Oct. 18, 1960 E. V. SCHULTE ET AL 2,956,639

COKE OVEN GAS NAPHTHALENE ABSORBING FINAL COOLER

Filed Jan. 22, 1959 2 Sheets-Sheet 1

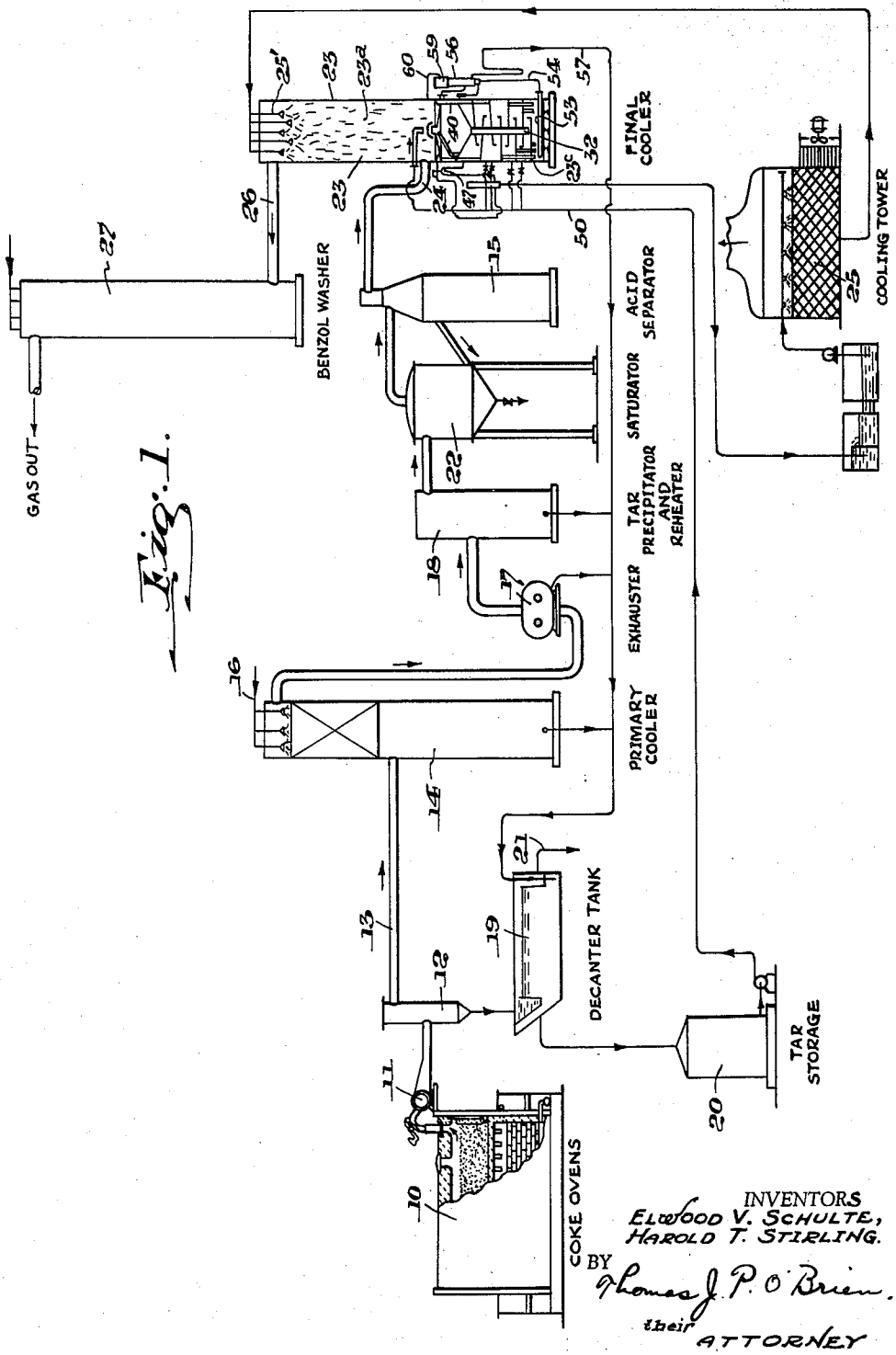


Fig. 1.

INVENTORS
ELWOOD V. SCHULTE,
HAROLD T. STIRLING.
BY Thomas J. P. O'Brien.
their ATTORNEY

Oct. 18, 1960 E. V. SCHULTE ET AL 2,956,639

COKE OVEN GAS NAPHTHALENE ABSORBING FINAL COOLER

Filed Jan. 22, 1959 2 Sheets-Sheet 2

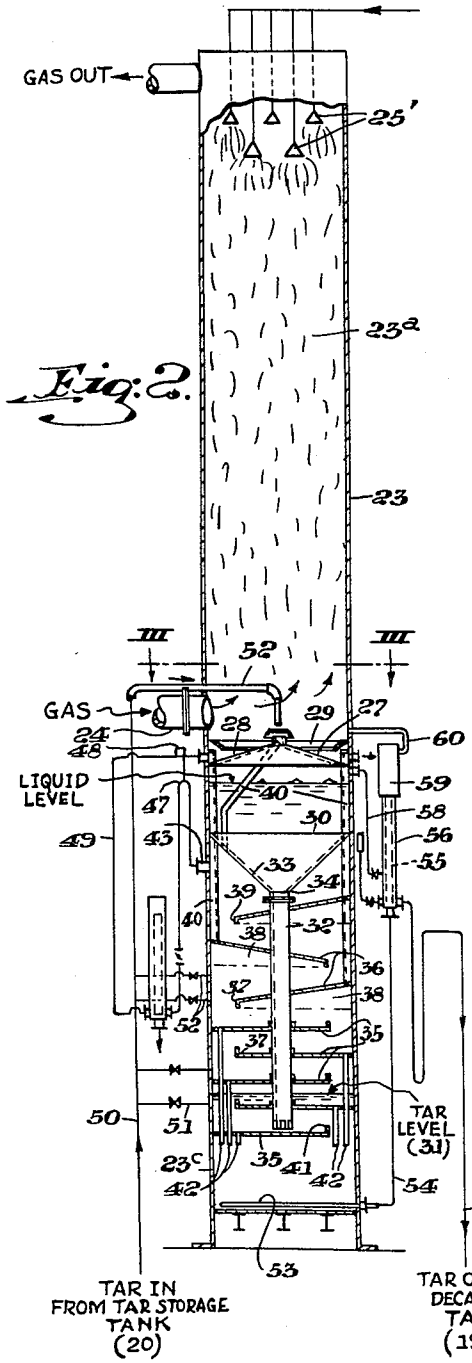


Fig. 2.

