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COKE OVEN GAS COOLER

Original Filed March 26, 1949

2 Sheets-Sheet 1

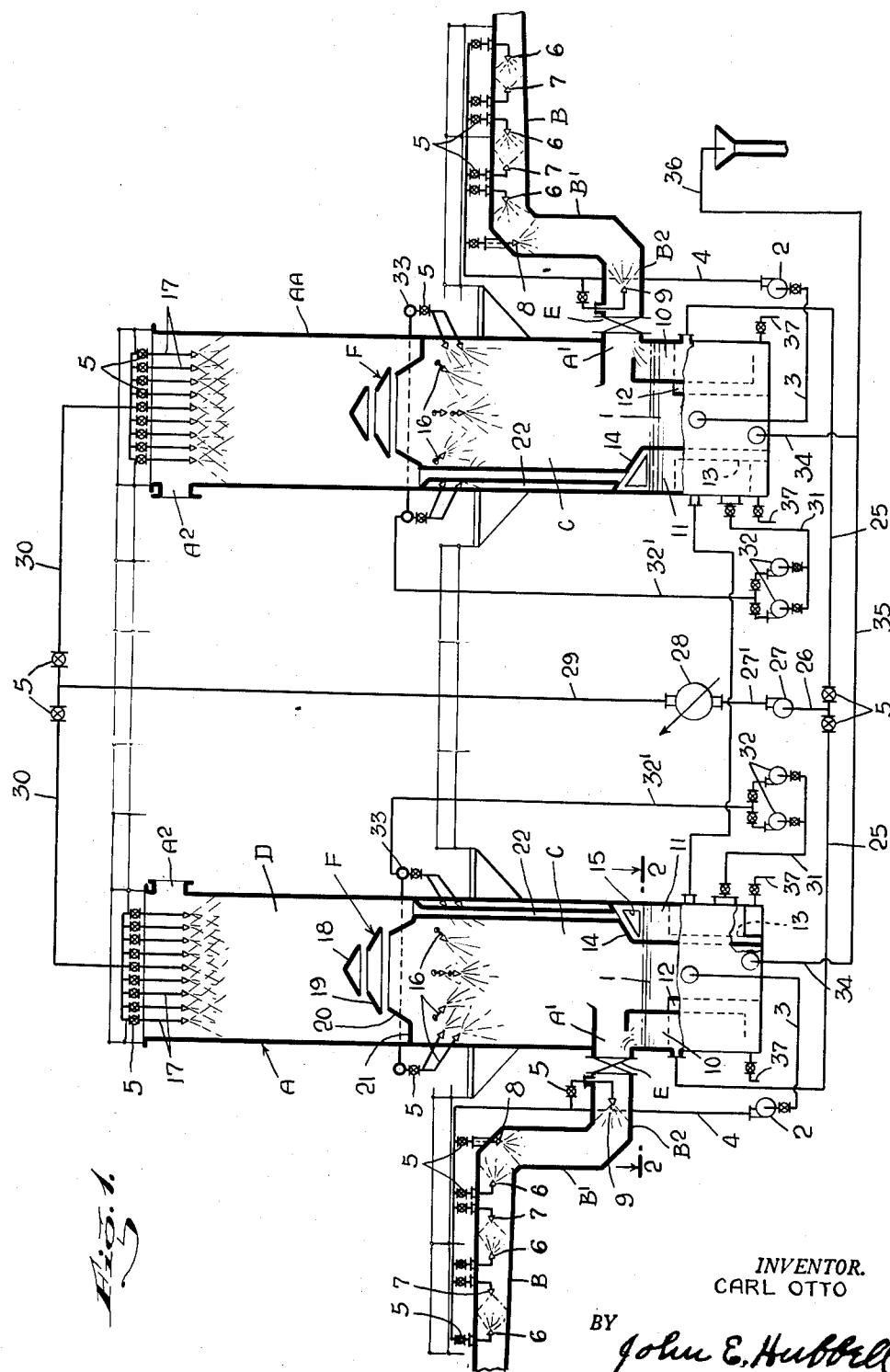


Fig. 1

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Fig. 2.

