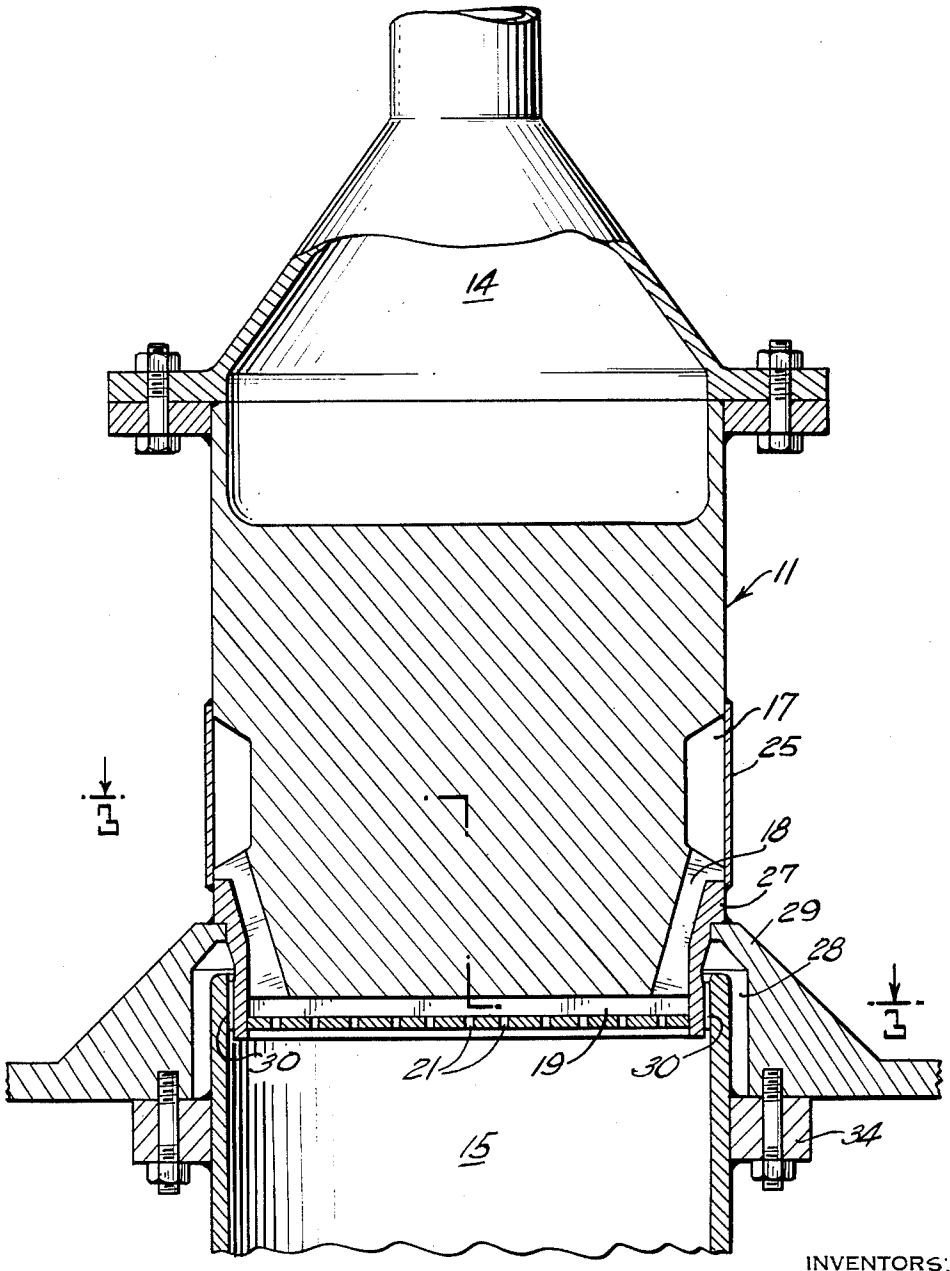
Feb. 18, 1964 F. F. A. BRACONIER ETAL 3,121,616

SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

Filed March 13, 1959 5 Sheets-Sheet 1

Fig. 1.




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SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