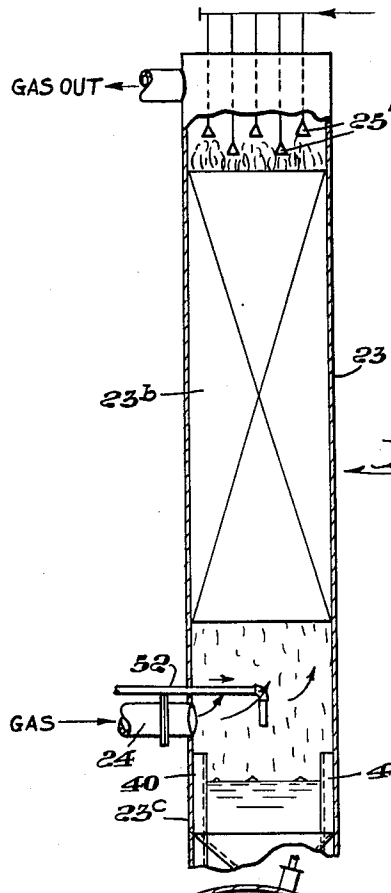


Fig. 4.

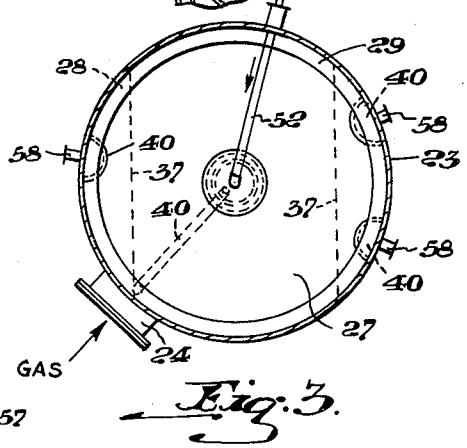


Fig. 3.

INVENTORS.
ELWOOD V. SCHULTE,
HAROLD T. STIRLING.

BY Thomas J. P. O'Brien.
their ATTORNEY.

United States Patent Office

2,956,639

Patented Oct. 18, 1960

2,956,639

COKE OVEN GAS NAPHTHALENE ABSORBING FINAL COOLER

Elwood V. Schulte and Harold T. Stirling, Pittsburgh, Pa., assignors to Koppers Company, Inc., a corporation of Delaware

Filed Jan. 22, 1959, Ser. No. 788,361

15 Claims. (Cl. 183—2)

This invention relates to improvements in the general operation of final cooler apparatus for coke oven chemical recovery plants, and more particularly, to improvements in the operation of such final coolers of the general type comprising a tower having an upper gas washing section and a lower water scrubbing section with a funnel immediately below the lower gas inlet to collect the cooling water from the washing section and a depending tail pipe, to discharge the water into a bath of solvent for naphthalene, such as tar, at the base of the scrubbing section, with zig-zag horizontal baffles between the base of the tail pipe and the apex of the cone of the funnel for decantation of the water before it overflows at a level below the top of the funnel to a water cooler for return to the upper part of the gas washing section of the tower. In such apparatus, tar is fed to the base of the lower scrubbing section, continuously at about the level of the second bottom baffle, and intermittently at higher levels, and mechanical means are provided for off-flow of tar from the base of the lower scrubbing section to maintain a constant level of the bath of solvent, such as tar, to absorb naphthalene which has condensed from the gas by the cooling water, to remove such naphthalene prior to flow of the water to the water cooler on its way back to the upper gas cooling section in the upper part of the tower.

In general, the object of the invention is the modification of the operation of the lower scrubbing section of such tower, whereby existing final coolers, as well as new installations, may be operated to prevent tar entrainment in the outlet water and carry-over of the tar to the pumps and water cooler, with higher velocities of flow of the scrubbed water in the scrubbing section, during its flow to the water cooler, than the scrubbing section is normally designed to operate, without increasing the height of the section and tower or requiring supplemental decantation equipment outside the tower in the limited ground area around the same for the purpose.

More specifically, a primary object of the invention is to effect such change in mode of operaion in a simple, economical and facile way requiring no additional equipment by altering the arrangement and location of the parts, in a manner equally adaptable to static type final coolers of the packed type and to all spray type coolers devoid of packing in the gas cooling section and operable with water pressure higher than customary with the packed column type cooler.

Accordingly, the invention comprises lowering the location of the funnel in the existing coolers, as well as new ones, and raising the water outlet to maintain below the gas inlet a head of the hot cooling water on the tail pipe at a level at least as high as the top of the funnel, and preferably, at a distance above the top of the funnel equal to the height of two of the lower baffles, disposing

three of the upper baffles to serve as foam collectors beneath their lower surfaces, and venting the three upper baffles, of a vertical row of baffles of greater height than the overall horizontal dimension of the baffles, to the gas space in the upper gas cooling section of the tower. Preferably, the upper three baffles are oppositely inclined, but they may be horizontal instead when provided with a deep weir lip.

