# United States Patent

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[54] **RAPID COOLING FOR HIGH-TEMPERATURE GAS STREAMS**
**2 Claims, 3 Drawing Figs.**

[52] **U.S. Cl.** .......... **261/118,** 23/277, 23/284, 48/102, 208/48 Q, 260/679, 261/28, 261/112
[51] **Int. Cl.** .......... **B01d 5/00**
[50] **Field of Search** .......... 48/211, 102, 196, 212, 215, 95, 107; 23/277, 284; 261/118, DIG. 54; 260/679, 676; 208/48 Q

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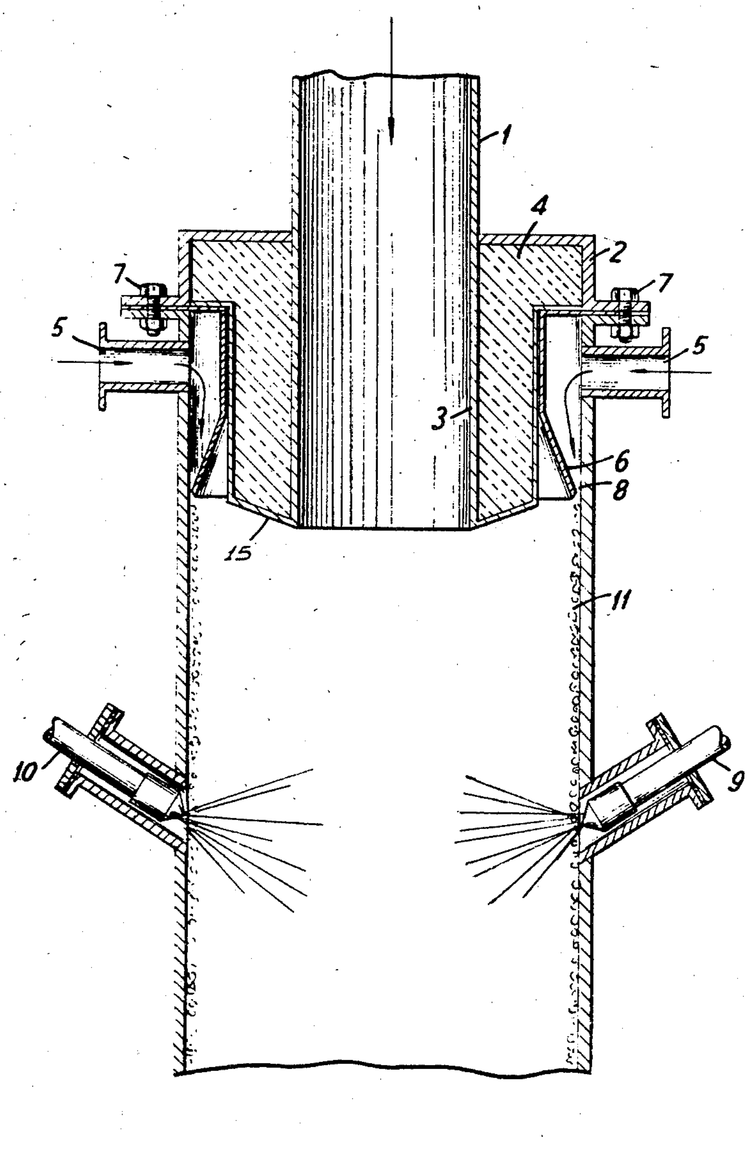
**ABSTRACT:** An improved method and apparatus for cooling a hot pyrolysis exit gas stream by flowing the gas stream downwardly through a quench zone, the walls of which are covered by a film of quench oil while spraying quench oil into the gas stream.