Filed March 13, 1959 5 Sheets-Sheet 2

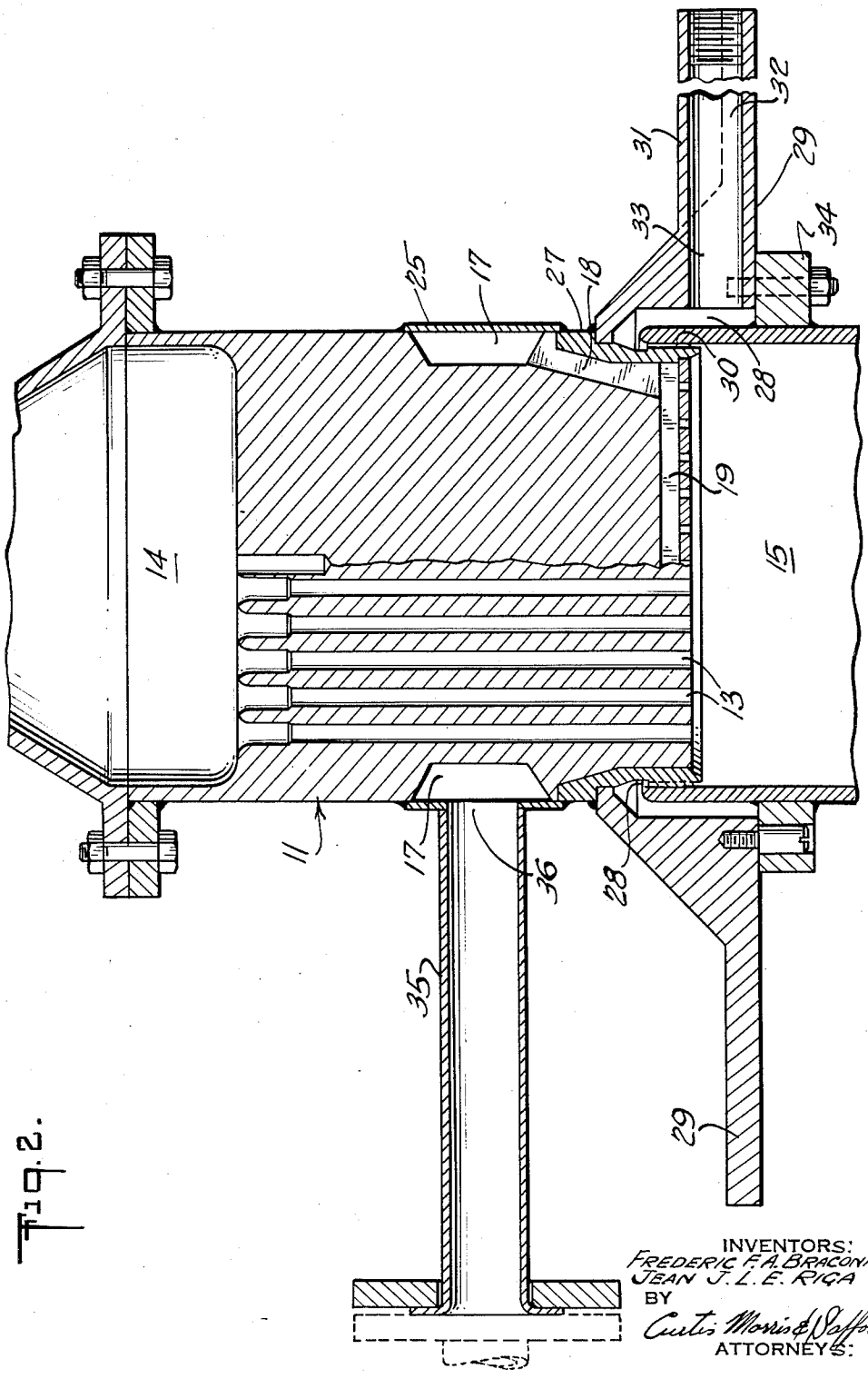



FIG. 2.

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SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

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Fig. 3.

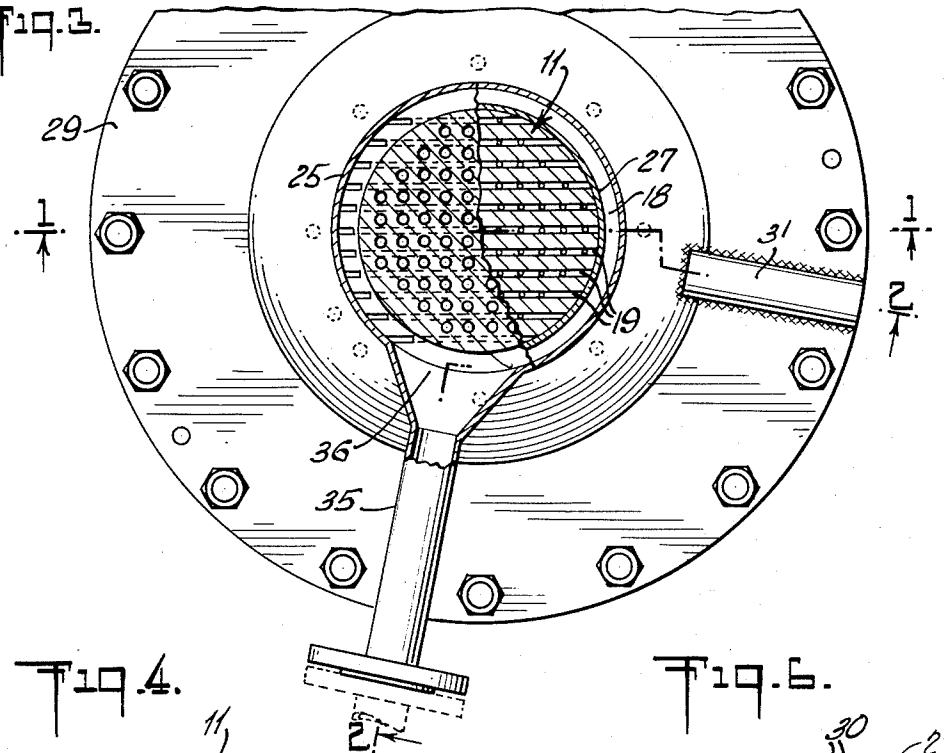



Fig. 4.

