May 8, 1956 G. S. MERRITT 2,744,730

APPARATUS FOR QUENCHING HIGH TEMPERATURE GASES

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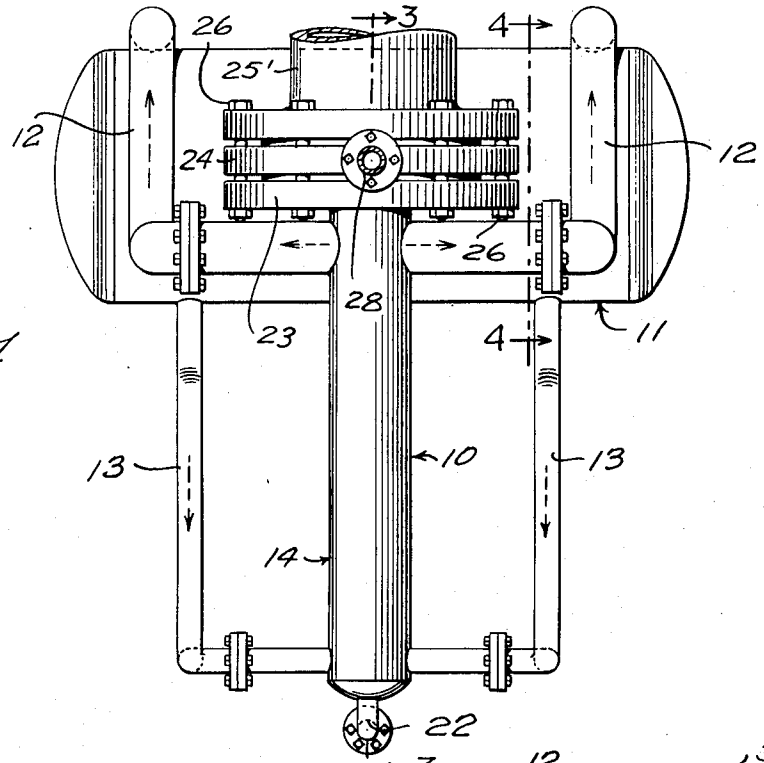