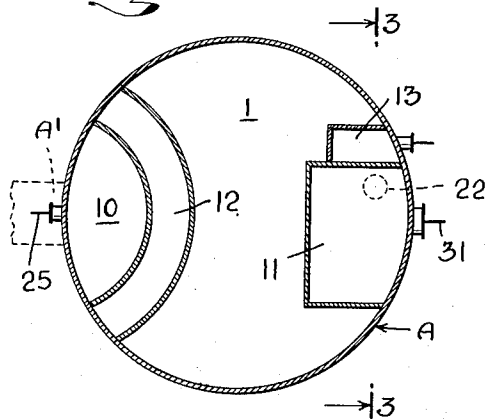


Fig. 3.

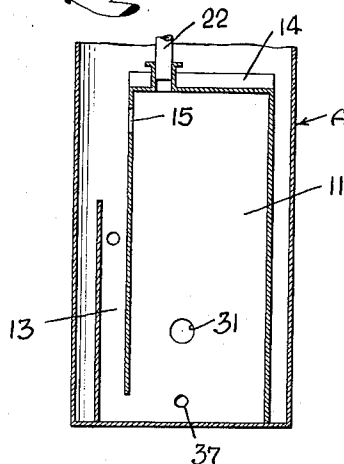
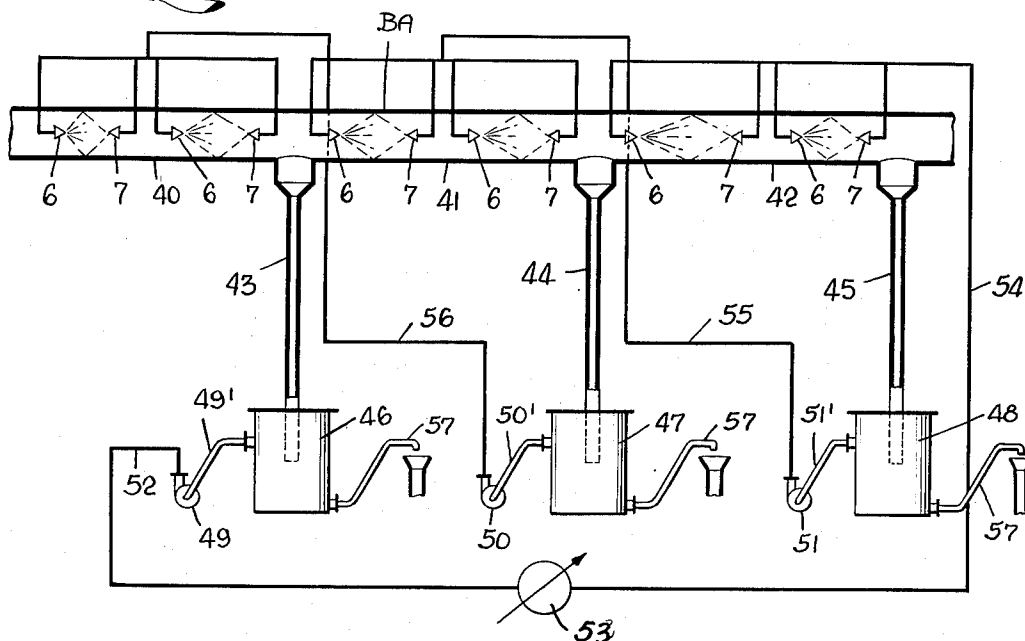


Fig. 4.



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COKE OVEN GAS COOLER

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Continuation of abandoned application Serial No. 83,715, March 26, 1949. This application January 26, 1953, Serial No. 333,250

3 Claims. (Cl. 261-11)

The general object of the present invention is to provide improved means for cooling coke oven gas received from the collecting main of a by-product coke oven plant. The gas withdrawn from a coke oven collecting main is at a temperature of about 100° C., and contains a considerable vapor content which condenses as the gas temperature is progressively lowered down to a temperature of 45° C. or so, which is a customary gas cooler outlet temperature. The condensate thus formed includes tars, tar oils and other substances having characteristics which have to be taken into account in the design and operation of gas cooling apparatus.