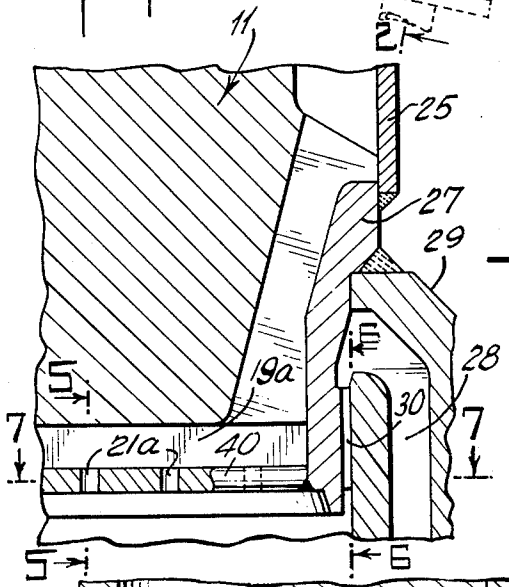



Fig. 6.

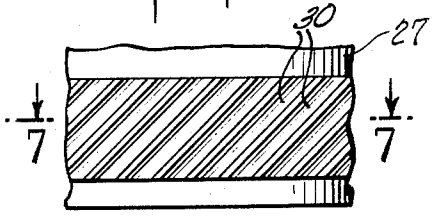



Fig. 7.

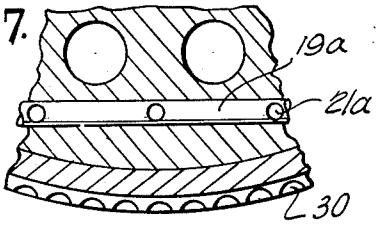
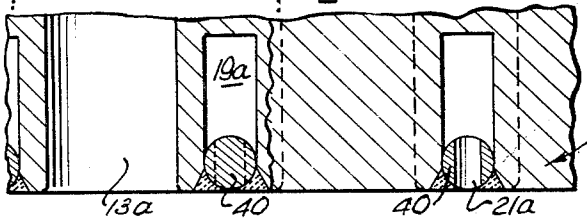



Fig. 5.




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SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

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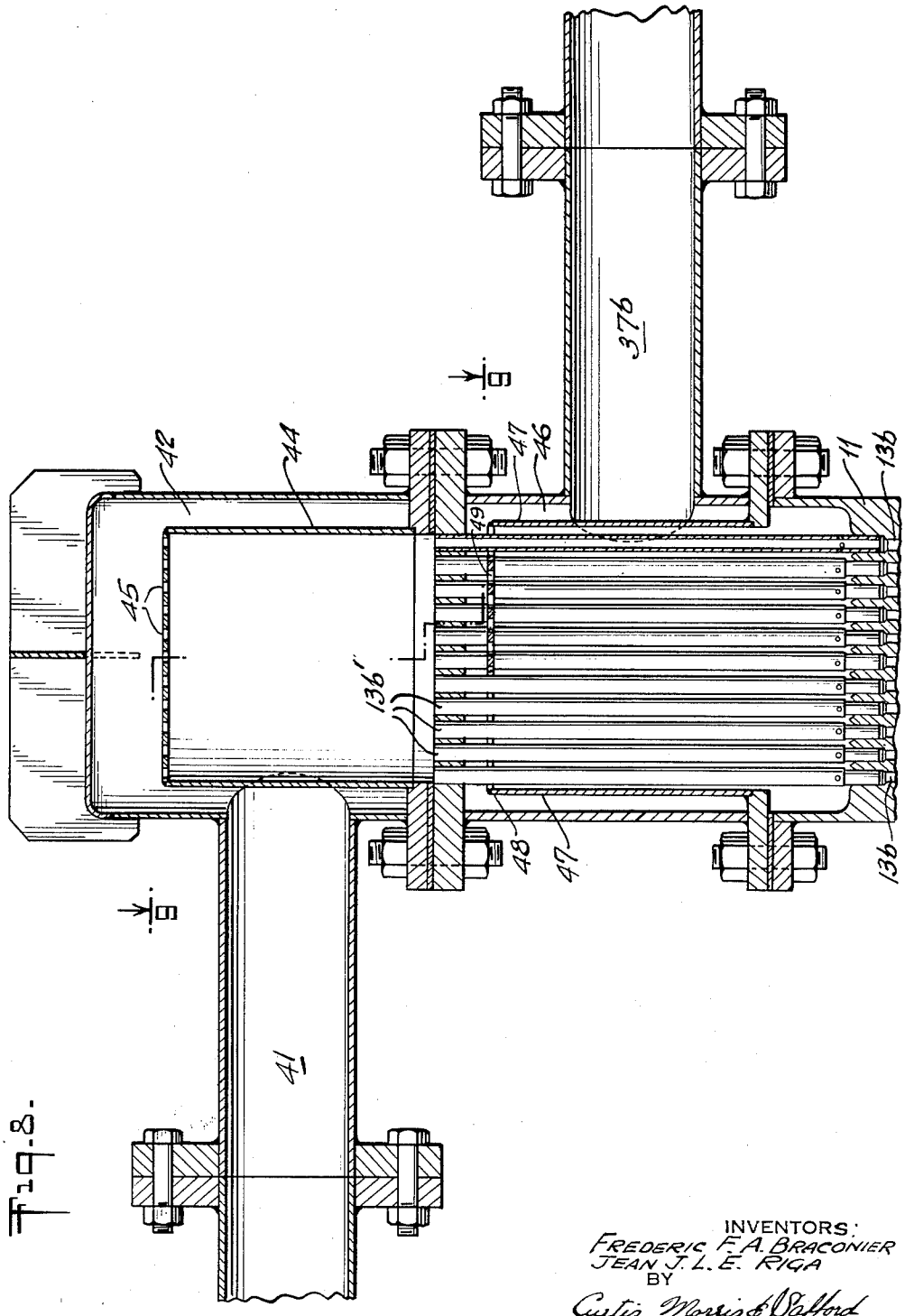



Fig. 8.