Preferably, each of the lower baffles are also provided with solvent drains to the bath below, and for all spray coolers a perimetrical ring is superposed above the perimeter of a conical deflector below the gas inlet to deaerate the water passing to the head of water above the tail pipe.

The standard method is to spray water into a tower in the form of an all spray section or a packed column, through which the gas passes from the exit of the ammonia saturator to the benzol or light oil scrubber. The purpose of this final cooler is to remove the heat that had been formed due to the compression of the gas at the exhauster before the reheater for the saturator, and also to remove the heat formed due to the reaction of sulfuric acid with ammonia in the saturator. The temperature of the gas leaving the saturator is lowered as much as possible with cooling water available at the plant to obtain maximum absorption of light oil from the gas in the benzol washers using the minimum of wash oil circulation. In this type of final cooler the water is sprayed into the upper gas cooling section where it contacts the gas countercurrently to remove the heat from the gas. The gas, in being cooled at the final cooler, frequently reduces the dewpoint of the naphthalene in the gas to a point lower than the dewpoint of the naphthalene in the gas leaving the primary coolers. Experience also indicates that the gas leaving the primary coolers frequently has a naphthalene content greater than that which would be present in the gas if it was merely saturated to its dewpoint. Naphthalene, therefore, that is condensed out of the gas, is washed with the water out of the base of the upper final cooler section and into a lower scrubbing section where the naphthalene is recovered by a solvent. The water is then pumped to the cooling tower where it is re-cooled in preparation for recirculation back to the upper final cooler section again.

In this lower scrubbing section, the water from the bottom of the upper gas cooling section of the final cooler flows through a funnel into a tail pipe downwardly to a point near the base of the lower section of the tower located below the upper final gas cooling section. Below the tail pipe or downspout a baffle deflects the water and causes it to turn upwardly to a point near the top of the tail pipe in the lower naphthalene absorbing or scrubbing section. Located above the base of the tail pipe, nine zig-zag horizontal baffle plates with openings at their ends alternating from side to side, direct the water horizontally back and forth as it passes between the trays or baffles progressively upwardly to a water overflow at the level of the top of the tail pipe in the lower naphthalene absorbing or scrubbing section. The opening at the end of each tray represents roughly 10% of the total cross-sectional area of the shell. The distance between trays is usually about two feet and the velocity of the water, as it flows between trays, is in the neighborhood of ten times the superficial upward velocity in the naphthalene absorbing section. The superficial upward velocity is that velocity that would exist if the water had moved uniformly upwardly through the tower when it was not equipped with any obstruction of any kind.

Coke oven tar is either fed continuously or batchwise to the lower naphthalene absorbing section and a tar level maintained a few feet above the bottom of the tail pipe. A heating coil submerged in the tar at the base of the lower naphthalene absorbing section keeps the tar at about 60–95° and assist in preventing emulsions.

The water, as it departs from the base of the tail pipe, flows upwardly through the bath of tar, and in doing so, loses its entrained naphthalene to the tar. The naphthalene dissolves in the tar. The de-naphthalenized water then overflows from a level below the top of the funnel at the top of the tail pipe in the naphthalene absorbing section, as described previously, to a hot well where conveniently it is removed by pump and delivered to the cooling tower to re-cool the water in preparation for additional cooling in the upper final cooler section. Experience over the years, and up until about the time of this invention, has been that this particular design of the lower naphthalene absorbing or scrubbing section was limited with regard to water rate to the extent that the nominal or superficial velocity upwardly of the water above the tar level in the lower naphthalene absorbing section could rarely exceed about 5/10 to 6/10 of a foot per minute without carrying tar out of the naphthalene absorbing section. Tar entrainment in the outlet water from this lower section is impractical or intolerable, and undesirable, because this tar, when it is exposed to air in the cooling tower, becomes oxidized and cooled and thereby deposits on the surfaces of the packing in the cooling tower. Eventually, these surfaces become so badly contaminated that the cooling tower must be taken out of service and cleaned. This is a troublesome and expensive procedure and it is apparent that it should be avoided, if possible.

In such conventional system the trays originally were equipped with a large number of perforations, about 5/16" diameter on 4" centers, and as a naphthalene absorber remains in service for a period of years, it becomes necessary to reduce very gradually the water rate that is passed through the naphthalene absorbing section in order to prevent carry-over of tar out of the section. Over the years, a pitch-like deposit accumulates, as a result of continuous operation, on each of the horizontal trays located in the lower naphthalene absorber section, so that the free area between trays became reduced. This results in a gradual increase in water velocity between trays to the extent that the heavier tar is carried across and upwardly with the water to the outlet. Removing the pitch-like deposits from the trays would restore the capacity of the unit from the standpoint of tar separation from water to that which existed when the unit is first placed in operation.

Enlargement of the perforations in the trays to approximately 1½" diameter, in order to keep the trays clean, indicates that the capacity of the lower naphthalene absorbing section, from the standpoint of tar separation from water, was no more, and perhaps less, than it had been before the holes in the trays were enlarged. In order to attempt to increase the capacity of the lower naphthalene absorbing sections, other schemes were also tried. These included increasing the free area of the opening at the ends of each of the trays, adding tar intermittently, adding tar to the naphthalene absorbing section at slower rates, eliminating perforations entirely from each of the trays and installing individual tray drains that carried the separated tar either to the tray below or directly to the tar located at the base of the lower naphthalene absorbing section. The experience from each of these changes in design was that the attempt to increase the capacity of the unit failed and that the superficial velocity of the water upwardly through the lower naphthalene absorbing section could not be increased much above the 5/10 to 6/10 of a foot per minute cited previously in this connection.