A specific object of the present invention is to provide a novel method of and apparatus for cooling gas in successive stages by spraying into contact with the gas, condensate liquor produced in the gas cooling operation, and supplied to the different stages at temperatures which are suitably lower than the gas temperatures in the respective stages.

In preferred forms of the present invention, the condensate formed in and passing through the first cooling stage is artificially cooled or refrigerated to a temperature suitable for use as the cooling agent sprayed into contact with the gas in the final cooling stage. A further object of the present invention is to provide simple and effective means for segregating condensate formed in and passing through each of the cooling stages preceding the final stage at a suitable temperature for use in cooling the gas passing through the preceding stage.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described preferred embodiments of the invention.

Of the drawings:

Fig. 1 is a diagrammatic elevation of a gas cooler of a desirable type;

Fig. 2 is a partial plan section on the line 2-2 of Fig. 1;

Fig. 3 is a partial elevation in section on the line 3-3 of Fig. 2; and

Fig. 4 is a diagrammatic elevation of a gas cooler differing from the cooler shown in Fig. 1.

The gas cooler shown by Figs. 1, 2 and 3, comprises two similar cooling towers or vertical tanks A and AA, and gas piping and liquor circulating provisions associated with each tower, so that each tower and piping and circulating provisions associated therewith form a unit which is a duplicate of the unit formed by the other tower and piping and circulating provisions associated therewith. In addition, the apparatus includes a liquor chiller or refrigerator and circulating provisions immediately associated therewith which are common to the two units. As shown, the tower of each unit receives hot gas from the collecting main associated with the unillustrated coke

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ovens which form the source of the gas treated in the tower, through piping including sections B, B' and B² adjacent the tower. Each of the cooling units shown in Figs. 1, 2, and 3 comprises three cooling stages or sections. The pipe sections B, B' and B² associated with each tower form the initial or first gas cooling stage of the corresponding unit, and lower and upper compartments C and D in the tower form the second and third cooling stages of the unit.

The immediately following description of the unit including the tower A, applies without significant change to the unit including the tower AA. Pipe section B, associated with the tower A, is slightly inclined downward from the horizontal toward the tower, so that liquid sprayed into the pipe section B, as hereinafter described, and condensate entering and formed in the pipe section B with the gas, will drain out of the pipe section B to the section B'. The latter is connected to and depends from the end of the section B adjacent the tower A, and has its lower end connected to the tower A through the short horizontal pipe section B² which includes a cut-off valve E.

In accordance with the present invention, liquor drawn from a liquid reservoir space or section 1 in the lower portion of the tower A through the inlet pipe 3 of a pump 2, is discharged through the pump outlet pipe 4 into the pipe sections B, B' and B² through spray nozzles 6, 7, 8 and 9. Each of said nozzles is connected to the pipe 4 through an individual regulating valve 5. As shown, there are three nozzles 6 and two nozzles 7, arranged to discharge liquor jets into the pipe B. The nozzles 6 and 7 alternate along the length of the pipe section B. Each nozzle 6 is preferably of the known type, adapted to discharge a conical spray jet, including liquor particles, distributed throughout the cone indicated in outline by the dotted lines associated with the nozzle.

The jets discharged by the nozzles 6 are directed toward the tower A. The nozzles 7 are arranged to discharge jets directed away from the tower A. Moreover, each nozzle 7 is advantageously of a type adapted to deliver a so-called umbrella spray in which all the spray liquor particles are adjacent the periphery of the cone outlined by the dotted lines associated with the nozzle. With the arrangement of nozzles described, the liquor discharged by each nozzle 7 unites with the liquor discharged by the nozzle 6 facing it to form a liquid mixture in the portion of the pipe B between the two nozzles which is cooler than gas passing through said pipe. In consequence, the temperature of the gas is progressively diminished as it moves through the pipe section. The liquor discharged by the nozzles 6 and 7 progressively nearer to the tower A are heated to progressively decreasing extents.

