United States Patent

Ter Haar

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[45] **May 16, 1972**

[54] WASTE-HEAT BOILER

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[73] Assignee: **Shell Oil Company,** Houston, Tex.

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[30] **Foreign Application Priority Data**

Jan. 21, 1970 Netherlands.....7000812

[52] **U.S. Cl.** .....**122/7 R,** 122/40

[51] **Int. Cl.**.....**F22b 1/18**

[58] **Field of Search**.....122/7 R, 40, 41, 114

[56] **References Cited**

UNITED STATES PATENTS

2,790,428	4/1957	Buttler	122/40 X
2,967,515	1/1961	Hofstede et al.	122/7

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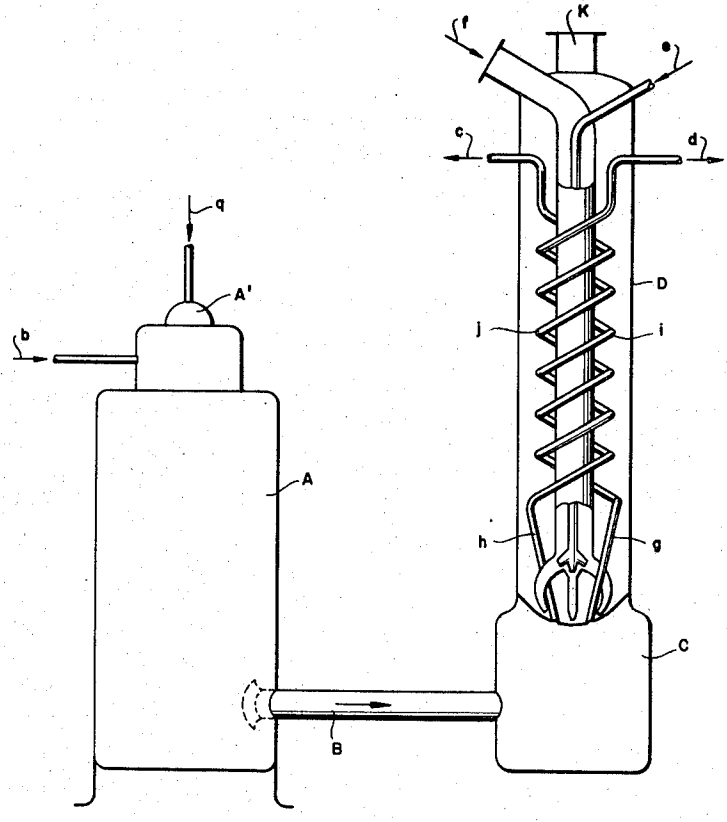
[57] **ABSTRACT**

An improved waste-heat boiler for cooling and recovering heat from hot gases. The improvement comprises employing two concentric tubes for delivering coolant liquid, the coolant liquid from the inner concentric tube under pressure serving as feed to a plurality of ejectors which draw coolant liquid from the outer concentric tube and by means of an arrangement of spray nozzle arms, direct the coolant against the bottom plate of the boiler and the inlet ends of the heat exchange tubes connected thereto.