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SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

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Fig. 9.

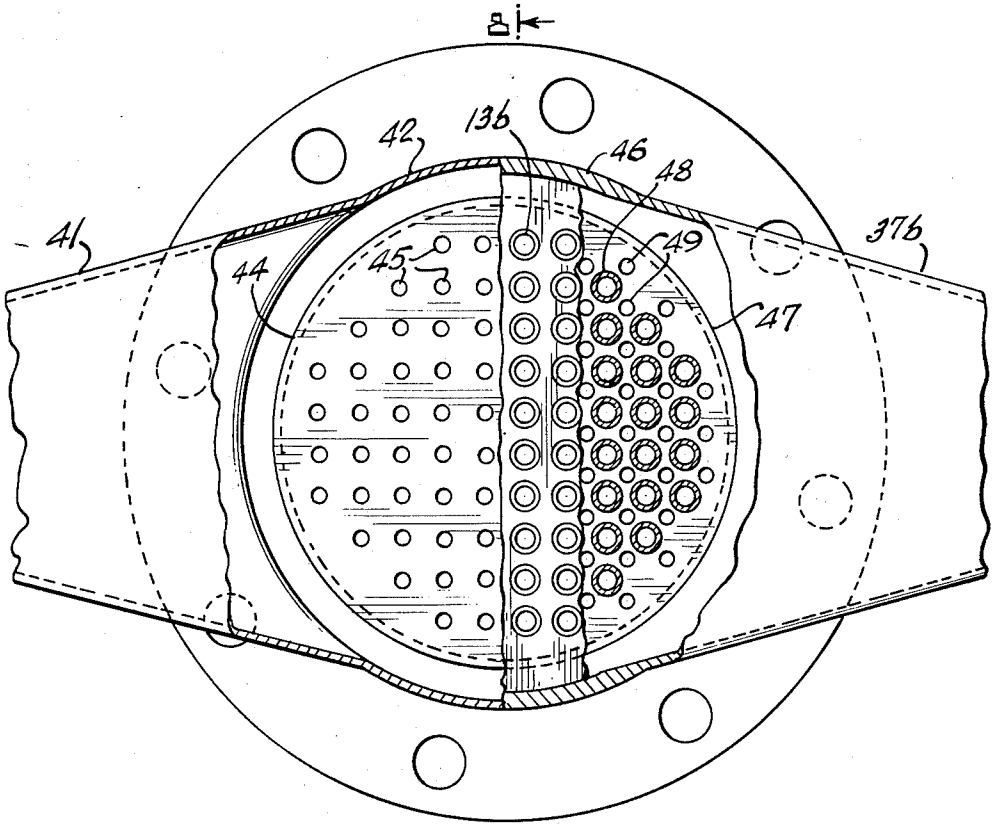



Fig. 10

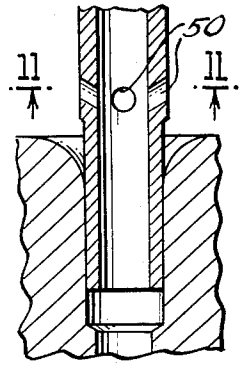
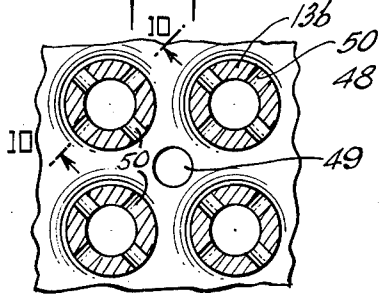



Fig. 11.




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United States Patent Office 3,121,616 Patented Feb. 18, 1964



3,121,616

# SOLID METAL BLOCK REACTION FURNACE FOR TREATMENT OF HYDROCARBONS

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Filed Mar. 13, 1959, Ser. No. 799,289
Claims priority, application Great Britain Apr. 8, 1958
5 Claims. (Cl. 23—277)

This invention relates to a gas distributor for furnaces used for the pyrolysis of hydrocarbons into less saturated hydrocarbons particularly acetylene, or into a carbon monoxide - and - hydrogen - rich gas. This is sometimes called a "partial combustion," since a portion of the hydrocarbon is burned, advantageously with pure oxygen, to provide heat required for pyrolysis of the remaining hydrocarbon. The gas used to support this partial combustion is referred to herein generally as a "comburent" gas.

Furnaces previously recommended for this purpose have comprised mixing chambers, in which the hydrocarbon to be decomposed and the oxygen were commingled in intimate mixture, as uniform as could be, and pyrolysis chambers, and gas distributors with multiple parallel passages between said chambers.