The single nozzle 8 is arranged to discharge a downwardly directed jet into the upper end of the pipe section B'. The adjacent nozzle 6 discharges liquor into admixture with that discharged by the nozzle 8. The nozzle 9 discharges into the horizontal pipe section B². As shown, the direction of discharge is away from the tower A.

The pipe section B² opens into the tower A when a cut-off valve is open, in such manner that the liquor flowing through said section passes initially into a reservoir section 10, while the gas passing into the tower through the pipe section B enters a spray chamber C above the liquor in the reservoir spaces or sections 1, 10 and 11. The section 10 opens at its lower end into a passage 12 closed at its lower end and opening at its upper end into the upper portion of the section 1. Baffle means are provided to prevent liquor raining down through the chamber C from entering the upper end of the section 10. The reservoir section 11 is in communication with the reservoir section 1 through a vertical passage 13 open at its

lower end to the section 11 and opening at its upper end into the section 1 at or about the level at which the passage 12 opens to the section 1. The liquor raining down through the chamber C is prevented from entering the section 11 by a roof member 14. The gas pressure in the upper portion of the section 11 is equalized with the pressure in the chamber C through a port 15 in the vertical wall of the section 11. The spray chamber C has its upper end separated from the superposed spray chamber D through a louver-like structure F. The gas passing through the tower A passes out of the latter through an upper gas outlet A² connecting to piping, not shown, through which gas passes away from the cooling apparatus.

Liquor is sprayed into the upper end of the spray chamber C through a multiplicity of spray nozzles 16 and liquor is sprayed into the upper end of the spray chamber D through a plurality of spray nozzles 17. The liquor sprayed into the chamber C by the nozzles 16 is directly received in the reservoir space 1 which may be regarded as external to the sections 10 and 11, although liquor may pass back and forth between the section 1 and the sections 10 and 11 through the passages 12 and 13, respectively.

The louver F as shown, comprises an upper conical section 18, an intermediate section 19 in the form of a hollow truncated cone, and a lower section 20 also in the form of a hollow truncated cone. The lower end of the section 19 is larger in diameter than the upper end, and smaller in diameter than the lower end of the section 20. Similarly, the diameter of the lower end of the section 19 is larger than the diameter of the lower end of the section 18 and the latter diameter is larger than the diameter of the upper end of the section 19. Sections 18, 19 and 20 are coaxial and are vertically displaced from one another. Liquor raining down through the chamber D is diverted by the louver F into an annular space surrounding the section 20 and above the horizontal flange or annular plate 21 which extends horizontally from the lower edge of the member 20 into engagement with the inner wall of the tank A. In practice, the member 21 may be welded at its periphery to the tank wall and welded at its inner edge to the lower end of the member 20 which is thus supported through the member 21 by the wall of the tower A. In practice, the louver sections 18 and 20 are also supported by the tank wall through the section 20 and annular member 21.

The liquor accumulating in the annular space above the member 21 drains into the reservoir section 11 through a vertical pipe 22 which as shown, is within the tower A though it might be external to the latter.

The liquor sprayed into the upper ends of the towers A and B, through the nozzles 17 in those towers, is drawn from the reservoir sections 10 of the two towers through pipes 25, each connected to the inlet pipe 26 of a circulating pump 27. The outlet pipe 25 of the pump 27 is connected to a liquor chiller or cooling apparatus 28 from which the liquor passes at reduced temperature through a pipe 29 to two branch pipes 30. One pipe 30 supplies liquor to each of the nozzles 17 in the tower A and the other pipe 30 supplies liquor to each of the nozzles 17 in the tower AA. As shown, the amount of liquor supplied to each of the nozzles 17 is controlled by the adjustment of a valve 5, individual to the nozzle. Each of the pipes 25 and 30 also includes a regulating valve 5 which may be adjusted to vary the rate of liquor flow through the corresponding pipe. The cooling apparatus 28 may well be of conventional heat exchanger type, operative to cool the liquor passing through the apparatus 28 from the reservoir sections 10 to a predetermined temperature which may be, and is herein assumed to be 37° C. That temperature is a little more than 30° C. below the temperature of the liquor in the pipe 27'. As shown, each pipe 25 is connected to the corresponding reservoir section 10 at a level intermediate the ends of the section, but nearer the upper end than the lower end.