5 Claims, 4 Drawing Figures



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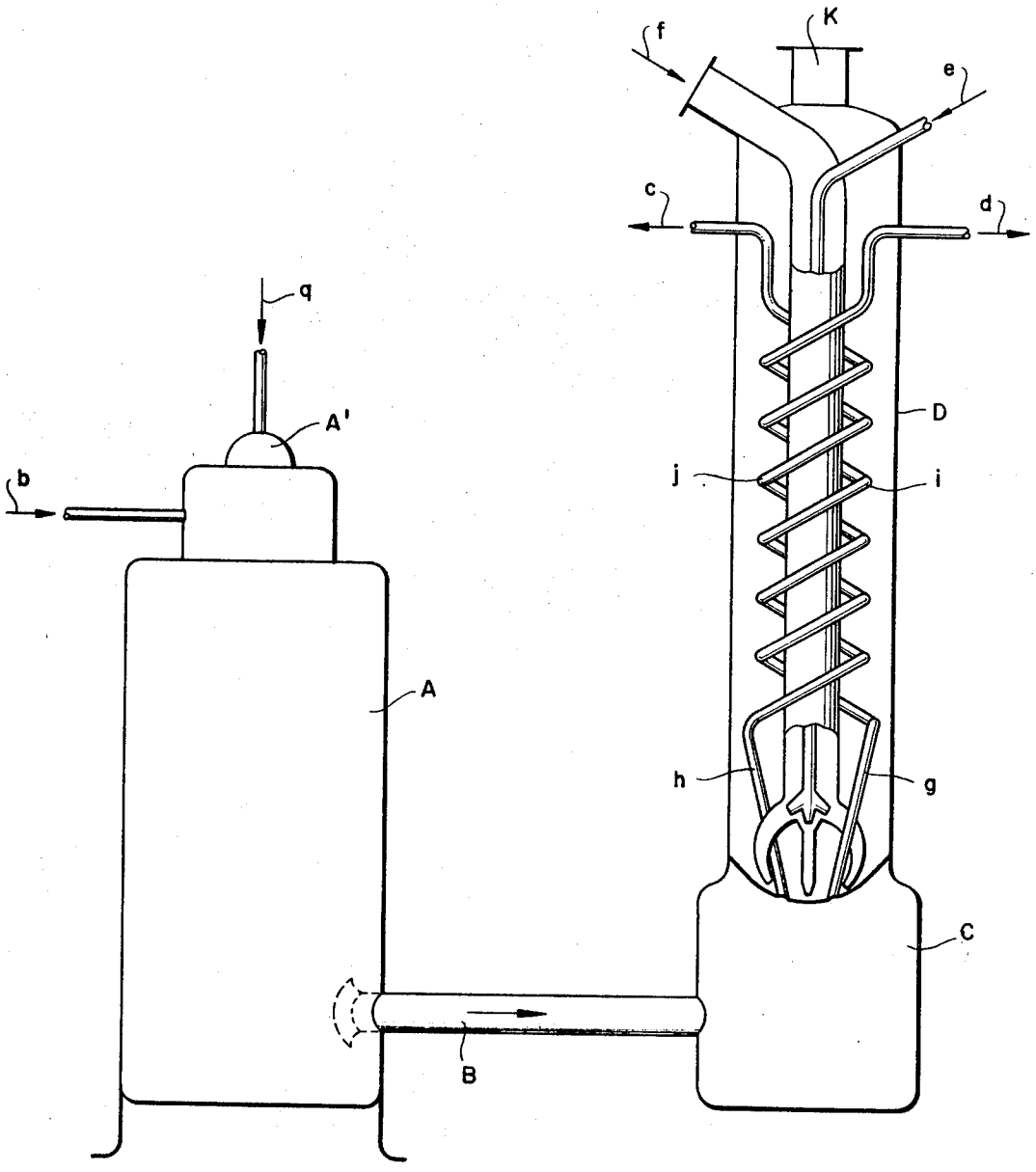

FIG. 1

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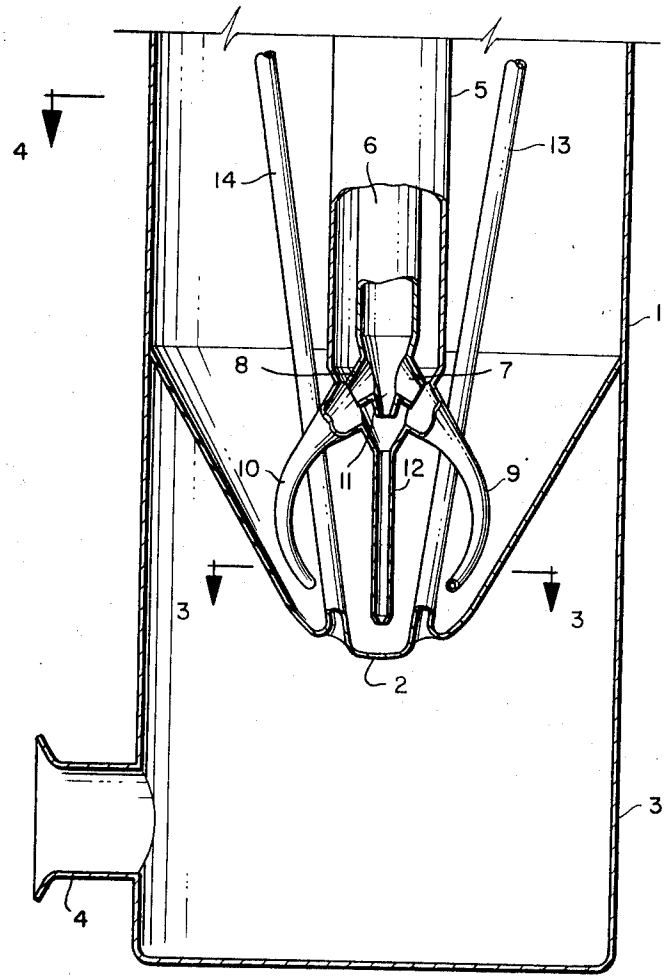