Fig. 1

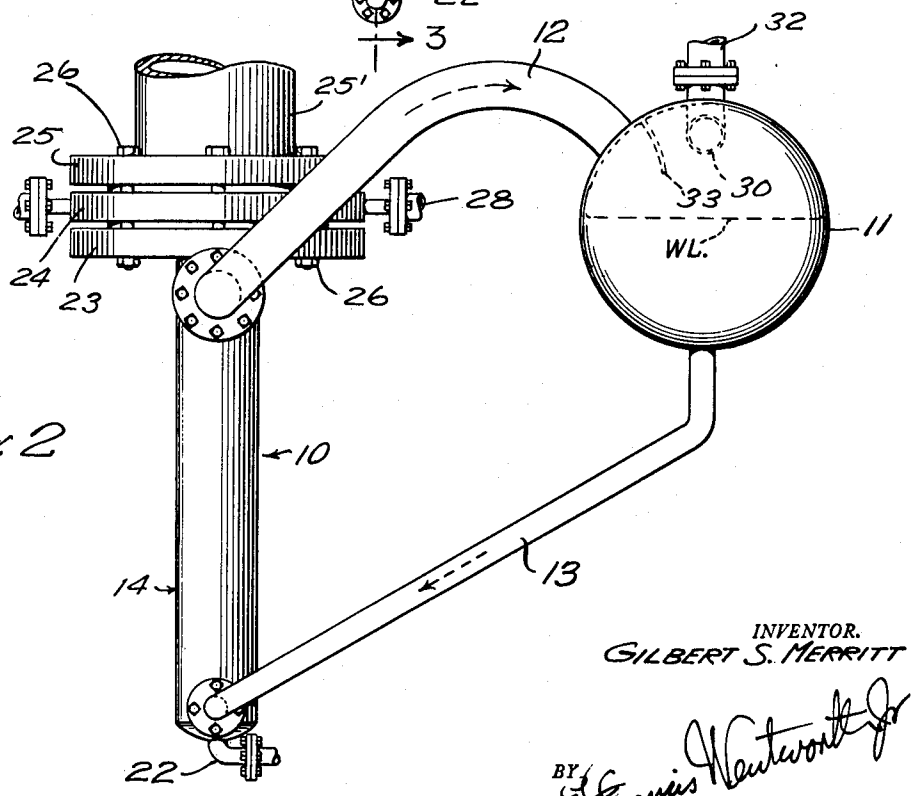


Fig. 2

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Fig. 3

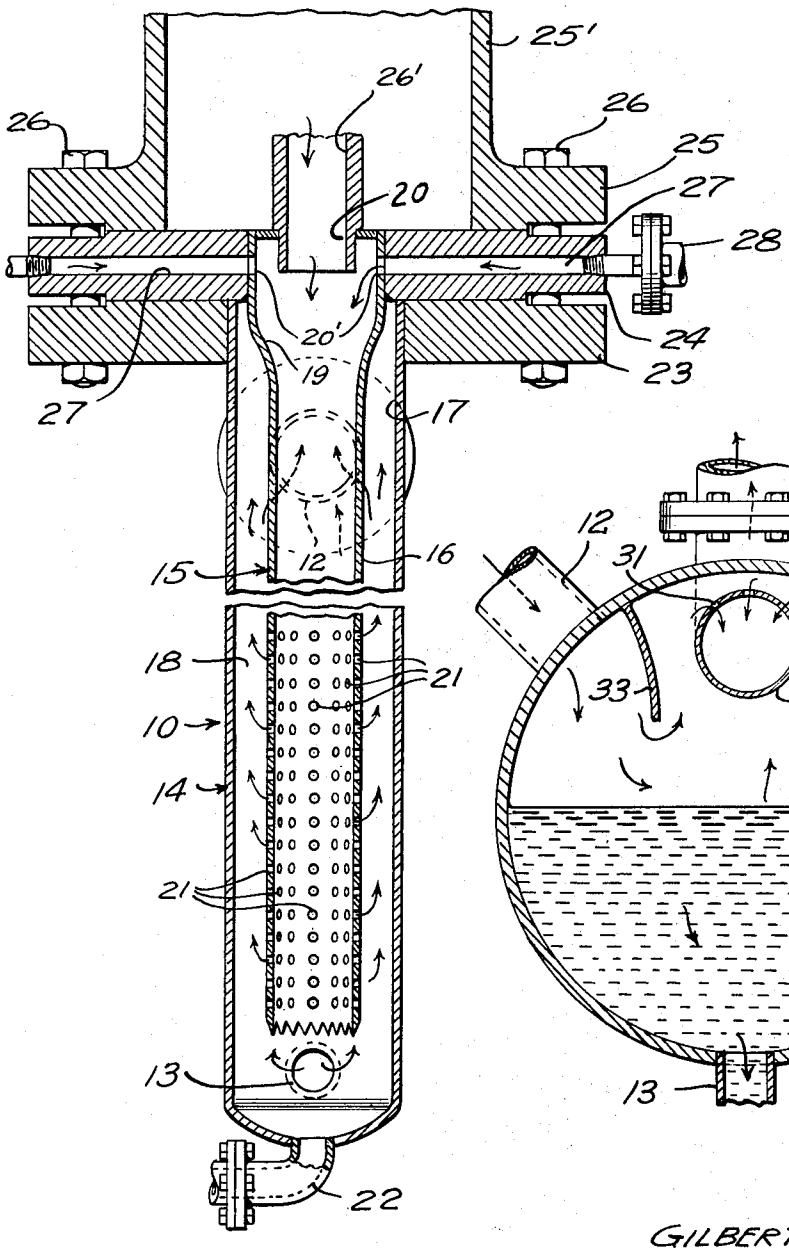


Fig. 4

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United States Patent Office 2,744,730 Patented May 8, 1956

2,744,730

APPARATUS FOR QUENCHING HIGH TEMPERATURE GASES

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Application September 30, 1953, Serial No. 383,308

8 Claims. (Cl. 257—1)

The present invention relates to quenching apparatus and more particularly to quenching apparatus for quenching, cooling, or scrubbing high temperature gases by direct liquid contacting of the gas.