The present inventors conceived that very likely one of the limiting factors in the capacity of these units was associated with the entrainment of fine gas bubbles in the water that was passing from the upper final cooler section down through the tail pipe and up through the tar in the lower scrubbing section. It was felt that any minute gas particles would cause a frothing action as the gas and water mixture changed direction at the base of the downcomer or tail pipe and passed upwardly through the tar solvent. Such gas particles would entrain tar and carry the tar upwardly to the top of the lower naphthalene absorbing or scrubbing section because of the fact that the presence of the gas in the tar would lower the average specific gravity of that particular mixture below the specific gravity of the water.

Test work and observations demonstrated that this conception regarding gas entrainment and its effect upon the capacity of the column was correct. The tests demonstrated that when a small amount of air or gas was entrained in the water passing downwardly through the tail pipe from the funnel and up through a layer of tar in the lower naphthalene absorber section, the allowable superficial velocity of water was about 5/10 to 6/10 of a foot per minute which was very much like the conditions found in practice in final cooler systems in coke plants. In other tests, with complete removal of air or gas from the water before it passes from the funnel down into the tail pipe and then upwardly through the tar layer, the present inventors were able to obtain superficial velocities of at least two feet per minute without entrainment of tar in that water as the water exited from the lower absorber section. To this end, the inventors lower the funnel and raise the water level outlet of the unit in the lower section to form a hold tank above the funnel, whereby the water, before it leaves the gas liquid contacting upper section of the final cooler, is given a retention time at low velocity, while still above the base of the funnel, of at least more than ten seconds and usually not more than three minutes to allow a major portion of the entrained gas to be separated by gravitational separation from the water before this water passes into and suddenly flows down at a much higher velocity through the tail pipe or downcomer, for contact with the tar in the lower naphthalene absorbing section, which very high velocity prevents residual gas from escaping to the head of the column of water by gravitational separation.

The inventors further found that the capacity of the lower naphthalene absorbing section could be further increased above that of previously designed units even if there still was some entrained gas or air in the water by entrapping the particles of the water that had the residual gas entrained therein, from the water, after it leaves the tail pipe, in a manner that they would not be allowed to reach the surface of the water below the funnel where the water flows out from the lower naphthalene absorber or scrubbing section of the final cooler to pass on to the water cooler. A sloping type of upper baffle has been found to be a simple means for the entrapment of these tar particles which have a gravity less than that of water due to the presence of the residual gas or air particles therein. However, there are other simple means that are effective for the entrapment without departure from the principle used. For example, the entrapping upper baffles are suitable when placed horizontally with a downwardly extending lip at the edge of the baffle adjacent the opening opposite this baffle. Also, the sloping upper baffle effect is obtained by building the baffle segments in horizontal steps, working downwardly stepwise to a point adjacent the opening.

The function of the upper entrapment baffles, of course, is not completed if the entrapped gas and its entrained tar are not allowed to escape from a point below said baffle and, therefore, vents are included as an escape mechanism to remove either separated and unseparated gas as rapidly as it accumulates. The capacity of the lower naphthalene absorbing section of the final cooler is thus increased from the standpoint of separating tar

from water flowing through the lower naphthalene absorbing section after said water has been in contact with said tar and while there is entrained gas or air in the water as it leaves the downcomer or tail pipe and enters the tar submerging the bottom of the tail pipe. It is now possible to obtain tar free water at velocity capacities greater than those obtainable previously in spite of the fact that some gas or air may be entrained in the water.

The entrainment problem is not as serious with final coolers designed with a contact surface made up of packing in the upper cooler section, as it is with the all spray type of gas cooler. When water is sprayed onto the surface of the packing at or near the top of the upper final cooler section, this water drains gently over the surface of the packing until it reaches the lowermost portion of the packing. From here it drops gently onto the surface of the water retained in the funnel of this type of cooler. Unfortunately, a packing is somewhat limited in capacity and greater gas velocities can be tolerated in the final cooler while obtaining satisfactory heat transfer by the use of an all spray upper section devoid of packing to create the surface required to transfer heat from the gas to the water. In this case, a plurality of sprays is used at one or more elevations in the upper cooler section. When spraying the water with differential pressures in excess of 3 or 4 lbs./sq. in. across the spray nozzles and spraying the water downwardly into the tower, the spray droplets impinge against the surface of the water at the base of the upper final cooler section at relatively high velocity. This rapid impingement aggravates the de-entrainment problem at the base of the upper cooler section and a greater retention time is thereby required in order to get the gas particles separated from the hold tank of water at the head of the tail pipe.

This disadvantage of an all spray type gas cooling upper section in combination with a lower naphthalene absorber section for purposes of removing naphthalene from the hot cooling water, is overcome here by the raised water level arrangement so as to operate the upper gas final cooler section with gas velocities in excess of one foot per second upwardly through the upper gas cooling section and with use of the required amount of water to obtain the desired cooling of the gas and still obtain superficial water velocities upwardly in the lower naphthalene absorber section greater than 0.5 foot per minute.

We have also overcome and minimized still further the effect of the spray impinging against the surface of the water bath by placing a conical baffle above the top level of the hold water retained in the funnel in the lower section of the final cooler with a perimetrical deflector ring above the perimeter of the conical baffle, so that the spray now impinges against this baffle to deaerate the liquid before it reaches contact with the hold water in the funnel. This has also made it possible to increase the capacity of the lower naphthalene absorbing section even with the all spray type upper gas cooling section.

While the invention as hereinabove set forth is primarily designed for, and particularly adapted to improve the general operation of, a coke oven gas final cooler of the special types set forth, without increasing the overall height of the tower or its lower water scrubbing solvent section, and without requiring location of auxiliary equipment around the ground area alongside the tower or its water cooler, to complete the de-tarring of the water before it enters the water cooler for return to the upper gas washing section, the invention is not limited in all its aspects to such specific embodiment of the invention, since much of the advantages of the invention is of utility in other countercurrent scrubbing, decanting, and emulsion separating operations and processes involving chambers containing gas in contact with aqueous mediums requiring separation of two immiscible mediums of different specific gravities. Hence, the invention, in its broader aspects, is not confined in all its uses to the specific use and specific embodiment herein-described and illustrated.