FIG. 2

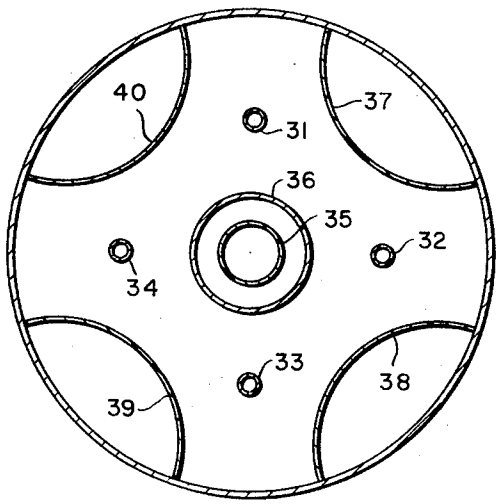

FIG. 4

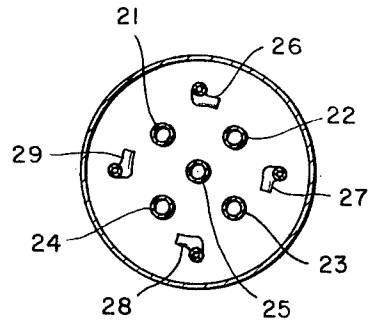

FIG. 3

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WASTE-HEAT BOILER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved apparatus for cooling and abstracting heat from high temperature gases with the generation of steam at superatmospheric pressures, e.g., pressures of from 5–150 atmospheres. The waste-heat boiler herein provided is particularly suitable for the recovery of sensible heat from hot, soot-containing gases obtained by partial combustion of hydrocarbons with oxygen or oxygen-enriched air, e.g., hydrogen and carbon monoxide-containing synthesis gas obtained from an oil gasification process.

2. Description of the Prior Art

Crude synthesis gas produced by the partial combustion of hydrocarbons generally is discharged from the reactor at a temperature of from 1,300° to 1,400° C. or higher, thus making it an obvious source of potential energy. The thermal energy in synthesis gas, however, can be recovered only with great difficulty utilizing conventional heat exchangers, because of the presence in such gas of large amounts of soot (i.e., free carbon), often up to 5 percent or more, which tends to deposit on the inside of the exchange tubes. A number of waste-heat boilers have been proposed for use in recovering heat from such gases, for example, the apparatus described in U.S. Pat. No. 2,967,515 to Hofstede et al. in which helically coiled tubes are employed, or that described in copending U.S. application Ser. No. 87,451, filed Nov. 6, 1970, in which a combination of straight and helically coiled heat exchange tubes are used. In boilers of this general design, hot gas obtained from the partial combustion of hydrocarbons is introduced into the waste-heat boiler and flowed through one or more straight and/or helically coiled tubes connected at their inlet ends to the bottom plate of the boiler. Coolant liquid is normally admitted into the waste-heat boiler through a vertical, radially spaced tube which can be provided with a nozzle so that the coolant is discharged against the hot bottom plate, after which it ascends upward into the space formed between the coolant tube and the shell of the waste-heat boiler, thereby cooling the straight and/or helically coiled tube or tubes accommodated therein.

In view of the high temperatures to which the bottom plate and gas inlet ends of the heat exchange tubes are exposed, it is of obvious importance that these surfaces be adequately cooled. However, this has often proved to be difficult in practice, particularly in waste-heat boilers wherein a plurality of heat exchange tubes are connected to the bottom plate, because of the interference of the tubes with the coolant flow which results in uneven cooling. Conventional waste-heat boilers equipped with a single coolant supply tube suffer from a further deficiency in that in the event of an interruption in the flow of coolant, e.g., because of an operational breakdown, high pressures and temperatures rapidly develop in the boiler creating a potentially hazardous situation. The present invention provides a means of overcoming these problems.