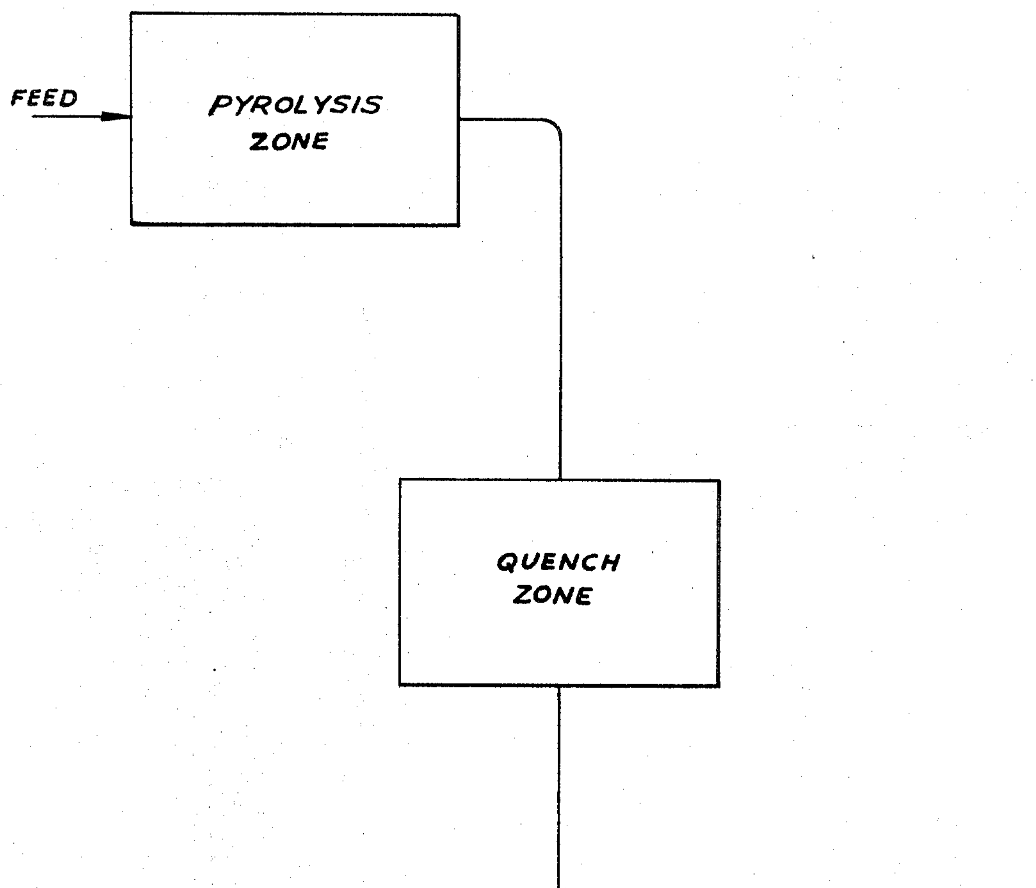



FIG. 1

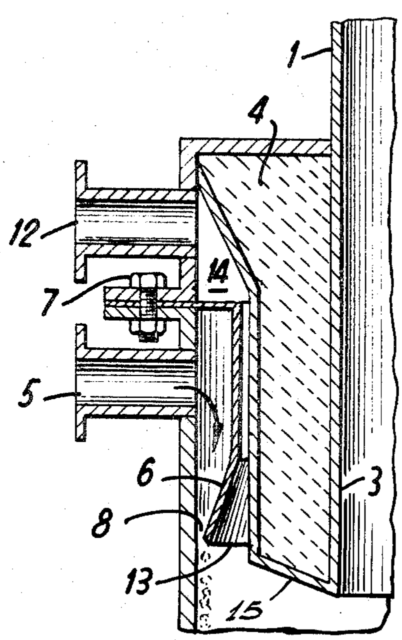



FIG. 3

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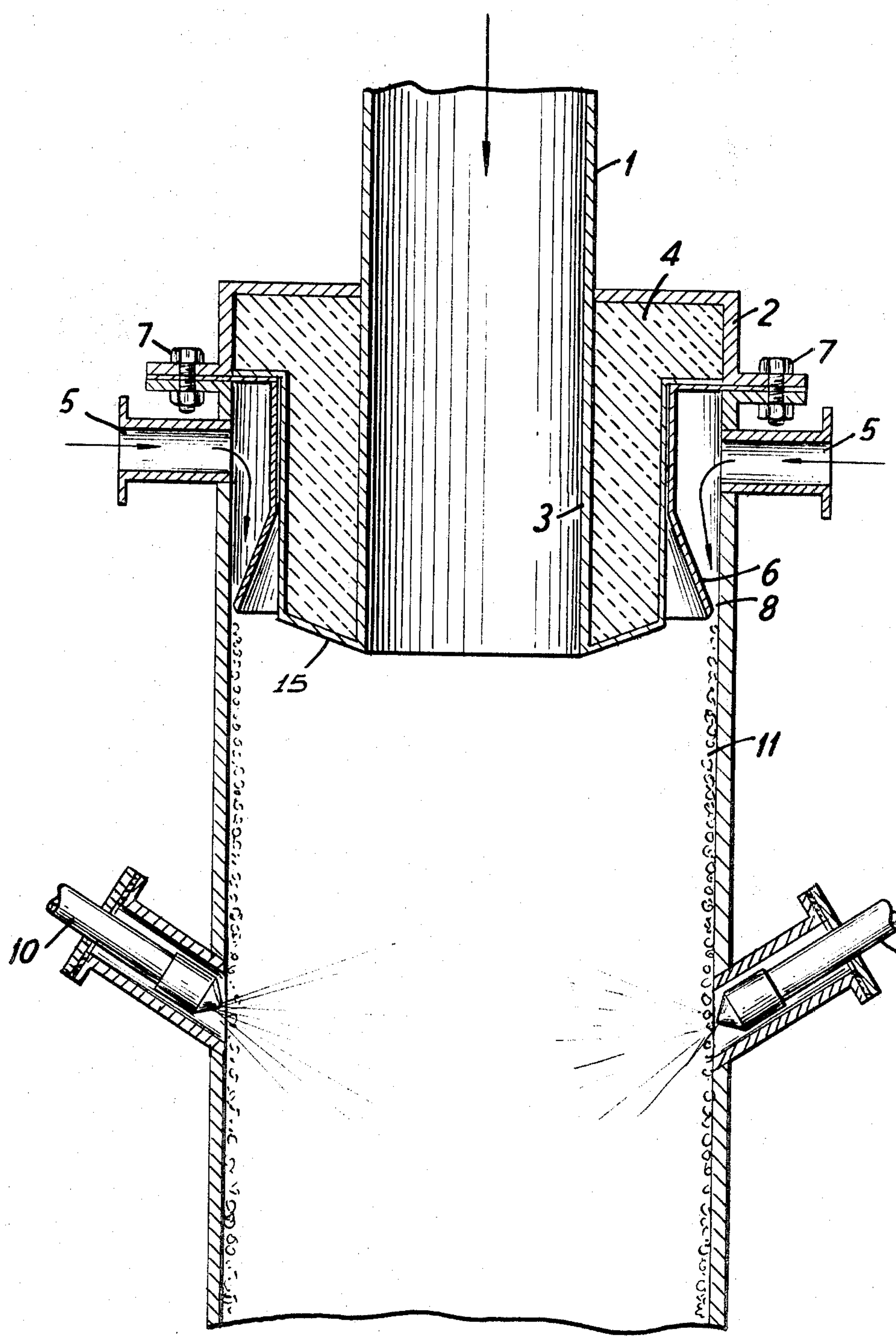


FIG. 2

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# RAPID COOLING FOR HIGH-TEMPERATURE GAS STREAMS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to quenching the gaseous products discharged from pyrolysis furnaces. More particularly, the present invention is directed to reducing the accumulation of inimical deposits of material such as tar or coke in the quench chambers associated with pyrolysis furnaces.

2. Description of the Prior Art

Pyrolysis, or cracking, of organic materials, such as hydrocarbons and petroleum distillates, has become common in industry. Pyrolysis temperatures are very high, generally ranging on the order of about 1,100° to 1,700° F. The art has also recognized the importance of rapidly cooling the hot gases leaving the pyrolysis zone in order to prevent or minimize auxiliary reactions which might tend to produce unwanted products, such as, tars and coke.

It has often been the practice in the past to introduce the hot cracked gas into a quenching zone where it is contacted with a quench liquid and rapidly cooled. A number of techniques have been suggested by the prior art for carrying out the rapid quenching operation from, say 1,600° F. to 500° F. or less. Many of these prior art techniques suffer from the disadvantage caused by the formation of solid coke deposits (or encrustation) on the walls of the quench chamber, the growth of these coke deposits eventually causing a harmful impedance to flow of fluids into or out of the quench chamber and often leading to the need for costly frequent cleaning.

The operating problems connected with the formation of coke deposits are particularly troublesome during the quenching of the products from pyrolysis of high-boiling oils such as naphtha, kerosene, and gas oils where, in the course of the quenching, high-boiling oil products are condensed out onto metal surfaces at relatively high temperatures. The condensed liquid is subject to pyrolysis-polymerization reactions leading to partial conversion to coke residue which remains on the surface of the quench chamber.