In these passages through the distributor, the flow rate of the gaseous reaction mixture was higher than the propagation velocity of any flame below said passages, so as to preclude flashback, and keep the flame spaced a little beyond the distributor. This is more particularly described and claimed in a copending application, Serial No. 715,404, filed February 14, 1958, now Patent No. 3,073,875.

It has also been recommended to provide such furnaces with means for introducing small quantities of oxygen into the reacting gases so as to make the flames more stable. The oxygen thus added will be hereafter referred to as "pilot oxygen."

Such distributors, as heretofore used, have been made of refractory ceramic material. However, due to the intense heat radiation from the flames, the high velocity of the reagent gases in the passages, and the mechanically poor structure of such distributors, because of the necessity for numerous passages therethrough, they are rapidly damaged and may soon become unserviceable.

It has also been proposed to use distributors which are completely metallic on the side exposed to the flame reaction, but these distributors are provided with cooling devices which, to the extent that they are effective to protect the distributor, also impair the efficiency of the process in the furnace.

In the case of acetylene production, in order to reduce the proportion of the reagents (hydrocarbons and oxygen) with is consumed by combustion, the reagents are advantageously preheated to a high temperature, but below that which would result in spontaneous ignition in the combustion mixture. Obviously, the advantages of preheating are substantially reduced by any circulation of cooling fluid in or around the distributor, which would lead to substantial loss of thermal energy from the feed gases or the combustion mixture.

According to this invention, we use a metallic distributor of such characteristics that heat is efficiently utilized and substantial waste of energy is not required.

In the accompanying drawings is shown a preferred apparatus for carrying into practical use the present invention, and also certain modifications are shown or described in this specification. These are given for purposes of illustration, in order that others skilled in the art may be enabled to make use of the invention and to adapt



and modify it according to the requirements and conditions of various particular uses. It should be understood that neither the drawings nor this specification are intended to be exhaustive, but rather to give such information and detail as will enable those skilled in the art to apply the present invention.

In these drawings:

FIGURE 1 is a diagrammatic view, in vertical axial section, taken on line 1—1 of FIGURE 3, showing a gas mixing and distributing device and a portion of the feed conduits and furnace for partial combustion and pyrolysis of hydrocarbon gases, to which it is appurtenant, all according to the present invention.

FIGURE 2 is a vertical sectional view on line 2—2 of FIGURE 3 showing a feed and distributor device embodying the present invention for supplying the reactant gases to the reaction chamber of the furnace.

FIGURE 3 is a cross sectional fragmentary view taken on line 3—3 of FIGURE 1.

FIGURE 4 is a fragmentary vertical section view similar to FIGURE 2, showing another embodiment of the invention.

FIGURE 5 is a cross section on line 5—5 of FIGURE 4.

FIGURE 6 is a fragmentary view in elevation of the grooved face on the periphery of the distributor, indicated by line 6—6 on FIGURE 4.

FIGURE 7 is a fragmentary cross section taken on line 7—7 of FIGURE 6.

FIGURE 8 is a fragmentary view in vertical axial section similar to that of FIGURES 1 and 2, but showing a modified embodiment and taken on line 8—8 of FIGURE 9.

FIGURE 9 is a cross sectional fragmentary view taken on line 9—9 of FIGURE 8.

FIGURE 10 shows, in vertical axial section, a fragmentary detail of the end of one of the feed tubes and the socket in the distributor block into which it fits; and

FIGURE 11 is a fragmentary cross sectional detail taken on line 11—11 of FIGURE 10.

Referring to FIGURES 1–3, the distributor 11 is shown as a cylindrical block, advantageously of refractory steel, having a thermal conductivity as high as possible. This distributor is traversed longitudinally by passages 13, each advantageously having a substantially constant cross section along its length, for passing the preheated gaseous reaction-mixture from the mixing chamber 14 to the combustion chamber 15, e.g., of the type shown in our copending application Serial No. 715,404, filed February 14, 1958, now Patent No. 3,069,248.

The reaction gases are mixed in the chamber 14 by known means, advantageously such as are disclosed by the copending applications Serial No. 664,400, filed June 7, 1957, or No. 726,248, filed April 3, 1958, now Patents No. 3,081,818 and No. 2,970,178, respectively.

On the periphery of the distributor block 11, and approximately at its half height, is an annular cavity 17 which serves as a header channel to receive additional oxygen and distribute it to a series of transverse passages 18, 19 which traverse the block 11, and are perforated at 21 along the inner face of the distributor (i.e., on the side facing the combustion chamber 15). These perforations 21 serve for distributing additional "pilot" oxygen in the combustion chamber to maintain stable flame conditions therein.

Such a distributor is mechanically and thermally stable since, on the one hand, it can be substantially all in one piece, instead of being welded together from many elements, and, on the other hand, it remains at a temperature substantially lower on the side facing the combus-

tion chamber than that which might cause overheating and consequent destruction or deformation.

This thermal stability of the distributor, under which the excess heat received on the inner face of the distributor from the flame is carried off and utilized by the preheated gases, is determined by:

(1) The arrangement of passages in the metallic cylindrical distributor block 11, through which the gaseous mixture is distributed over the transverse area;

(2) The perforation ratio, i.e., the ratio of the total transverse area of the open passages at the inner face of the distributor exposed to the flame (herein referred to as the "hot face"); and

(3) The diameter of said passages.