In addition to the general objects recited above, the invention has for further objects such other improvements or advantages as may be found to obtain in the structure and general operation of a final cooler in a coke oven gas chemical recovery system as shown on the drawings and hereinafter-described or claimed.

In the accompanying drawings:

Figure 1 is a schematic side elevational arrangement of a train of apparatus elements for processing coke oven gas to remove benzol therefrom which includes the present invention therein;

Figure 2 is a schematic vertical cross-section of the final cooler therein, with the upper gas cooling section in the form of an all spray chamber devoid of packing;

Figure 3 is a horizontal sectional view taken on the line III—III of Figure 2;

Figure 4 is a partial view of the upper portion of Figure 2, but with the upper gas cooling section in the form of a packed column with sprays to deliver the cooling water to the top of the packing for trickling through the same to the lower water scrubbing section.

The same reference numerals are used for like parts in each of the several views.

Referring to the drawings, there is indicated at **10** a coke oven battery, from which coke oven gas is derived, and which passes out through the collecting main **11** to a downcomer **12**, for tar and aqueous condensate of the gas, and thence, through a line **13** to the primary cooler **14**, through which the gas passes countercurrently to cooling water from lines **16**, and thence is forwarded by exhauster **17** to a combined tar precipitator and reheater **18**. In the primary cooler **14** the gas is cooled to about 25° C., and tar and ammonia liquor therefrom are drained to the hot drain decanter tank **19** which discharges the tar to the tar storage tank **20** and overflows ammonia liquor through line **21**.

The gas from the exhauster **17** enters the tar extractor **18** at about 30° C. from the reheater therein, and leaves at the same temperature to enter the ammonia removal means in the form of a saturator **22** at said 30° C. temperature. In the saturator the ammonia of the gas reacts with sulfuric acid to form ammonium sulfate which precipitates therein, the water of crystallization passing off with the gas at a slightly higher temperature as a result of the reaction. From the saturator **22** the hot gas passes to an acid separator **15** which removes any adhering acid.

As the gas to be debenzolized should be at a lower temperature for this purpose, the gas then passes into a final cooler **23** through the gas inlet line **24**, and the cooled gas leaves through the gas outlet line **26** to enter the light oil, or benzol, scrubber **27** wherein the gas is scrubbed with wash oil to absorb the light oil, i.e., benzene and its homologues, etc. From the benzol scrubber the gas is lead to further gas processing equipment, or use, or to a gas holder for further service.

In the final cooler **23**, the upper section of the tower is given over to direct gas washing with cold water which enters through spray heads **25'** from a water cooler **25**. The gas leaves at the upper end of the tower and enters at the intermediate level of inlet **24**.

As shown in Figure 2, the upper gas cooling section **23***a* is devoid of packing and the gas is washed by sprays of water under higher pressure than when a packing **23***b* is used as shown in Figure 4.

Referring to Figure 2, for the all spray type cooler, a conical deflector **27** is disposed across the tower **23** immediately below the gas inlet **24**, with a peripheral space **28** between the same and the vertical wall of the tower **23**, and downwardly extending deflector ring tray **29** is superposed over the deflector **27** above the space **28** to arrest the spray from the spray heads **25'** before the liquid of the spray passes through said space **28**, thus

deaerating the spray liquid of some of the coke oven gas and of any carryover air from the air cooled water cooler **25**.

A funnel **33** is located below the deflector **27** with the top **30** of the funnel at a distance below the deflector, which distance is about equal to the height of three of the horizontal zing-zag baffle spaces above the top level **31** for a tar bath at the bottom of the lower naphthalene-absorption water-scrubbing section **23***c* in the lower part of the final cooler tower **23**. A tail pipe **32**, disposed axially of the tower **23**, leads from bottom outlet **34** for the funnel **33** to terminate above the lowermost of a series of horizontal zig-zag baffles **35** below, which are spaced about 2 feet apart, one above another. The bottom tray is set about six feet above the bottom or base of the lower scrubbing section, and the zig-zag baffles are in a vertical row or series of five horizontal lower baffles and three upper oppositely inclined baffles **36**, with the fixed closed end of these baffles raised about an inch above their free open ends **37** to provide a foam collecting area **38**.

The free ends **37** of the inclined baffles **36** are provided with depending lips **39** to act as weirs, each of which is spaced the same distance, about 2 feet, above a tray below, which is the same spacing as the spaces between the horizontal trays lower down in the lower water scrubbing section **23***c*. The foam areas **38** are vented to the gas space **23***a* above in the upper gas cooling section at a level just below the gas inlet **24** to the upper gas cooling section **23***a* by vents **40**, and the inclined baffles **36** range up to the level of the top of the tail pipe **32**, which is the level of the outlet from the funnel **33**.

The lower horizontal baffles or trays are each provided with tar retaining lips **41** and tar drains **42**.

The scrubber water is taken off from the lower scrubbing section **23***c* by a liquid outlet **43**, located above the top of the tail pipe **32**, just below the top perimeter of the funnel **33**, by means of an adjustable over-flow mechanism **47** set to maintain a water liquid level in the lower scrubber section at a level above the top perimeter of the funnel **33** and just below the gas inlet **24** to the upper gas cooling section **23***a* of the final cooler. This overflow level controller **47** is vented by a line **48** to an emergency water over-flow line **49** leading from a higher level above the funnel **33** in the water scrubbing section **23***c*.

Tar from the tar storage tank **20** is fed as solvent into the lower water scrubbing section by automatic means therefor **50**, continuously at a lowermost level **51**, preferably at the level of the second tray **35** from the bottom, and intermittently at several higher levels **52** to wash down naphthalene accumulations.