This harmful coke deposition phenomenon is particularly troublesome at the point in the cooling of the pyrolysis gas mixture where the dew point of the gas mixture is just reached and the first small amount of condensed liquid appears. At this point of incipient condensation the very small amount of liquid forming flows very slowly and thus is subjected longest to the pyrolytic-condensation reactions leading to coke deposits. Generally, the rate of coke formation is most rapid when the initial condensation of the pyrolysis product is in the temperature range of about 500°—900° F.

One of the advantages of the present invention is the avoidance of the harmful coke deposits during rapid quenching through the critical 500°—900° F. range with a suitable means for minimizing or eliminating thin, long residence liquid films in the 500°—900° F. range.

The prior art has suggested the use of oil having a high boiling point to wash the cracking residues from the pyrolysis gases as well as to keep the walls free of deposits of tar. The very basic suggestion of using oil having a high boiling point to wash the cracking residues out of the pyrolysis gas and keep the walls of a quench chamber free from tar is made in the German publication Erdol und Kohle-Erdgas-Petrochemie, 15 Jahr, Apr. 1962, pp. 270—273. Also, U.S. Pat. No. 3,353,803 (Nov. 21, 1967) discloses a quench chamber, the inner walls of which are provided with a water film to prevent the deposition of solids.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method and apparatus for maintaining the walls of the quench zone of a cracking unit free from an accumulation of inimical coatings.



It is a further object of the present invention to provide an apparatus which will facilitate the introduction of quench liquid at the wall area of a quench chamber.

In accordance with this invention, there is provided a method and apparatus for quenching hot pyrolysis gases which minimizes harmful coke deposition. By a novel method of introducing the quench fluid into the quench chamber, pyrolysis gases may be cooled to below their dew points under conditions where the chamber walls surrounding the initial condensation are covered by rapidly flowing thick liquid films in which the short residence time at high temperature markedly reduces the extent of the pyrolytic-condensation reactions and coke deposition.

In accordance with the method of this invention, hot pyrolysis gases leaving the pyrolysis furnace or cracking zone are conveyed, under pressure, generally downwardly into a quenching zone. The upper portion of the quenching zone surrounds the lowermost portion of the conduit delivering hot gas from the cracking zone to the quenching zone. The said conduit extends a short distance into the quench chamber and is separated therefrom by a suitable insulation means, said means comprising a layer of solid insulation or preferably a combination of solid insulation and one or more annular zones which may be purged by inert fluid such as steam or nitrogen.

At a point along the interior surface of the quenching chamber located preferably upwardly of the lowermost end of the conduit delivering hot gases into the zone, means are provided for flowing a film of quench oil over the entire interior surface of the quench zone. The film of quench oil will generally flow continuously downwardly along the vertically extending walls of the quench zone.

In addition to the means for flowing a film of quench oil, a means or plurality of means are also provided for spraying quench oil into the quench zone into contact with the hot pyrolysis gases whereby cooling is effected.

The length of the quench zone and the temperature and boiling range characteristics of the quench oil are selected in accordance with the initial temperature of the pyrolysis gases and the final temperature desired to be achieved by quenching. At the bottom of the quench zone, means are located for flowing quench oil and quenched gases to suitable fractionating means.

The quench fluid employed is preferably an oil that is capable of wetting the metal walls of the quench zone. Suitable quench oils are those known to the prior art, including various gas oils and light petroleum distillates. The boiling range of the quench liquid should be such that not more than about 75 percent will be vaporized when in use. Similarly, the entry temperature of the quench liquid will be selected in accordance with the final temperature desired for the material leaving the quench zone. The quench liquid which flows down the wall and the quench liquid which is sprayed into the quenching zone may be from the same source or from separate sources, according to availability. When separate sources are used, the higher boiling of the two liquids should be directed to flow down the quench chamber wall while the lower boiling liquid is sprayed into the quench zone.

Further details on the practice of this invention can be obtained from the following drawings in which,

FIG. 1 represents a schematic drawing showing the location of the quench zone in relation to the preceding pyrolysis zone and the subsequent fractionating zone;

FIG. 2 is a sectional elevational view of the upper portion of the quench zone showing one embodiment of the apparatus for applying a film of quench liquid to the walls of the quench zone;

FIG. 3 is a partial sectional elevational view of the upper portion of the quench zone showing another embodiment of the apparatus for applying a film of quench liquid to the walls of the quench zone.