In consequence, the liquor passed to the chiller by the pump 27 is normally at the maximum temperature attained in any portion of the liquor circulation system, since under normal operating conditions the temperature of the liquor in the upper portion of the section 10 is the same as the temperature of the liquor passed into the towers A and AA through their respective inlets A'.

The rate at which liquor is withdrawn from each of the reservoir sections 10 will sometimes be greater and will sometimes be less than the rate at which liquor is passed into the upper end of the section 10 by the corresponding pipe section B². When more liquor is being withdrawn from section 10 through the pipe 25, than is being supplied to the section 10 by the corresponding pipe B², the liquor level in the section 10 will fall below the level of the liquor in the reservoir section 1. Liquor will then pass into the lower end of the section 10 from the corresponding reservoir section 1, through the passage 12 as required to maintain the rate of withdrawal. Conversely, when liquor is being withdrawn from either section 10 at a rate lower than the rate at which liquor is supplied to the upper end of said section by the corresponding pipe section B², the liquor level in the section 10 will rise, and some of the liquor supplied by the pipe B² will then pass away from the section and into the corresponding reservoir section 1 through the passage 12.

The liquor sprayed into the chamber C of the tower A through the spray nozzles 16 is drawn from the reservoir section 11 of the tower A through a pipe 31. The latter is the inlet pipe for a pump, or as shown, for a pair of pumps 32, connected between the pipe 31 and the pump outlet pipe 32'. The latter discharges into a bus pipe 33 which surrounds the tower A, and is connected through individual valves 5 to the various nozzles 16. Similarly, the liquid sprayed into the spray chamber C of the tower AA, through the corresponding nozzles 16, is liquor withdrawn from the reservoir section 10 of the tower AA through a pipe 31 connecting the last mentioned reservoir section 10 to the inlets of a pump or pumps 32, associated with the tower AA. The outlets of the last mentioned pipes are connected through a corresponding pipe 32' and bus pipe 33 surrounding the tower AA, to the nozzles 16 within that tower.

Condensate passing into the towers A and AA through the corresponding pipe sections B² and the condensate separated from the gas in the towers, eventually passes from the towers through individual outlet pipes 34 into a liquor overflow pipe 35. The latter is connected to the reservoir section 1 at or adjacent the bottom of the tower. Pipe 35 includes a portion 36 above the level of the bottom of the tower which fixes the normal liquor level in the reservoir section 1. That level is some distance above the level of the pipe portion 36, since the gas pressure of the tower is below the pressure of the atmosphere. The liquor withdrawn from the cooling apparatus through the pipe 36 is ordinarily passed to apparatus for recovering various condensate constituents of value including in particular, tars, and compounds from which ammonia can be separated in a well known manner. Heavy tars, etc., accumulating in the lower portions of the reservoir sections 10 and 11 may be drawn off from time to time through valved draw-off connections 37.

The apparatus shown diagrammatically in Fig. 1, is designed and adapted for use in cooling 90,000,000 cubic feet of coke-oven gas per 24-hour day. This means that gas is being passed into each of the towers at the average rate of about 31,250 cubic feet per minute. Each pump 2 has a normal output of 2,500 gallons per minute, and each of the pumps 32 is of similar capacity and the pump 27 passes liquor at the average rate of 6,000 gallons of liquor per minute through the cooling apparatus 28. The relative amounts of liquor pumped by the different pumps can be regulated by means of the individual regulating valves 5 in the inlet connections to the different pumps.