These factors are chosen in view of the temperature at which the gases are supplied, and the flame temperature in the furnace, so that heat transmitted to the hot face of the distributor by direct radiation from the flame is carried off by the gases passing through the distributor. As the gaseous mixture is already preheated and is merely further preheated by this passage and, furthermore, as the passages 13 are distributed over the transverse area, there is at the front of the distributor no excessive temperature gradient, which would lead to a deformation or collapse by melting at the face of the distributor. Moreover, the energy of this radiation is thus returned to the reaction zone as the final preheat in the gaseous mixture, so that less combustion is required and, therefore, less oxygen and less hydrocarbon are supplied to provide heat for the pyrolysis.

By preheating the gases above the temperature of spontaneous combustion of the entire supply of reactants, if mixed together, a further gain in efficiency is attained—i.e., less of the gas is required for burning and more, therefore, produces the intended products. This reduction in the amount of combustion heat required permits a lesser proportion of oxygen in the reaction mixture, and this in turn raises the temperature of spontaneous combustion (assuming all gases to be homogeneously mixed). Thus, the efficiency is multiplied.

In order to further reduce the amount of combustion required and thus further multiply the efficiency, we mix with the hydrocarbon gas feed less than the total oxygen required to maintain a stable flame, but advantageously enough to assure heating of all parts of the gas to the pyrolysis temperature in the reaction chamber, and we then supply additional oxygen in small jets homogeneously distributed over the transverse area of the chamber, which stabilizes the flame in the chamber. This we generally refer to as "pilot" oxygen.

With due regard to the nature of the treated hydrocarbon and the degree of preheating of the gaseous reagents, the diameter of the distributor feed passages 13 must be kept within limits such that the flow rate (linear speed) through them is higher than the flame propagation velocity in the mixture, whereby to avoid backfires, but is low enough to keep the flame close to the ends of the mixing passages 13.

The header channels 17 for distributing the pilot oxygen and the conduits 19 have such cross section that the initially cold oxygen circulates therein with a rate giving it a relatively important thermal transmission coefficient. In consequence, said oxygen gets heat from radiation by the flame in the furnace 15 through the metal of the distributor face. This heat, although not a serious loss of calories from the combustion zone, is nevertheless very effective to increase the flame-stabilizing activity of said oxygen and for controlling heating up of the distributor face by radiation from the flame.

It is important that such a completely metallic distributor will remain thermally stable, without excessive overheating of the face on the side of the combustion chamber. This is attained, according to this invention, by the heat transmission between the distributor and the gases passing therethrough.



However, it is also important that the flow rate and the Reynolds number for the gaseous mixture, at the outlet of each passage 13 of the distributor are adjusted to obtain and to maintain a stable, well defined flame front.

Systematic experiments with a mixture of methane and oxygen have shown that, when preheating said mixture to 600° C., the diameter of the passages 13 of the distributor are advantageously in the range of from 12 to 13 mm., with a spacing of 24 mm. between the axes of said passages. Such a diameter results in a well-defined flame front, while said spacing gives the heat stability of the distributor.

When the preheating temperature of the gaseous mixture is higher, the outlet rate of the mixture from the passages 13 of the distributor is advantageously reduced, i.e., by increasing the diameter of each passage. Thus, at a temperature of approximately 700° C., the diameter of the passages is about 14 mm. For much higher preheating temperatures, the reactivity of the gaseous mixture is sufficiently increased so that it is not necessary to reduce the outlet rate of the mixture and diameters of 12 to 13 mm. are again suitable.

Other experiments with gaseous mixtures of oxygen and a methane-rich gas containing hydrogen (i.e., gases more reactive than methane) showed that the diameter of the passages 13 ought to be lower than 12–13 mm., e.g., 10 to 11 mm., according to the preheating temperature.

In general, the diameter of the passages 13 ought to be between 10 and 14 mm. to maintain a stable and well defined flame front in the combustion chamber but said diameter may vary according to the nature of the fuel gas and the thermal conductivity thereof, as well as the temperature and throughput of the mixture of said fuel gas and oxygen.

In general, also, the spacing between the axes of the passages 13 must be kept between 1.8 and 2.2 times the diameter of the passages, preferably about 2 times the diameter, to obtain the desired thermal stability of the distributor.

The gaseous mixture must also be distributed homogeneously in the combustion chamber under stable conditions of flow from the outlets of the distributor, in spite of turbulence of the reagents which may occur at the inlets to said passages. For this purpose, the passages 13 have sufficient length, e.g., 15 to 20 times the diameter of the channels, and their ends are appropriately profiled.

A preferred embodiment comprises locating the passages with their axes on the corners of squares (i.e., on equidistant parallel planes and spaced along said plane by the same distance as that between the planes). A hole for introducing pilot oxygen into the combustion chamber is situated at the center of each of said squares. Such a distribution of the different holes leads to a particularly homogeneous distribution of the reagents in the combustion chamber.

The distributor 11, as shown, can be made from a solid block with the channels 17 and 18 machined out and the passages 13, 19 and 21 drilled out, or the passages 13 and 19 may be formed by cores when block 11 is cast, the passages 17 and 18 being formed as grooves by corresponding ridges on the casting mold.