The tar is withdrawn from the base or bottom of the lower scrubbing section **23***c* through a tar outlet **53** by automatic decanter means operable to maintain the bath or pool of tar at a constant level, submerging the lower end of the tail pipe **32**, at about the level of the second tray **35** from the bottom of the scrubbing section **23***c*.

As shown, this automatic decanter means comprises a riser line **54** which leads to the bottom of an inner tube **55** open at its top to an outer conduit **56**. The tar is returned to the tar decanter tank **19** by a line **57** leading from the bottom of the outer conduit **56**.

The tar which is released of gas in the vents **40** is drained to the outer conduit **56** by means of drain lines **58**. The level of the tar bath is controlled by a tar regulator **59** vented at **60** to the upper gas cooling section **23***a*. As conventional, the tar is heated by means, not shown, to keep it fluid.

The structure and operation is the same with the tower constituted of a packing, as in Figure 4, except that as the cooling water merely trickles on the head of the hold tank of water which is above the funnel, the conical deflector **27** and ring **29** are eliminated as unnecessary with water merely trickling down from the packing **23***b*.

In the table below, are the operating data with the unit arranged as in Figure 2.

TABLE

Operating data—five horizontal trays, three sloping trays, sprayed water feed with feed hold-up tank

Run No.	17	18	19	20
Water Rate, g.p.m.	70	88.5	129	97
Superficial Water Velocity, ft./Min.	0.97	1.23	1.79	1.35
Tar Rate, g.p.m.	2¼	2¼	2¼	2¼
Tar Level, Trays	3	3	3	3
Water Inlet Temp., ° C.	32	38	40	42
Tar Inlet Temp., ° C.	96.1	98.9	96.6	93.4
Temp. Bet. 1st and 2nd Tr., ° C.	53	45	45	45.5
Top Condition	Excellent	Good	Bad	Passable
Moisture in Tar Foam	=25.1— by weight			

The top surface was in excellent condition during run No. 17 when the superficial velocity was about 0.97 foot per minute. Run No. 18, during which the superficial velocity was 1.23 feet per minute, had a faint trace of fine froth on the top surface. A very occasional group of bubbles rose through the No. 1 vent. However, the surface conditions in this run were good and appeared to be better than they had been in run No. 14, when there was no hold tank and the superficial velocity was only 1.12 feet per minute.

The superficial velocity was increased to 1.79 feet per minute in run No. 19. A considerable amount of fine froth began to accumulate on the surface which would not in itself have been serious. However, there were several large patches of tar and air which floated up making the run definitely not passable. Tar foam began to flow from the No. 1 vent to the drum. However, the foam over-flow rate was only about half as fast as it had been in a run when there was no hold-up tank and the superficial velocity was only 1.42 feet per minute. There was about two inches of tar foam in the No. 2 vent and an occasional bubble in the No. 3 vent.

The water rate was decreased in run No. 20 until the superficial velocity was 1.35 feet per minute. The top conditions were definitely passable. A slight stream of tar flowed from the No. 1 vent, and the conditions in the Nos. 2 and 3 vents remained about the same. This is an improvement in passable water rate over that in a run during which there was no inlet hold tank and the superficial water velocity was only 1.12 feet per minute. It is also a great improvement over operation with horizontal trays when the maximum tolerable superficial velocity was only about half as much.

After the completion of run No. 20 the splash plate and ring baffle were removed. The top conditions became much worse showing that a large amount of the air entrainment is relieved when the impingement of the spray on the water surface is stopped.

In operation with the water spray from the all spray chamber **23***a* trained on the ring deflector **29** and conical deflector **28**, the quantity of gas entrainment is initially appreciably decreased by said deflectors and is then further decreased by the hold tank body of water when retained in the funnel **29** above the top of the tail pipe **32**. With the three vented, generally horizontal slanted trays above the five truly horizontal trays, it is possible to operate at superficial upward velocities as high as 1.12 feet per minute without the hold tank of water and 1.35 feet per minute with the hold tank of water.

The water is retained at such a low velocity in the hold tank that most of the entrained gas rises to the surface and passes into the gas stream above. In the tail pipe the velocity is at a rate that the residual entrained gas cannot pass up but passes on through the bath of solvent at the base of the tail pipe.

In the solvent bath the naphhalene is absorbed from

the water and in so doing, some tar picks up some of the entrained gas from the water and forms globules lighter than the solvent and water. As the hot cooling water traverses the zig-zag pathway horizontally, the tar which has entrained gas rises to the bottom surface of the trays as the water flows horizontally along the baffles. The tar which releases the entrained gas settles back down to the top surface of a tray below and thence passes through the drains to the bath of solvent below. Tar globules and released gas finally rise to the collecting areas below the inclined baffles, enter the vents at a water level below the upper outlet for the scrubbed water. The water thus leaves the scrubbing section free of carryover tar solvent and naphthalene, and the lighter tar and gas rise through the vents releasing the gas into the gas cooling section at a level above the water outlet. As the tar is released of its entrained gas it settles in the vents to flow off through the tar drains to the tar offtake means.

In typical operation, tar is continuously added opposite the No. 2 tray from the bottom at a rate between one gallon of tar per ton of coal carbonized per day and about 10 gallons of tar per ton of coal carbonized per day. The tar can also be added intermittently instead of continuously.

The invention as hereinabove set forth in embodied in particular forms of construction and method of operation, but may be variously embodied within the scope of the claims hereinafter made.