Referring to FIG. 1, it is indicated that feed enters the pyrolysis zone wherein it is cracked and converted to lighter products which leave generally at a temperature between

1,100° F. to 1,700° F. The pyrolysis products flow generally downwardly through the quench zone into a fractionating zone where the quench liquid and various desired products are separated. The quench liquid may then be recycled in whole or in part to the quench zone.

The quench zone is more particularly illustrated in FIG. 2. The conduit **1** from the cracking zone, not shown, extends downwardly into the quench chamber **2**. The terminal portion **3** of the conduit **1** may be surrounded by a layer of insulation **4** to protect the walls of quench chamber **2** from the extremely high gas temperatures. The insulation may be a solid type as shown in FIG. 2 or may be a combination of the solid type and one or more insulating gaps as shown in FIG. 3. The quench chamber **2** suitably can be a metal pipe or chamber having an opening for receiving the lowermost portion **3** of conduit **1**.

Means are provided in quench chamber **2** for continuously delivering a film of quench liquid along the vertically extending walls of quench chamber **2**. As shown in FIG. 2, there are one or more entry ports **5** connected to a source, not shown, of quench liquid at the desired temperature. A metal ring **6** is positioned within the upper part of quench chamber **2** and, as shown, is connected to quench chamber **2** by suitable connecting means such as bolts **7** or by fusion welding. The ring **6** is essentially frustoconical in configuration with a maximum diameter somewhat smaller than the inside diameter of the quench chamber. As a consequence, a small annular opening **8** is provided between the lowermost edge of the ring **6** and the wall of quench chamber **2**. One or more spray means, such as shown by nozzles **9** and **10**, are provided and are connected to a quench liquid supply, not shown, and are positioned to spray quench liquid supply, under pressure, into quench chamber **2**.

When the gases passing through conduit **1** are at a temperature low enough that harmful coking of the nozzle does not occur, a single downwardly directed nozzle centrally located near the exit of the conduit **1** may be used.

The relative dimensions of the parts in the quench zone can be determined in accordance with the desired conditions. Generally, conduit **1** can have dimensions of between about 3 and 18 inches in diameter with quench chamber **2** having a diameter generally at least 4 inches greater than that of conduit **1**. The annular opening **8** should be small and will preferably be less than one-quarter of an inch in diameter.

In operation, cracked gas at an elevated temperature and under pressure passes through conduit **1** and exits through the lowermost portion of conduit **1** into quench chamber **2**. Quench liquid at a temperature below its boiling point is delivered through entry ports **5** and annular opening **8** to deliver a film of quench liquid **11** on the surface of quench chamber **2**. Additional quench liquid is simultaneously injected into the stream of pyrolysis products through nozzles **9** and **10** and any additional nozzles, not shown, found to be necessary to achieve the desired final temperature. The presence of insulation **4** serves to decrease the flow of heat from conduit **1** to ring **6**, thus helping to maintain the ring at a relatively low temperature, ensuring that a minimum of unwanted side reactions will occur in the vicinity of annular opening **8**, thus minimizing harmful coke deposition in that area.

The insulation **4** can be of any common variety of insulating material such as, for example, diatomaceous earth and will have a thickness such that the temperature on the external portion of the insulation will not exceed about 150° F. higher than the quench oil entry temperature. The insulating material is retained in position and protected from the gaseous and liquid environment by a metallic covering **15**. As seen in FIG. 2, the metallic covering **15** is attached directly to the terminal opening **3** of conduit **1** and to the metal wall of the quench chamber **2** by suitable means such as welding.

In a representative system, a pyrolysis gas containing 100 parts by weight of hydrocarbons and 80 parts by weight of steam is passed through conduit **1** into quench chamber **2** where it is cooled using a quench oil which is a gas oil having a specific gravity of 0.910 and a boiling range of 450° F. to 850° F. and which is introduced into the quench chamber at a temperature below 450° F. The hydrocarbon composition of the pyrolysis gases is approximately by weight, 1 percent hydrogen, 13.5 percent methane, 27.4 percent $C_2$'s, 13.2 percent $C_3$'s, 7.0 percent $C_4$'s, 31.4 percent $C_5$–400° F., and 6.5 percent heavy oil. Following the quenching operation, the temperature of the mixture leaving the quench chamber is 575° F.