Many chemical reactions, particularly those involving combustion require the rapid cooling or quenching of the gaseous reaction products. For example, rapid cooling of high temperature effluent gases from a pressurized synthesis gas generator in which a reaction involving the partial combustion of natural gas with oxygen is necessary as is the rapid cooling of high temperature effluent gases from a pressurized gas generator in which fuel, oil, coal or other carbonaceous material is reacted with oxygen, oxygen enriched air, or air. Such cooling is frequently accomplished by the direct injection of a volatile liquid into the hot product gases of the chemical reaction. The temperature of the effluent gases is thus quickly lowered due to the rapid transfer of heat from the gases into the liquid with the resultant vaporization of all or a portion of the liquid medium.

Most methods of gas quenching are dependent upon an unfailing supply of injection quench liquid since failure of liquid injection, even momentarily, results in the passage of hot unquenched gases down stream of the normal quench injection point which permits such hot gases to enter piping or equipment not designed to withstand this abnormally high temperature condition. Such condition is particularly hazardous if the apparatus is operating under high pressure. Furthermore, in systems utilizing direct injection of quench liquid, it is difficult to assure adequate and effective gas-liquid contact without the injection of a large excess of quench liquid. Without effective gas contacting, it is possible for gas to pass through such apparatus without complete scrubbing or for the quench apparatus in which the operation takes place to be subjected to wide temperature fluctuations where contacted by hot gases or cold liquid rather than a uniform gas-liquid mixture.

The present invention provides quenching apparatus in which a reservoir of quenching liquid is maintained so as to permit continuation of the quenching operation for a reasonable period of time after stoppage or reduction of the normal quench liquid flow to the apparatus.

This invention also provides a quenching apparatus with continuous circulation of quench liquid so that soot and other solid particles scrubbed from the gases and mixed with the liquid can be easily removed from the apparatus with the blowdown.

The present invention further provides quenching apparatus wherein there is a continuous internal circulation of quenching liquid by means of a gas lift effect, which permits the establishment of high liquid to gas ratios with effective gas and liquid contact and effective scrubbing or quenching of the gas, without the injection of a large excess of quench liquid.

This invention still further provides quenching apparatus which operates at substantially the same temperature, thus avoiding differences in thermal expansion of the apparatus.

The present invention also provides quenching apparatus in which the heat transfer therein is by direct contact between a gas and liquid thereby eliminating scaling or fouling of the apparatus and constricted areas where scaling build-up would retard flow.

In accordance with the present invention, hot effluent gases and liquid pass downwardly into the inner tube of a quenching vessel or tower and outwardly through perforations in the lower portion of the tube into an outer tube in which intimate contacting of the gas and liquid scrubs and cools the gas. A gas-liquid mixture thereafter passes upwardly in the outer tube and through a riser into disengaging or separating drum wherein liquid and gas are separated from said mixture thereof, the separated scrubbed or quenched gases leave the drum through a vapor outlet in the upper part of the drum while the separated liquid passes into a liquid containing portion in the lower part of the drum and is continuously circulated therefrom to the outer tube of the quenching vessel or tower by downcomers connecting the drum and said outer tube. The continuous circulation of liquid is maintained between the drum and outer tube of the quench tower due to the difference in density between the heavier liquid flowing downwardly in the downcomer and the lighter gas-liquid mixture passing upwardly in the outer tube and riser. The large capacity of the drum provides a reservoir of water to maintain recirculation of the liquid in case of failure of initial liquid supply to the outer tube.