Confining bands 25 and 27 may then be fitted over the periphery and welded, to close the channels 17 and 18, and an external flange ring 29 may be welded to the band 27, leaving a header passage 28 for water, which flows through grooves 30 to provide a flowing curtain, as described and claimed in a copending application, Serial No. 715,404, filed February 14, 1958. An inverted channel member 31 is welded to the ring 29 over radial groove 32 to form, with the hole 33, a feed pipe for the water curtain header passage 28. The bottom of the passage 28 is closed when the flange 29 is clamped onto the supporting flange 34 on the exterior of the furnace 15.

A pilot oxygen supply pipe 35 is aligned with a hole 36

in the band 25 and is welded thereto, giving communication with the header channel 17.

Because of the integral construction, it is feasible to make the passages 13 both small and close together. Thus, even in the example just described, the close proximity of these passages is not seriously limited by the need for the passages 19 between them.

If desired, the distributor can be cast in one piece with the various flanges and passages all formed by disintegrable cores. If it is more convenient, the pilot oxygen passages may be formed as grooves 19a (FIGURES 4 and 5) into which are welded rods 40 drilled to form the pilot holes 21a.

In FIGURES 8 to 11 is shown another embodiment of the invention which also embodies improvement inventions. In this case, one of the reactant gases, advantageously the hydrocarbon, is fed through the conduit 41 to the annular chamber 42. An interior chamber 44 serves in this embodiment as means for assuring uniform distribution of the incoming gas throughout the transverse area of the chamber. The sides of this chamber 44 are closed to the gases, but the top is perforated with a plurality of openings 45, one for each of the passages 13b'. A head space above the top of chamber 44 is sufficient to allow free radial or spiral flow to all the openings 45. Thus, the gas, on entering the chamber 44, divides itself into parallel currents, each entering at 45 and passing to the tube 13b' below it. These tubes 13b' are fitted into enlarged ends of the passages 13b in the distributor 11b. Advantageously, their bores are the same, so that there is a substantially continuous smooth passage for the gases through 13b' and 13b.

The other reactant, advantageously oxygen, is fed by the conduit 37b to the annular chamber 46 within which is the interior chamber 47 provided at its top with a head space for transverse flow and openings 48 in said top fitted to the tubes 13b and intermediate openings 49 which, like the openings 45, serve as means for assuring uniform distribution of the gas from the feed conduit 37b. In this case, however, the gas current flowing down from each opening 49 divides itself near the bottom of the chamber 46, so as to feed four inlet openings 50 into the adjoining tubes 13b, as shown in FIGURE 11. As shown in the preferred embodiment, the openings 50 are radial to the gas currents which flow vertically down from the openings 49, and since there are four tubes arranged around these currents, there are four openings 50 in each tube.

The distributor 11 completes the feed apparatus for the furnace. The form of the distributor, shown in FIGURE 8, may be like that of FIGURE 1, described above.

The diameter of the passages in this block 11 is such as to respond to the following conditions:

(*a*) Pre-heating of the reactive gases, e.g., to a temperature of 800 to 850° C. without danger of flash-back into the passages 13.

(*b*) Stability of the flame against blowing out, even though blow-out of the flame should be feared when reactants are strongly heated.

*Example*

The metallic distributor 11, in this instance, is manufactured from a cylindrical block of refractory steel, with 18% of nickel, 8% of chromium and stabilized with titanium. This block is 200 mm. in diameter and 230 mm. in height. 32 channels 13 have been bored in that block for passage of the mixture of the gaseous reagents. These channels have a diameter of 14 mm. and are disposed so that the axes of said channels are at the corners of squares having sides of 26 mm. In the centers of said squares, channels 21 for the distribution of pilot oxygen have been bored, each of said channels having a diameter of 5 mm. Other channels 21 have been also bored on the periphery of the distributor so that, on the whole, we have 45 channels 21.

Said channels 21, with a height of 5 mm., connect the combustion chamber with 9 transverse passages 19, each having a diameter of 10 mm. and communicating with the feed-ring channel through channels 18, the axes of which are inclined approximately 15° with respect to the axis of the burner.

Said distributor has been adapted both to the mixing device represented in FIGURES 1 and 2, consisting of only one truncated mixing chamber, and to the multitubular mixing device represented in FIGURE 8.

In both cases, 97.5% pure oxygen in amount of 160 Nm.³/h. (calculated to 0° C. and 760 mm. Hg) and 325 Nm.³/h. of methane have been introduced in the mixing device, both reagents being preheated to 685° C. The mixture of the reagents is divided into the 32 channels 13 and is uniformly distributed into the combustion chamber 15. 20 Nm.³/h. of additional oxygen are also distributed into said chamber through the 45 channels 21. The gaseous reagents are ignited in chamber 15, resulting in a partial combustion reaction with the formation of acetylene, which is stabilized by quenching, namely, by injecting cold water transversely across the stream of product gas.

The conversion rate of methane into acetylene is 29%.

For one ton of acetylene, the specific consumptions are 6050 Nm.³ of methane and 4.800 kg. oxygen (calculated as pure).