SUMMARY OF THE INVENTION

It has now been found that the heat exchange tubes and bottom plate of a waste-heat boiler can be efficiently cooled by the use of two concentric cooling tubes connected to a novel ejector-nozzle arrangement as hereinafter described. A plurality of ejectors are employed in this arrangement, issuing from the inner of the above-mentioned concentric tubes. These ejectors are fed by coolant under pressure from the inner concentric tube and serve to draw coolant from the outer concentric tube. The coolant discharged from the ejectors and that drawn from the outer tube is directed by means of a plurality of spray nozzle arms against the bottom plate of the waste-heat boiler and the inlet ends of the heat exchange tubes, thereby cooling the same.

DESCRIPTION OF PREFERRED EMBODIMENTS

In a preferred embodiment of the invention, the heat exchange tubes comprise two or more helically coiled tubes each connected to a straight tube through which the hot gas is initially flowed. The straight tubes may be of relatively short length and thus serve merely as connecting pieces, or may be selected longer, if desired, for constructional reasons or to reduce the temperature of the gases before they enter the first coil of the helically coiled tubes.

In one embodiment of the waste-heat boiler of the invention, a central ejector issuing vertically from the lower end of the inner concentric tube is employed, together with at least one ancillary ejector issuing laterally from the lower end of said tube. In this embodiment, the spray nozzle arms extending from the outer concentric tube will be positioned so as to cooperate with and receive coolant from the ejectors, and to direct coolant streams against the bottom plate and the inlet ends of the exchange tubes. The use of a central and plurality of ancillary ejectors and corresponding central and ancillary spray nozzle arms ensures even cooling of the bottom plate and inlet ends of the exchange tubes. This is particularly the case if the number of ancillary ejectors is equal to the number of straight tubes and these ejectors cooperate with the spray nozzle arms arranged symmetrically and issuing between the straight tubes. These arms are preferably curved in such a way that the outflowing coolant acquires a direction of movement with a horizontal velocity component.

In the aforedescribed embodiment, the coolant in the outer concentric tube can be used to provide a measure of cooling even if the flow of coolant in the inner tube is interrupted. This can be conveniently accomplished, for example, by connecting the outer tube to a storage vessel containing coolant located above the waste-heat boiler, so that a continued supply of coolant is ensured even if coolant pressure in the inner tube should fail.

In a specific embodiment of the apparatus, the space of the waste-heat boiler in which the ejector nozzle arrangement is accommodated, has, at the point of connection of the ejectors and nozzles to the concentric tubes, a free cross-sectional area which does not exceed 30 percent of the space accommodating the helical coils. This results in an improved flow of the coolant through the waste-heat boiler.

The above free cross-sectional area may be given the desired value by arranging baffle plates, which, for example, with a waste-heat boiler having four straight tubes, may have the shape of a curved shield and be disposed symmetrically along the wall of the space, the concave side facing the wall.

If desired, the temperature of the gases to be cooled may be lowered by injecting a coolant, for example, water, into the gases after they have left the reaction chamber. This precooling of the gases may be carried out continuously or temporarily, for example, if difficulties should be encountered in supplying coolant to the waste-heat boiler.

The invention will now be further explained with reference to the diagrammatic drawings, which illustrate different embodiments of the apparatus according to the invention.

FIG. 1 is a diagrammatic representation of an apparatus for the partial combustion of hydrocarbons and the cooling thereof.

FIG. 2 is a side view of an embodiment of the waste-heat boiler.

FIG. 3 shows a cross section of an embodiment of the waste-heat boiler through the space accommodating the straight tubes, i.e., immediately above the outflow point of the spray nozzle arms with which the ancillary ejectors cooperate. The waste-heat boiler depicted has four helical coils each connected to a straight tube.

FIG. 4 shows a cross section of an embodiment of the waste-heat boiler through the space accommodating the straight tubes, i.e., at some distance above the level at which the ejector-nozzles are connected. The waste-heat boiler is provided with four helical coils each connected to a straight tube and

with four baffle plates which are arranged in the space accommodating the straight tubes and which extend near to the bottom plate.

