this application is the second furnace shown at the right of Fig. 1 and in Figs. 2 and 3.

It will be understood that this furnace consists essentially of a regenerative mass 111 which is above and supported on a steam boiler 160. The mass 111 has passages 113 through which both gases of combustion and gas to be treated pass downwardly into and through tubes 161. The gases of combustion are produced in a combustion space 130 which surrounds the upper end of the mass 111 which rests upon and is supported by the upper end of the boiler 160. Combustion gases from the combustion space 130 pass through a throat 131 into a space 115 which is in open communication with the upper end of the passages 113 and also in open communication with a space 152 inside a dome 150. The boiler 160 has a shell 162 and the space inside the shell and around the tubes 161 is at all times kept filled with water under superatmospheric pressure by means common in the boiler art and therefore not shown. Gases, that is both combustion gases and gases which have been treated after having passed downwardly through the mass 111 and boiler 160, are delivered to a space 114 below the boiler. Combustion gases are carried from the space through a pipe 145 and a valve 147 to a stack 46. The gases which have been treated are removed from the space 114 through a pipe 142 and a valve 143. The gas to be treated is delivered through a pipe 53 to the space 152. The entire furnace is placed inside a metal shell lined with heat refractory material.

The furnace may be conveniently operated on a recurrent cycle, the first step of which is heating the mass 111. No gas being supplied through the pipe 53, combustion is set up in the combustion space 130 by the burners 132 of which there may be a plurality equally spaced around the combustion space 130. The gases of combustion so generated pass downwardly first through the passages 113 and then through the tubes of the boiler 160. During the treating period the gases to be treated also pass downwardly and thus first in contact with the very hot surfaces of the regenerative mass causing a very rapid reaction. The top of the first regenerative mass 11 may be maintained at a temperature under which substantial amounts of acetylene are not formed, the acetylene being almost exclusively formed in the second regenerative mass. This is accomplished by separately heating the two masses and so controlling the temperature of the two masses that acetylene formation is restrained in the first mass and greatly promoted in the second.

Although the second furnace has a special utility when used, as described above, with the first furnace to produce acetylene from gaseous mixtures containing products formed in the first furnace, it has also a general utility quite apart from this specific use and the scope of the invention is distinctly claimed in the appended claims and should not be restricted to any particular use.

I claim as my invention:

1. An apparatus useful for the pyrolytic decomposition of hydrocarbons comprising the combination of a first and a second regenerative furnace, said regenerative furnaces comprising an outer shell enclosing elongated upright regenerative masses having passageways extending lengthwise therethrough, chambers surrounding the ends of said regenerative masses, said chambers forming substantially annular combustion spaces about the end position of said regenerative masses, annular throats constituting communication between said combustion spaces and spaces adjacent the end of said masses into which said passageways open, domes positioned on the top of both said first and second furnace which domes embrace dome space communicating with said regenerative masses, burners opening into said annular combustion spaces, another chamber in direct communication with the opposite end of said first regenerative mass, an inlet communicating with said other chamber for admitting hydrocarbon to be treated during a treating cycle, said apparatus construction being characterized in that the dome spaces aforementioned at the head of the regenerative masses are directly and communicatively connected together by conduit means of restricted dimensions containing an injector whereby the gas flow from the head of the first regenerative mass may be accelerated to the head of the second regenerative furnace and the construction being further characterized in that the end of the second regenerative mass opposite from the second regenerative dome space is communicatively connected to and through a heat exchange means, whereby hydrocarbon flow may be caused to take place up through the first regenerative mass, then through the restricted conduit member to and down through the second regenerative mass and out through said heat exchange means.

2. An apparatus useful for the pyrolytic decomposition of hydrocarbons comprising the combination of a first and a second regenerative furnace, said regenerative furnaces comprising an outer shell enclosing elongated upright regenerative masses having passageways extending lengthwise therethrough, chambers surrounding the ends of said regenerative masses, said chambers forming substantially annular combustion spaces about the end position of said regenerative masses, annular throats constituting communication between said combustion spaces and spaces adjacent the end of said masses into which said passageways open, said throats being of a constricted construction, constricted with respect to an area perpendicular to the gas flow of at least one-third of the area on a horizontal plane of the combustion spaces, burners opening into said annular combustion spaces, another chamber in direct communication with the opposite end of said first regenerative mass, an inlet communicating with said other chamber for admitting hydrocarbon to be treated during a treating cycle, said apparatus construction being characterized in that the spaces aforementioned at the head of the regenerative masses are directly and communicatively connected together by conduit means containing an injector whereby the gas flow from the head of the first regenerative furnace may be accelerated to the head of the second regenerative furnace and the construction being further characterized in that the end of the second regenerative mass opposite from the spaces afore-

mentioned is communicatively connected to and through a heat exchange means, whereby gas flow may be caused to take place up through the first regenerative mass, then through the conduit member containing injector to and through the second regenerative mass and out through said heat exchange member.

3. An apparatus useful for the pyrolytic decomposition of hydrocarbons comprising the combination of a first and a second regenerative furnace, said regenerative furnaces comprising an outer shell enclosing elongated upright regenerative masses having passageways extending lengthwise therethrough, chambers surrounding the ends of said regenerative masses, said chambers forming substantially annular combustion spaces about the end position of said regenerative masses, throats constituting communication between said combustion spaces and spaces adjacent the end of said masses into which said passageways open, burners opening into said annular combustion spaces, another chamber in direct communication with the opposite end of said first regenerative mass, an inlet communicating with said other chamber for admitting hydrocarbon to be treated during a treating cycle, said apparatus being characterized in that the spaces aforementioned at the head of the first and second regenerative masses are directly and communicatively connected together by conduit means of restricted dimensions made up of an

outer conduit having a tapered end which tapered end contains a tapered inner conduit, whereby the gas flow from the head of the first regenerative furnace may be accelerated to the head of the second regenerative furnace and the construction being further characterized in that the end of the second regenerative mass opposite from the chamber above the second regenerative mass is communicatively connected to and through a heat exchange unit, whereby gas flow may be caused to take place up through the first regenerative mass, then through the restricted conduit member, then down through the second regenerative mass and out through said heat exchange unit.

RUDOLPH LEONARD HASCHE.

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