We claim:

1. Final cooler apparatus for coke oven gas chemical recovery plants comprising: a tower constituted of an upper gas cooling section having an intermediate gas inlet to the tower in communicable connection with an ammonia saturator, an upper outlet for finally cooled gas from the tower in communicable connection with a light oil scrubber for the coke oven gas, and means for introducing cooling water to the upper portion of said upper section, and a lower water scrubbing section having its top below said gas inlet and in open communication with the base of the upper section of said tower to receive hot cooling water therefrom, a funnel in said lower section with its top perimeter at a spaced distance below said gas inlet, a tail pipe disposed axially of said tower and extending from the outlet of said funnel down to a spaced distance above the base of the lower section, a vertical series of horizontal zig-zag flow baffles of greater height than the horizontal dimensions of the lower section disposed in the lower section to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, the upper baffles of the series being disposed to serve as foam collectors beneath their under surfaces and having vents therefrom to the gas cooling section above the funnel, a water outlet from said lower section at a level above the uppermost of the vertical series of baffles but below the underside of said funnel, conduit means for outflow of water from the water outlet with provision for maintaining a water liquid level in said lower section at a level above the top perimeter of the funnel and below said gas inlet, a water cooler connected with said water outlet for cooling the water from said conduit means and provided with means for returning the cooled water back to the means for introducing cooling water to the upper section of the final cooler, means for introducing solvent of a different specific gravity from water into the lower section, means for draining solvent from the lower baffles of the series to the base of the lower section at a level which is below the lowermost baffles below the base of the tail pipe, and outlet means for offtake of the drained solvent from the base of the lower section with provision to maintain a bath of the solvent around the base of said tail pipe.

2. Apparatus as claimed in claim 1, and in which the upper baffles, which are disposed to serve as foam collectors, comprise oppositely inclined baffles with their lower free ends spaced the same distance above a baffle below, which is the same as the distance between the lower baffles with the solvent drains, and in which each vent is provided with a drain for flow of solvent to the outlet means for offtake of solvent from the base of the lower section.

3. Apparatus as claimed in claim 1, and in which the upper gas cooling section is one of the all spray type devoid of packing and in which a conical deflector and a superposed perimetrical ring deflector is interposed at a level between the gas inlet to the gas cooling section and the level for the top of the liquid above the tail pipe in the lower water scrubbing section.

4. Apparatus as claimed in claim 1, and in which the upper gas cooling section is one of the packed type containing water and gas dispersing contact material between the gas inlet and the water inlet to the upper section, and in which the chamber area between the base of the packing and the level for the top of the liquid in the lower water scrubbing section is devoid of obstructions to the downflow of liquid.

5. Final cooler apparatus for coke oven gas chemical recovery plants comprising: a tower constituted of an upper gas cooling section having an intermediate gas inlet to the tower in communicable connection with an ammonia removal means, an upper outlet for finally cooled gas from the tower in communicable connection with a light oil scrubber for the coke oven gas, and means for introducing cooling water to the upper portion of said upper section, and a lower water scrubbing section having its top below said gas inlet and in open communication with the base of the upper section of said tower to receive hot cooling water therefrom, a funnel in said lower section with its top perimeter at a spaced distance below said gas inlet, a tail pipe disposed axially of said tower and extending from the outlet of said funnel down to a spaced distance above the base of the lower section, a vertical series of horizontal zig-zag flow baffles of greater height than the horizontal dimensions of the lower section disposed in the lower section to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, the upper baffles of the series being disposed to serve as foam collectors beneath their under surfaces and having vents therefrom to the gas cooling section above the funnel, a water outlet from said lower section at a level above the uppermost of the vertical series of baffles but below the underside of said funnel, conduit means for outflow of water from the water outlet with provision for maintaining a water liquid level in said lower section, a water cooler connected with said water outlet for cooling the water from said conduit means and provided with means for returning the cooled water back to the means for introducing cooling water to the upper section of the final cooler, means for introducing solvent of a different specific gravity from water into the lower section, means for draining solvent from the baffles of the series to the base of the lower section below the base of the tail pipe, and overflow outlet means for offtake of the drained solvent from the base of the lower section with provision to maintain a bath of the solvent submerging the base of said tail pipe but below said water outlet.

6. Apparatus as claimed in claim 5, and in which the upper baffles which are disposed to serve as foam collectors, comprise oppositely inclined baffles with their lower free ends spaced the same distance above a baffle below, which is the same as the distance between the lower baffles with the solvent drains, and in which each vent is provided with a drain for flow of solvent to the outlet means for offtake of solvent from the base of the lower section.

7. Final cooler apparatus for coke oven gas chemical recovery plants comprising: a tower constituted of an upper gas cooling section having an intermediate gas inlet to the tower, an upper outlet for finally cooled gas from

the tower, and means for introducing cooling water to the upper portion of said upper section, and a lower water scrubbing section having its top below said gas inlet and in open communication with the base of the upper section of said tower to receive hot cooling water therefrom, a funnel in said lower section with its top perimeter at a spaced distance below said gas inlet, a tail pipe disposed axially of said tower and extending from the outlet of said funnel down to a spaced distance above the base of the lower section, a vertical series of horizontal zig-zag flow baffles of greater height than the horizontal dimensions of the lower section disposed in the lower section to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, the baffles of the series being disposed to serve as foam collectors beneath their under surfaces and having vents therefrom to the gas cooling section above the funnel, a water outlet from said lower section at a level above the uppermost of the vertical series of baffles but below the underside of said funnel, conduit means for outflow of water from the water outlet with provision for maintaining a water liquid level in said lower section at a level above the top perimeter of the funnel and below said gas inlet, means for introducing solvent of a different specific gravity from water into the lower section, and overflow outlet means for offtake of solvent from the base of the lower section with provision to maintain a bath of the solvent submerging the base of said tail pipe but below said water outlet.

8. Apparatus as claimed in claim 7, and in which the upper baffles, which are disposed to serve as foam collectors, comprise oppositely inclined baffles with their lower free ends spaced the same distance above a baffle below, which is the same as the distance between the lower baffles with the solvent drains, and in which each vent is provided with a drain for flow of solvent to the overflow outlet means for offtake of solvent from the base of lower section.

9. Apparatus as claimed in claim 7, and in which the upper gas cooling section is one of the all spray type devoid of packing and in which a conical deflector and a superposed perimetrical ring deflector is interposed at a level between the gas inlet to the gas cooling section and the level for the top of the liquid above the tail pipe in the lower water scrubbing section.