Referring now to FIG. 1, part A represents a reactor for partially combusting hydrocarbons which is provided with fuel supply line *q* leading to burner part A' of the reactor, and oxygen supply line *b*. Steam, if used, can be supplied through either *q* and/or *b*. Part B is a connection between the reactor and connecting piece C. The hot gases are passed through the connection B and the connecting piece to waste-heat boiler D which is provided with two straight tubes and two helical coils, discharges *c* and *d* for the cooled gases, inlets *e* and *f* for the coolant (e.g., water) and outlet *k* for the coolant. The straight tubes are designated by *g* and *h*, and the helical coils by *i* and *j*.

FIG. 2 is a side view of a part of the embodiment of the waste-heat boiler. The waste-heat boiler comprises cylindrical vessel **1** having bottom plate **2**, placed on connecting piece **3** which is provided with gas supply line **4**. The waste-heat boiler further comprises concentric tubes **5** and **6** through which the coolant is supplied (under pressure in tube **6**), the bottom ends of which are linked to a spray nozzle comprising central ejector **11** which cooperates with central arm **12** and two ancillary ejectors **7** and **8** which cooperate with arms **9** and **10**, respectively. The coolant, preferably water, is supplied through concentric tubes **5** and **6** and is sprayed against the bottom plate by the arms **9**, **10** and **12**, after which it flows upwards thereby cooling the straight tubes designated by **13** and **14**.

FIG. 3 is a cross section through the space accommodating the straight tubes, taken immediately above the discharge point of the spray nozzle arms of the embodiment shown in FIG. 2, but which has four helical coils, each connected to a straight tube. The cross section shows the four straight tubes, the central arm of the spray nozzle and the four arms with which the ancillary ejectors cooperate. In the drawing, reference numerals **21**, **22**, **23** and **24** designate the straight tubes, **25** is the central arm of the spray nozzle and **26**, **27**, **28** and **29** are the arms with which the ancillary ejectors cooperate. The outflowing coolant acquires a horizontal component of movement as a result of the lateral curvature of arms **26**, **27**, **28** and **29**.

FIG. 4 is a cross section through the space accommodating the straight tubes of an embodiment of the waste-heat boiler having the configuration shown in FIG. 3, but in which the cross section is taken at some distance above the point at which the ejector-nozzle arrangement is connected. The cross section shows the four straight tubes, the concentric tubes through which the coolant flows and the baffle plates for the coolant. In the drawing the reference numerals **31**, **32**, **33** and **34** designate the straight tubes, **35** is the inner tube through which the coolant flows under pressure, **36** is the outer tube from which the coolant is drawn by the ejectors, and **37**, **38**, **39** and **40** are the baffle plates for the coolant.

I claim as my invention:

1. A waste-heat boiler for generating vapors from a coolant by heat transfer from a high temperature gas which comprises: (1) a closed vessel having a bottom plate and an outlet means for discharging vaporized and liquid coolant; (2) a plurality of straight tubes into which hot gas is introduced, each connected at its inlet end to the bottom plate and at its outlet end to a helically coiled tube through which the gas is flowed and discharged from an upper part of said vessel; (3) two vertical concentric tubes for supplying coolant liquid mounted within said vessel in a radially spaced relation thereto and defining with said vessel an elongated annular space in which said straight and helically coiled tubes are situated; (4) a central ejector and plurality of ancillary ejectors by means of which coolant is drawn from the outer of said concentric tubes, said ejectors issuing from the lower end of the inner of said concentric tubes and being fed by coolant supplied therefrom; (5) a central spray nozzle arm and plurality of ancillary spray nozzle arms extending from the lower end of the outer concentric tube, positioned so as to receive the coolant discharged from the ejector and drawn from the outer concentric tube, and discharge the same against the bottom plate and the inlet ends of said straight tubes.

2. The waste-heat boiler of claim **1** wherein the number of ancillary ejectors is equal to the number of straight tubes and the ancillary spray nozzle arms are arranged symmetrically and issue between the straight tubes.

3. The waste-heat boiler of claim **2** wherein the spray nozzle arms are curved laterally so that the discharged coolant acquires a direction of movement with a horizontal velocity component.

4. The waste-heat boiler of claim **1** wherein the space at the point the ejectors and spray nozzle arms are connected to the concentric tubes has a free cross-sectional area of less than 30 percent of the space accommodating the helical coils.

5. The waste-heat boiler of claim **1** wherein baffle plates are present in the space accommodating the straight tubes.

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