The general operation of the apparatus shown in Fig. 1

will be apparent from the foregoing description. It is primarily characterized by its simple and effective provision for maintaining and segregating the sources of liquor of different temperatures utilized as spray liquor in the three different cooling stages of each cooling unit. The liquor sprayed through the nozzles 17 into the final cooling stage of each unit is at a predetermined temperature, assumed herein to be 37° C., to which the liquor drawn from the reservoir sections 10 by the pump 27 is cooled by the cooling apparatus 28. Liquor passed to the cooling apparatus by the pump 27 is at the approximately maximum liquor temperature in the cooling apparatus and will be at an average temperature of slightly below 69° C., on the assumption that the gas passes into each tower from the corresponding pipe section B² at a temperature of about 69° C. That assumption is based on the assumption that the gas leaving the collecting main has cooled down from 100° C., to about 80° C., in passing through elongated piping connecting the pipe section B to the collecting main. The liquor collecting in the reservoir sections 12 is at a temperature intermediate with the temperature of 37° C. at which liquor is supplied to the nozzles 17, and the temperature of about 63° C. at which liquor drawn from the reservoir section 1 by the pumps 2 is supplied through pipe 4 to the spray nozzles 6, 7, 8 and 9.

By adjustments of the valves 5 in the inlet connections to the various pumps 2, 27 and 32, the relative amounts of liquor drawn from the reservoir sections 1, 10 and 11 of each of the towers T and TA may be regulated. The adjustment of the last mentioned valves also has some regulating effect on the conditions under which liquor will flow in one direction or in the other direction between the reservoir section 1 and each of the reservoir sections 10 and 11, in each of the towers A and AA.

In the modified gas cooler BA, shown in Fig. 4, the cooling action is effected in a horizontal section of a suction pipe or main through which gas is passed from the collecting main to apparatus in which the cooled gas is used or stored, or more usually, to apparatus, such as an ammonia saturator, in which the gas is subject to further treatment. As shown, the cooling pipe section BA of the suction pipe is divided into three sections or cooling stages, 40, 41 and 42. Each of said sections includes two spray nozzles 6, which may be identical with the spray nozzle 6 of Fig. 1, and two spray nozzles 7, which may be identical with the spray nozzle 7 of Fig. 1. Each nozzle 6 discharges in the direction of gas flow through the cooling pipe BA and each nozzle 7 discharges in the opposite direction. The spray discharged by each nozzle 6 is thus met by the liquor spray discharged by the adjacent nozzle 7. Condensate formed in and sprayed into each of the cooling sections or stages 40, 41 or 42 is drained away through drain pipes 43, 44 and 45 respectively, connected to the gas outlet ends of the respective cooling sections or stages. The drain pipes 43, 44 and 45 discharge into separate circulating tanks or reservoirs 46, 47 and 48 respectively.

Circulation pumps 49, 50 and 51 have their respective inlet pipes 49', 50' and 51' connected to the tanks 46, 47 and 48, respectively. The outlet pipe 52 of the pump 49 passes liquor from the tank 46 to the inlet of a chiller or liquor cooling apparatus 53. The latter may be similar to the cooling apparatus 28 of Fig. 1. From the cooler 53, the liquor passes through the pipe 54 to the spray nozzles 6 and 7 in the final cooling stage or section 42 of the cooler BA. The outlet pipe 55 of the pump 51 passes the liquor collected in the reservoir 48 from the cooling stage 42 to the spray nozzles 6 and 7 of the stage or cooling section 41 of the cooler BA. The outlet pipe 56 of the pump 50 passes liquor drawn from the cooling stage 40 to the spray nozzles 6 and 7 in the initial stage or cooling section 40 of the gas cooler BA.