The invention will be understood from the following description when considered in connection with the accompanying drawings forming a part thereof and in which:

Fig. 1 is an end elevational view of one embodiment of the apparatus of the present invention;

Fig. 2 is a side elevational view of the apparatus of the invention shown in Fig. 1;

Fig. 3 is an enlarged vertical section along line 3—3 of Fig. 1; and

Fig. 4 is an enlarged transverse section along line 4—4 of Fig. 1.

Like characters of reference refer to the same or to similar parts throughout the several views.

Referring to the drawings, the apparatus of the present invention, as illustrated, comprises a substantially vertical quenching vessel or tower **10** in communication with a substantially horizontally extending disengaging or separating drum **11** through a plurality of gas-liquid riser tubes **12** and liquid downcomers **13** (Figs. 1 and 2).

Vessel **10** comprises an outer substantially vertically extending cylindrical casing or outer tube **14**, mounted at the top thereof in a flange **23** hereafter described, within which is disposed a substantially vertical and concentrically arranged inner tube **15** which inner tube **15** is mounted at the top in a flange **24**, hereinafter described.

Tube **15** extends downwardly within outer tube **14** to a point short of the bottom thereof and has its outer periphery **16** in spaced relationship with the inner periphery **17** of tube **14** to form a substantially vertical annular passage **18** therebetween. The upper portion **19** of inner tube **15** is enlarged into a substantially bell shape and provided with a vapor inlet **20** in the top thereof (Fig. 3) which is in communication with reactor vessel **25'** through connector **26'**. Tube **15** has a plurality of liquid inlets **20'** in the sides thereof through which vapor and liquid is introduced thereinto for contacting one another. The lower portion of tube **15** is provided with a plurality of outlet perforations or apertures **21** to discharge a vapor

and liquid mixture therefrom into passage 18. The bottom of the tube 15, as shown, is preferably open.

Outer tube 14 is closed at the bottom while riser tubes 12 are in communication at one end thereof with the passage 18 in the upper portion of said passage above the perforations 21 in tubes 15 and a plurality of downcomer tubes 13 communicate with passage 18 in the lower portion thereof, below the bottom of the inner tube 15. Downcomers 13 permit the introduction of liquid into passage 18 from drum 11 while the risers 12 conduct a vapor and liquid mixture from the upper part of passage 18 to drum 11. A liquid outlet drain or blowdown 22 is provided in the bottom of tube 14 to blow down the apparatus when necessary.

Outer tube 14 of vessel 10 is secured to substantially horizontal support flange 23 which flange is provided with a central bore while inner tube 15 is secured to substantially horizontal quench flange 24 also having a central bore therein. Flange 24 overlaps passage 18 (Fig. 3) at the top thereof thereby closing said passage. Quench flange 24 is positioned between support flange 23 and reactor flange 25 and the flanges secured in a rigid and fluid-tight manner in relationship to one another by a plurality of bolts 26 disposed in spaced holes in the outer flange peripheries. Quenching tower or vessel 10, is thereby mounted on reactor vessel 25' at the bottom thereof.

Quench flange 24 has a plurality of horizontal liquid inlet passages 27 extending therethrough opposite or in line with the liquid inlets 20' of tube 15 to provide for the introduction into tube 15 of liquid from a liquid feed conduit 28 which feed conduit receives feed from an outside source, not shown.

Drum 11 is provided in the upper portion thereof with a longitudinally extending dry gas pipe 30 (Fig. 4) having a plurality of spaced orifices 31 in the upper part of said pipe. Preferably, drum 11 is positioned so that the normal water line WL is substantially opposite or adjacent quench flange 24 (Fig. 2). A vapor outlet line 32 is connected to pipe 30 and extends outwardly of drum 11 at the top thereof so that vapor passes outwardly of drum 11 through pipe 30 and outlet line 32. Riser tubes 12 have the inlet ends thereof in communication with the upper portion of outer tube 14 (Figs. 1 and 2) and the discharge ends thereof in communication with the upper portion of drum 11. A downwardly curved impingement baffle 33 is secured to the inner periphery of the drum adjacent the top thereof and adjacent the discharge end of risers 12 and extends longitudinally of the drum in such a position so that vapor-liquid mixture entering the drum through the risers will impinge thereon and cause the vapor and liquid particles to become separated from said mixture. The downcomers 13 have their discharge ends in communication with the lower portion of outer tube 14 and their inlet ends in communication with the drum at the bottom thereof so as to provide circulation or flow of liquid from the bottom of the drum to tube 14.