Comparative experiments effected with a comparable apparatus, except that the distributor is provided with a cooling device, show that, for one ton of acetylene, the consumptions are higher, namely, 6.700 Nm.³ for the methane and 5.600 kg. for the oxygen, the conversion rate of methane into acetylene being then only of 26%.

Methane and oxygen preheated at 750° C. have been treated with the distributor of the invention, in the apparatus with the multitubular mixing device of FIGURE 8. A pyrolysis gas has been obtained which, calculated as dry, contained 9% by volume of acetylene.

The distributor has been used during long experiments and it has been found to be thermally quite stable and no back-fires occurred into the mixing device.

Reference is also made to co-pending application Ser. No. 432,216, filed May 25, 1954 (based on a prior Belgian application filed June 30, 1953), now abandoned, and to the continuation thereof, Ser. No. 825,619, filed December 22, 1958, now Patent No. 3,069,248.

We claim:

1. In a pyrolysis furnace having a combustion chamber into which are supplied a preheated mixture of reactant gases including a combustible gas and a comburent gas for partial combustion reaction therein producing a hot flame and a gas distributor for supplying and distributing said mixture of gas axially into said combustion chamber in a plurality of gas streams uniformly spaced over the cross section of said combustion chamber and for confining said hot combustion flame reaction to said combustion chamber, the combination which comprises for said gas distributor a solid block of refractory metal including a substantial plurality of axially extending borings defining a plurality of passages for said plurality of gas streams through said distributor, said distributor extending axially of said furnace from said combustion chamber in a direction upstream of the flow of said mixture of gases and the cross section of said distributor being substantially coextensive with the cross section of said combustion chamber for defining at one end thereof a reaction face at which said hot flame of said combustion reaction occurs upon emergence of said preheated mixture of gases from said passages through said distributor into said combustion chamber, the internal diameter of each of said plurality of bored passages through said distributor being within the range of approximately 10–14 mm. and said passages being uniformly distributed over the cross section of said distributor with the axes of adjacent said passages being spaced within the range of about 1.8–2.2 times said internal diameter providing solid metal por-

tions of said distributor between and among said bored passages therethrough whereby heat generated at said reaction face of said distributor by said flame is conducted upstream through said distributor and transferred to said mixture of gases following through said plurality of passages for cooling said reaction face of said distributor, means in said distributor and upstream of said reaction face thereof for supplying a further portion of said comburent gas separately among said axial borings and through said distributor for additional heat removal therefrom, and means for introducing said further portion of said comburent gas into said combustion chamber distributed over substantially the entire cross section of said reaction face of said distributor and intermixed with said individual gas streams for combustion therewith in said combustion chamber.

2. In a reaction furnace having a combustion chamber into which are supplied a preheated mixture of reactant gases including a combustible gas and a comburent gas for partial combustion reaction therein producing a hot flame, a gas distributor for supplying and distributing said mixture of gases axially into said combustion chamber and in a plurality of gas streams uniformly spaced over the cross section of said combustion chamber and for confining said flame combustion reaction to said combustion chamber, which gas distributor comprises a solid block of refractory metal axially extending from said combustion chamber in a direction upstream of the flow of said reactant gas mixture thereto, the cross section of said axially extending distributor being substantially coextensive with the cross-section of said combustion chamber for defining at one end thereof a reaction face at which said flame of said combustion reaction occurs upon emergence of said gases from said distributor into said combustion chamber, a substantial plurality of axially extending and closely spaced borings through said distributor forming tubular passages for supplying said preheated gas mixture through said distributor into said combustion chamber in individual streams uniformly distributed over the cross-section of said combustion chamber and said reaction face of said distributor, the portions of said distributor between adjacent said passages being solid metal and each of said passages having an internal diameter within the range of about 10–14 mm. and being distributed uniformly over the cross section of said distributor with the axes of adjacent passages being spaced within the range of 1.8–2.2 times said internal diameter whereby heat generated at said reaction face by said flame recation is conducted upstream through said distributor and transferred to said gas mixture flowing



through said passages for cooling said reaction face of said distributor, a plurality of transverse passages through said distributor and between adjacent said axial borings for introducing further portions of said comburent gas into said preheated mixture of gases within said axial passages at a point spaced upstream of said reaction face, said axially bored passages being located with the axes thereof at the corners of squares, and said transverse passages having outlets disposed at the centers of each said square and in flow communication with said axial passages for said admixing of said additional comburent gas into said preheated gas mixture within said axial passages.

3. A gas distributor as recited in claim 1 in which said means for supplying said further comburent gas includes a plurality of transverse passages through said distributor and between adjacent said axial borings, and perforations in said reaction face of said distributor providing flow communication between said transverse passages and said combustion chamber in interstitial spaces between said axial borings for introducing said further comburent gas in a plurality of axial streams interspersed with said streams of said reaction gas mixture.

4. A gas distributor as recited in claim 1 in which the length of the said axial passages for supplying said combustible gas is within the range of about 15 to 20 times the diameter thereof.

5. A gas distributor as recited in claim 1 in which said means for supplying said further portion of said comburent gas includes a plurality of transverse passages through said distributor and between adjacent said axial borings, and in which said means for introducing said further portion of said comburent gas into said combustion chamber includes means for admixing said additional comburent gas into said preheated gas mixture within said tubular passages at a point spaced substantially upstream of said reaction face.

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