As a further example of the practice of this invention, a similar pyrolysis gas mixture entering at a temperature of 1,200° F. is quenched with a similar gas oil at a temperature of 270° F. The hot pyrolysis gases are delivered to and through conduit **1** whose diameter is 16 inches at a rate of about 46,000 lb./hr. The quench chamber **2** has a diameter of 24 inches and quench oil is delivered through annular opening **8** at a rate of approximately 700 g.p.m. with the annular opening **8** being 0.135 inches. A single solid cone spray head **9** is provided, operating to deliver about 300 g.p.m. of quench oil from a pressure of 40 p.s.i. g. The total flow of quench oil is regulated to obtain an exit temperature from the bottom of the quench chamber **2** of 350° F. Approximately 10 percent of the quench oil is vaporized and 90 percent exits as liquid. The total length of the quench chamber **2** is about 14 feet.

In another application, a similar pyrolysis gas mixture entering at a temperature of 1,650° F. is quenched by spraying in a similar gas oil at a temperature of 400° F. The hot pyrolysis gases are delivered to and through conduit **1** whose diameter is 8 inches at a rate approximately 20,000 lb./hr. The quench chamber has a diameter of approximately 18 inches. A heavier quench oil of specific gravity 1.02 and boiling range 600° F. to 1,200° F. is delivered through annular opening **8** at the rate of approximately 100 gallons per minute at an inlet temperature of 580° with annular opening **8** being one-sixteenth of an inch. Three solid cone spray heads, one in addition to **9** and **10** are provided, each operating to deliver 55 gallons per minute of quench oil from a pressure of 40 p.s.i.g. The sprayed oil rate is regulated to obtain an exit temperature of the gas leaving the bottom of quench chamber **2** of 588° F. About 50 percent of the quench oil is vaporized. The total length of quench chamber **2** in this instance is about 16 feet.

The embodiment of the present invention depicted in FIG. 3 includes the provision of an annular chamber **14** between the metallic wall **15** and the frustoconical ring **6** which defines the annular nozzle opening **8** for the quench liquid. As in the embodiment of the present invention shown in FIG. 2, an annular array of openings or ports **5** are provided through which quench liquid or oil may be introduced and directed downwardly through an annular opening **8** to coat the walls of the quench chamber **2** with a film **11**. Similarly, the insulation **4** and metallic retaining wall **15** therefore are also present in this embodiment. However, an annular insulation chamber **14** is located between the insulation liner **15** and the annular frustoconical ring **6**. The annular insulation chamber **14** provides an additional thermal insulation structure to protect the quench liquid chamber and nozzle opening **8** from the hot gas discharging from the lowermost portion **3** of the conduit **1**. A plurality of openings **12** are provided through which an inert gas such as steam or nitrogen may be introduced into the system and directed downwardly through the annular chamber **14** between the metallic ring **6** and the metallic insulation liner **15**. The inert gas, which is supplied to the system from a source not shown, is passed through the annular chamber **14** for the purpose of keeping it free of any residue accumulation.

Although the embodiment depicted in FIG. 3 shows a single annular chamber **14** between the metallic ring **6** and the insulation retaining wall **15**, two or more substantially concentric annuli can be provided. When a plurality of annular insulating chambers **14** are used, they are arranged to afford the steam entering the system through openings **12**, with access means to facilitate the passage of steam therethrough.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is shown in the drawings and described in the specification but only as indicated in the appended claims.

What I claim is:

1. Apparatus for quenching a cracked gas stream from a hydrocarbon-cracking furnace comprising a conduit extending into a quenching zone for delivering hot cracked gases generally downwardly into the quenching zone, a quenching chamber surrounding the lowermost portion of said conduit means, said quenching chamber having a larger cross-sectional area than the delivery conduit and extending downwardly to receive the downward flow of the cracked gas stream exiting from the conduit means, an internal sleeve located intermediately of the delivery conduit and the wall of the quench chamber, a frustoconical extremity on the bottom of the internal sleeve defining an annular opening to direct a



flow of quench oil downwardly along the downwardly extending walls of the quench chamber to contact and cool cracked gas flowing therethrough; a layer of solid insulation arranged between the internal sleeve and the portion of the hot gas delivery conduit, which solid insulation layer is configured and arranged to afford at least one annular gap between the internal sleeve and the layer of solid insulation, a plurality of spray nozzles located below the entry of the flowing film of quench oil for spraying additional quench oil into the quenching chamber, to contact and cool cracked gas flowing therethrough, wherein the quench oil has a volatility such that it will be only partially vaporized during the passage through the quench zone.

2. Apparatus as in claim 1 further comprising means for passing inert gas through the annular gap forming part of the insulation means.