In operation, hot effluent and high pressure gases or vapor from a combustion reaction flow downwardly from reactor vessel 25' through connector 26' into the upper end of tube 15 of quenching vessel 10 through inlet 20. Quenching liquid, for example, water, is passed through feed conduit 28 and passages 27 in quench flange 24 into the upper end of tube 15 through liquid inlets 20'.

The hot effluent gases and quench liquid contact one another in tube 15, the gases being partially quenched by said contact, the gas-liquid mixture thereafter passing downwardly into the lower portion of the tube 15 and out of the lower portion of the tube through perforations 21 into the annular passage 18 between tubes 14 and 15. Perforations 21 permit uniform distribution of the mixture into passage 18. The higher upstream pressure of the incoming effluent gases from the reactor 25' causes the incoming gas and liquid to form a gas-liquid phase or mixture which occupies the larger part of passage 18 during the whole time of operation of the apparatus.

Intimate gas-liquid mixing and contacting takes place in passage 18 with part of the heat content in the original high temperature effluent gas being transferred to the liquid to thereby flash a portion of the water from a liquid state to a gaseous state to lower the gas temperature. The gas-liquid mixture thereafter flows upwardly in passage 18 and out thereof through riser tubes 12 in the upper portion of tube 14. The gas-liquid mixture thereafter flows upwardly in risers 12 and enters the vapor space in the upper portion of gas disengaging drum 11 impinging against baffle 33 therein thereby separating liquid and gas from the mixture thereof. The separated liquid falls downwardly into the liquid space in the drum and the separated gas portion passes around the end of the baffle and upwardly into dry gas pipe 30 through openings 31. The gas thereafter passes from drum 11 through dry pipe 30 and vapor outlet line 32 for further processing or use in a system, not shown. The liquid which has been separated from gas-liquid mixture falls into the liquid space in the drum and returns to passage 18 in quench vessel 10 through downcomers 13.

In the present apparatus, should the normal flow of quench liquid to quench flange 24 be reduced or shut-off, a continuous circulation of liquid is maintained between disengaging drum 11 and quench vessel 10 through downcomers 13 for a reasonable period of time after such shut-off because liquid separated from the mixture of gas and liquid flowing into drum 11 through risers 12 is returned to the liquid space of the drum for further circulation.

Continuous circulation of the liquid takes place between drum 11 and vessel 10 by means of the gas lift effect or driving force which is due to the difference in fluid density between the liquid in downcomers 13 and the mixed gas-liquid phase in the annular passage 18 and gas risers 12. The greater density of the liquid in drum 11 causes the liquid to keep flowing downwardly in downcomers 13 into the lower portion of annular passage 18. The mixture in passage 18 will rise therein and flow out of vessel 10 through risers 12 to drum 11 where the gas and liquid portions will be separated as hereinbefore described. This continuous circulation with the resultant quenching of gas entering vessel 10 will continue until the level of water in drum 11 is completely depleted due to vaporization of it by the quenching of the incoming gas. Thus, the present quenching device maintains a reservoir of quenching liquid in the drum as an ample safety factor to permit continuation of the quenching operation in case of stoppage of quench liquid thereto.