10. Final cooler apparatus, comprising: a water scrubbing section having at its top a water inlet to receive water containing gas and a water immiscible constituent, a funnel in said scrubbing section with its top perimeter at a spaced distance below said water inlet, a tail pipe disposed axially of said funnel and extending from the outlet thereof down to a spaced distance above the base of said scrubbing section, a vertical series of horizontal zig-zag flow baffles of greater height than the overall horizontal dimension of the scrubbing section disposed in the latter to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, the upper baffles of said series being disposed to serve as foam collectors beneath their undersurfaces and having vents therefrom to a gaseous area at a level above the water inlet, a water outlet from said scrubbing section at a level above the uppermost of the vertical series of baffles but below the underside of the funnel, conduit means for outflow of water from the water outlet with provision for maintaining a water liquid level above the top perimeter of the funnel and below said water inlet, means for introducing a solvent of greater specific gravity than water and immiscible therewith into the scrubbing section, means for draining solvent from the lower baffles of said series to a point below the base of the tail pipe, and overflow means for offtake of solvent from the base of said scrubbing section at a level below the base of the tail pipe with provision for maintaining a bath of solvent submerging the base of said tail pipe but below said water outlet.

11. Apparatus as claimed in claim 10, and in which the upper baffles, which are disposed to serve as foam collectors, comprise oppositely inclined baffles with their lower free ends spaced the same distance above a baffle below, which is the same as the distance between the lowermost baffles with the solvent drains, and in which each vent is provided with a drain for flow of solvent to the overflow outlet means for solvent from the base of the lower section.

12. Apparatus as claimed in claim 10, and in which a conical deflector and a superposed perimetrical ring deflector is interposed at a level between the water inlet and the level for the top of the liquid above the tail pipe in the scrubbing section.

13. Apparatus for separating naphthalene from water containing entrained gas, comprising: a water scrubbing section having at its top a water inlet to receive water containing gas and water immiscible naphthalene, a funnel in said scrubbing section with its top perimeter at a spaced distance below said water inlet, a tail pipe disposed axially of said funnel and extending from the outlet thereof down to a spaced distance above the base of said scrubbing section, a vertical series of horizontal zig-zag flow baffles disposed in the scrubbing section to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, a water outlet from said scrubbing section at a level above the uppermost baffle but below the underside of the funnel, conduit means for outflow of water from the water outlet with provision for maintaining a water liquid level above the top of the perimeter of the funnel and below said water inlet, means for introducing a liquid solvent for naphthalene of greater specific gravity than, and immiscible with, water into the scrubbing section, and overflow means for offtake of solvent from the base of said scrubbing section at a level below the base of the tail pipe with provision for maintaining a bath of the solvent submerging the base of said tail pipe but below said water outlet.

14. Apparatus for separating naphthalene from water containing entrained gas, comprising: a water scrubbing section having at its top a water inlet to receive water containing gas and water immiscible naphthalene, a funnel in said scrubbing section with its top perimeter below said water inlet, a tail pipe disposed axially of said funnel and extending from the outlet thereof down to a spaced distance above the base of said scrubbing section, a vertical series of horizontal zig-zag flow passages disposed in the scrubbing section to range upwardly from below the base of the tail pipe to the top thereof around the outside of the tail pipe, said series of baffles being of greater height than the overall horizontal dimension of the water scrubbing section and having the upper baffles disposed to serve as foam collectors beneath their undersides and provided with vents therefrom to a gaseous area at a level above the water level of the scrubbing section, and the lower baffles of the series of baffles having drains for draining solvent directly to a level in the base of the scrubber below the base of the tail pipe, a water outlet from said scrubbing section at a level above the uppermost baffle of the series thereof but below the underside of the funnel, conduit means for outflow of water from the water outlet with provision for maintaining water in the scrubber at a level above the uppermost baffle of said series thereof, means for introducing a liquid solvent for naphthalene of greater specific gravity than and immiscible with water into the scrubbing section, and outlet means for off-take of the drained solvent from the base of the scrubber with provision for maintaining a bath level of the solvent for submerging the base of said tail pipe with the top level of the bath below said water outlet.

15. A method of scrubbing final cooler water from coke oven gas plants to remove naphthalene therefrom, comprising: continuously accumulating final cooler water aforesaid as a body of water gravitationally descending in a funnel to a tail pipe therefor and retained at low

velocity of flow above said tail pipe for a time to allow a major portion of the entrained gas to gravitate upwardly out of the body before the water enters the tail pipe, flowing the water from the body at higher velocity through the tail pipe into a bath of solvent for naphthalene that is immiscible with and of greater specific gravity than water at the base of said tail pipe, to leave the naphthalene of the water in the solvent, flowing the water upwardly for outflow of the water around the tail pipe to an upper level, above the top of the tail pipe but below the funnel through a series of horizontal zig-zag flow paths at a velocity in each horizontal flow path greatly in excess of the superficial upward velocity to said upper level, draining solvent from each of a plurality of the lower horizontal flow paths to the bath of solvent below, and entrapping escaping gas and lighter globules of solvent containing entrained gas at the top of the upper horizontal flow paths and venting said gas to a

gaseous area outside said water area to prevent the gas and lighter solvent from reaching the upper level above the top of the tail pipe for outflow of the water, feeding solvent to, and withdrawing solvent from, the bath to maintain the bath of the solvent at a level for submerging the base of the tail pipe with the top level of the bath of solvent below said upper level above the top of the tail pipe for outflow of water, and withdrawing the water at the upper level for outflow of water in a manner to maintain a body of water in the funnel at a level above the top of the tail pipe as aforesaid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,776,021	Van Ackeren	Jan. 1, 1957
2,810,450	Hartmann	Oct. 22, 1957
2,887,174	Ray	May 19, 1959