As shown, pump inlet pipes 49', 50' and 51' are connected to the respective tanks or reservoirs 46, 47 and

48, each at a level somewhat below the top of the corresponding tank but well above the bottom of the tank. Each of the tanks 46, 47 and 48 is provided with an individual overflow pipe 57 which is connected to the tank at a level appreciably below the level at which the corresponding pump inlet pipe is connected to the tank. As shown, however, each overflow pipe 57 has its discharge end at approximately the same level at which the corresponding pump inlet is connected to the tank. With the described arrangement, the relatively heavy tar accumulating in the lower portion of each tank will be forced out through the corresponding overflow pipe 57 at a rate dependent on the elevation of the liquor level in the tank above the level of the pump inlet connection to the tank. When the liquor level in the tank falls or rises, the outflow through the corresponding pipe 57 respectively decreases or increases. During periods in which the condensate discharge into any one of the tanks 46, 47 and 48 is temporarily smaller than normal, the corresponding pump may withdraw liquor from the tank at about the rate at which liquor is supplied to the tank. Normally, however, the rate at which liquor is supplied to each tank is higher than the rate at which the liquor is withdrawn by the corresponding pump, and the liquor level maintained in the tank is high enough to make the rate of discharge through the outlet 57 equal to the excess of the rate at which liquor is supplied to the tank over the rate at which liquor is withdrawn from the tank by the corresponding recirculating pump 49, 53 or 55.

As those skilled in the art will recognize, the stage cooling action effected in the cooler BA is generally like the stage cooling action effected in each of the towers A and AA and associated pipe sections B, B' and B². In the single cooling unit of Fig. 4, as in each cooling unit of Fig. 1, the gas enters the intermediate gas cooling section or stage at a temperature lower than it enters the initial gas cooling stage and is hotter than the gas entering the final gas cooling stage. In each of the cooling units also, the cooling liquor sprayed into the intermediate cooling stage is at a temperature which is lower than the temperature of the cooling liquor sprayed into the initial section, and higher than the temperature at which liquor is sprayed into the final cooling stage.

This application is a continuation of my prior application, Serial No. 83,715, filed March 26, 1949, now abandoned.

While in accordance with the provisions of the statutes, I have illustrated and described the best forms of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the forms of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. An apparatus for multi-stage cooling gas withdrawn from a collecting main receiving hot gas from by-product coke ovens, comprising in combination, a structure enclosing substantially unobstructed first, second and third cooling spaces through which the gas being cooled may successively pass, said structure being a vertically elongated tank comprising a lower section surrounding a liquor holding space, an intermediate section surrounding said second space, an upper section surrounding said third space, partition means between said intermediate and upper portions formed with passages for the flow of gas from said intermediate section into said upper section and forming a wall of a collecting space for liquor sprayed into said third space, and partition means dividing said liquor holding space into three sections, a conduit for passing liquor from said collecting space into one of said liquor holding sections, separate spray nozzles associated with each of said spaces for spraying liquor

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into said spaces, means for withdrawing liquor from said first space including condensate and liquor previously sprayed into said space, a liquor cooler, means including a pump for moving liquor withdrawn from said first space through said cooler and into the nozzles associated with said third space, means for withdrawing liquor from said third space including condensate and liquor previously sprayed into said third space, means for passing liquor withdrawn from said third space into the nozzles associated with said second space, means for withdrawing liquor from said second space including condensate and liquor previously sprayed into said second space and means for passing the liquor withdrawn from said second space into said spray nozzles associated with the first space, said tank having an inlet for the passage of gas from said first space into said second space, and for the passage of liquor from said first space into a second liquor holding section, the third liquor holding section being open at its upper end to receive liquor sprayed into said second space.

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2. A combination as specified in claim 1, including means providing an overflow outlet from said third liquor holding section establishing a predetermined liquor level in said liquor holding space, and in which said third section is in communication with one at least of said first and second liquor holding sections at a level intermediate said predetermined level and the lower end of said liquid holding space.

3. A combination as specified in claim 1, in which the tank inlet for the passage of gas from said first space into said second space is a lateral inlet.

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