The continuous internal circulation of quench liquid from drum 11 through downcomers 13 into passage 18 of vessel 10 and back into drum 11 in admixture with gas through risers 12 by means of the gas lift effect further permits the establishment of high liquid to gas ratios with effective gas quenching and scrubbing without the injection of a large excess of quench liquid. Quench liquid injected into quench flange 24 need only be in an amount necessary to make up for the vaporization needs and the necessary blowdown requirements to prevent an accumulation of solids in the quench liquid being recirculated by downcomers 13.

Inasmuch as various modifications may be made in the form of the invention herein disclosed and in the location of the parts of the apparatus without departing from the principles thereof, it will be understood that the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. In gas quenching apparatus wherein gases pass in heat exchange relationship with liquid, a gas quenching vessel, means forming a liquid and vapor space in said quenching vessel, means for introducing liquid into said apparatus to provide the liquid and vapor space with the liquid, gas conducting means in communication with a

source of gas to be quenched and with the liquid and vapor space of the vessel to discharge gas into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, means forming a liquid-vapor disengaging space and a liquid reservoir space, said liquid-vapor disengaging space being in communication with said liquid and vapor space to receive the mixture of gas and liquid from the latter for separting the gas from the liquid, gas outlet means communicating with said liquid-vapor disengaging space to discharge separated gas therefrom, the liquid reservoir space being in communication with the liquid-vapor disengaging space for receiving the separated liquid and with the lower portion of the liquid and vapor space to provide the latter with separated liquid of greater density than the gas-liquid mixture, said liquid reservoir space providing a level of liquid with respect to the gas-liquid mixture in said liquid and vapor space to provide a head of liquid effective to cause both displacement of the gas-liquid mixture upwardly in the liquid and vapor space for flow to the liquid-vapor disengaging space and continuous circulation of the liquid between the liquid reservoir space and the liquid and vapor space, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last mentioned flow of liquid.

2. In gas quenching apparatus wherein gases pass in heat exchange relationship with liquid, a vertically arranged gas quenching vessel, means forming a liquid and vapor space in said gas quenching vessel, means for introducing liquid into said apparatus to provide the liquid and vapor space of the vessel with liquid, gas conducting means in communication with a source of gas to be quenched and with the liquid and vapor space of the vessel to discharge gas into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, means forming a liquid-vapor disengaging space and a liquid reservoir space, said liquid-vapor disengaging space being in communication with the upper portion of said liquid and vapor space to receive the mixture of gas and liquid from the latter for separating the gas from the liquid, gas outlet means communicating with said liquid-vapor disengaging space to discharge separated gas therefrom, the liquid reservoir space being in communication with the liquid-vapor disengaging space for receiving the separated liquid and with the lower portion of the liquid and vapor space to provide the latter with sparated liquid of greater density than the gas-liquid mixture, said liquid reservoir space providing a level of liquid with respect to the gas-liquid mixture in said liquid and vapor space to provide a head of liquid effective to cause both displacement of the gas liquid mixture upwardly in the liquid and vapor space for flow to the liquid-vapor disengaging space and continuous circulation of the liquid between the liquid reservoir space and the liquid and vapor space, said displacement and circulation being effective both during the flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

3. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel, means forming a liquid and vapor space in said gas quenching vessel, means for introducing liquid into said apparatus to provide the liquid and vapor space with liquid, gas conducting means in communication with a source of gas to be quenched and with the liquid and vapor space of the vessel to discharge gas into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, vapor and liquid separating means communicating with said liquid and vapor space for receiving the mixture of gas and liquid from the latter and for separating the liquid from the gas, said vapor and liquid separating means comprising a liquid reservoir space for receiving the liquid separated from the mixture of gas and liquid, gas outlet means in communication with said vapor and liquid separating means to discharge separated gas therefrom, the liquid reservoir space communicating with the lower portion of the vapor and liquid space to provide the latter with separated liquid of greater density than the gas-liquid mixture, said liquid reservoir space providing a level of liquid with respect to the gas-liquid mixture in the liquid and vapor space to provide a head of liquid effective to cause both displacement of the gas-liquid mixture upwardly in the liquid and vapor space for flow to the vapor and liquid separating means and continuous circulation of the liquid between the liquid reservoir space and the liquid and vapor space, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

4. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel, means forming a liquid and vapor space in said gas quenching vessel, means for introducing liquid into said apparatus to provide the liquid and vapor space with liquid, gas conducting means in communication with a source of gas to be quenched and with the liquid and vapor space of the vessel to discharge gas into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, a container having an upper vapor space and a lower liquid reservoir space, said upper vapor space being in communication with the upper portion of said first mentioned liquid and vapor space for receiving the mixture of gas and liquid and for separating the liquid from the gas, gas outlet means in communication with the upper vapor space to discharge separated gas therefrom, the lower liquid reservoir space being in communication with the upper vapor space for receiving the separated liquid therefrom, said liquid reservoir space communicating with the lower portion of the liquid and vapor space to provide the latter with separated liquid of greater density than the gas-liquid mixture and a head of liquid effective to cause both displacement upwardly of the gas-liquid mixture in the liquid and vapor space for flow to the upper vapor space and continuous circulation of the liquid between the liquid reservoir space and the liquid and vapor space, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

5. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel comprising an upright outer tube, and an upright inner tube positioned within the outer tube with the outer periphery of the inner tube in spaced relationship with the inner periphery of the outer tube to form a liquid and vapor space therebetween, means for introducing liquid into said apparatus to provide the vapor and liquid space with liquid, said inner tube having a gas inlet opening and a plurality of gas outlet openings in the wall thereof to communicate the interior of the inner tube with the vapor and liquid space, means in communication with a source of gas to be quenched and with the gas inlet opening to provide passage of gas to be quenched into the inner tube and through the gas outlet openings into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, vapor and liquid separating means in communication with said liquid and vapor space for receiving the mixture of gas and liquid from the latter and for separating the liquid from the gas, said vapor and liquid separating means comprising a liquid reservoir space for receiving the separated liquid, gas outlet means communicating with said vapor and liquid separating

means to discharge separated gas therefrom, the liquid reservoir space being in communication with the lower portion of the liquid and vapor space to provide the latter with separated liquid of greater density than the gas-liquid mixture and to provide a head of liquid effective to cause both displacement upwardly of the gas-liquid mixture in the liquid and vapor space for flow to the vapor and liquid separating means and continuous circulation of the liquid between the liquid reservoir space and the liquid and vapor space, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

6. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel comprising an upright outer tube and an upright inner tube positioned within the outer tube with the outer periphery of the inner tube in spaced relationship with the inner periphery of the outer tube to form a liquid and vapor space therebetween, means for introducing liquid into said apparatus to provide the liquid and vapor space with liquid, said inner tube having a gas inlet opening at the upper part thereof and a plurality of gas outlet openings in the wall to communicate the interior of the inner tube with the liquid and vapor space, means communicating a source of gas to be quenched with the gas inlet opening to provide for passage of gas through the inner tube and into the liquid in the liquid and vapor space for intimate mixing of the gas with the liquid to provide a gas-liquid mixture in said space, vapor and liquid separating means for separating liquid from vapor and comprising a liquid reservoir space, conduit means communicating the upper part of the liquid and vapor space with the vapor and liquid separating means to provide the latter with the mixture of gas and liquid wherein the liquid is separated from the gas in said vapor and liquid separating means, said liquid reservoir space receiving the separated liquid, gas outlet means communicating with the vapor and liquid separating means to discharge gas therefrom, second conduit means communicating the liquid reservoir space with the lower portion of the liquid and vapor space to provide the latter with separated liquid of greater density than the gas-liquid mixture, said liquid reservoir space and said second conduit means providing a head of liquid effective to cause both displacement of the gas-liquid mixture upwardly in the liquid and vapor space for flow to the vapor and liquid separating means and continuous circulation of the liquid between the liquid reservoir space and liquid and vapor space, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

7. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel comprising an upright outer tube and an inner tube positioned within the outer tube with the outer periphery of the inner tube in spaced relationship with the inner periphery of the outer tube to form a liquid and vapor space therebetween, means for introducing liquid into said apparatus to provide the liquid and vapor space with liquid, said inner tube having a gas inlet opening and a plurality of gas outlet openings in the wall of the inner tube to communicate the interior of the latter with the liquid and vapor space, gas conducting means in communication with a source of gas to be quenched and with the gas inlet opening to provide passage of the gas within the inner tube and through the gas outlet openings into the liquid in said liquid and vapor space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, a vapor and liquid vessel for separating liquid from vapor and having a vapor space in the upper part thereof and a liquid space below said vapor space, conduit means communicating the upper part of the liquid and vapor space with the vapor space in said vapor and liquid vessel to provide the latter with the gas-liquid mixture whereby the liquid is separated from the vapor in said vapor and liquid vessel, said liquid space being in communication with the vapor space to receive separated liquid therefrom, gas outlet means communicating with said vapor space for discharging separated gas therefrom, second conduit means communicating the liquid space of the vapor and liquid vessel with the liquid and vapor space to provide the latter with separated liquid of greater density than the gas-liquid mixture, the surface of the liquid in the liquid space of the vapor and liquid vessel being at an elevation above the other end of the second conduit means to provide a head of liquid effective to cause both displacement upwardly of the gas-liquid mixture in the liquid and vapor space for flow to the vapor space of the vapor and liquid vessel and continuous circulation of the liquid between the liquid space and the liquid and vapor space of said quenching vessel, said displacement and circulation being effective both during flow of liquid into the liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

8. In gas quenching apparatus wherein gas is passed in heat exchange relationship with liquid, a gas quenching vessel comprising an upright outer tube and an upright inner tube disposed within the outer tube and spaced from the latter to define a liquid and vapor space, said inner tube extending longitudinally of the outer tube and having its lower end spaced from the lower end of the outer tube, said inner tube further having a gas inlet opening and a plurality of gas outlet openings spaced from the gas inlet opening, said gas outlet openings being formed in the wall of the inner tube to communicate the interior of the latter with the liquid and vapor space, means for introducing liquid into said apparatus to provide the liquid and vapor space with liquid, means in communication with a source of gas to be quenched and with the gas inlet opening to provide for the passage of gas in the inner tube and through the gas outlet openings into the liquid in said space for intimate mixing of the gas with liquid to provide a gas-liquid mixture in said space, a vapor-liquid outlet formed in the outer tube at an elevation between the gas inlet opening and the gas outlet openings of the inner tube for discharging the gas-liquid mixture from the liquid and vapor space, a vapor and liquid drum having a vapor space in the upper part thereof and a liquid space below said vapor space, first conduit means communicating the vapor-liquid outlet with the vapor space of the vapor and liquid drum to provide the vapor space with the mixture of vapor and liquid, means in said vapor space for separating liquid from the vapor whereby the separated liquid is collected in the liquid space of the vapor and liquid drum, gas outlet means communicating with the vapor space of the vapor and liquid drum for discharging separated gas therefrom, a liquid inlet formed in the lower portion of said outer tube at an elevation between the bottom of the latter and the lower end of the inner tube, second conduit means communicating the liquid space of the vapor and liquid drum with the liquid inlet to provide the vapor and liquid space with separated liquid of greater density than the gas-liquid mixture in said liquid and vapor space, the surface of the liquid in the liquid space of the vapor and liquid drum being spaced above the liquid inlet a distance sufficient to provide a head of liquid effective to cause both displacement upwardly of the gas-liquid mixture in said liquid and vapor space for flow to the vapor space of the vapor and liquid drum and continuous circulation of the liquid between the liquid space of the vapor and liquid drum and the liquid and vapor space of said gas quenching vessel, said displacement and circulation being effective both during flow of liquid into the

liquid and vapor space from the liquid introducing means and for a predetermined time interval after reduction or cessation of said last-mentioned flow of liquid.

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