

THE RECOVERY OF THE BY-PRODUCTS OF COAL.

A MONOGRAPH

DESCRIBING THE SEMET-SOLVAY BY-PRODUCTS PLANT AND PROCESSES AT

HOLT, ALA.

BY

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A Monograph.

Describing the Semet-Solvay Coal By-Products Plant and Processes at  
Holt, Ala.

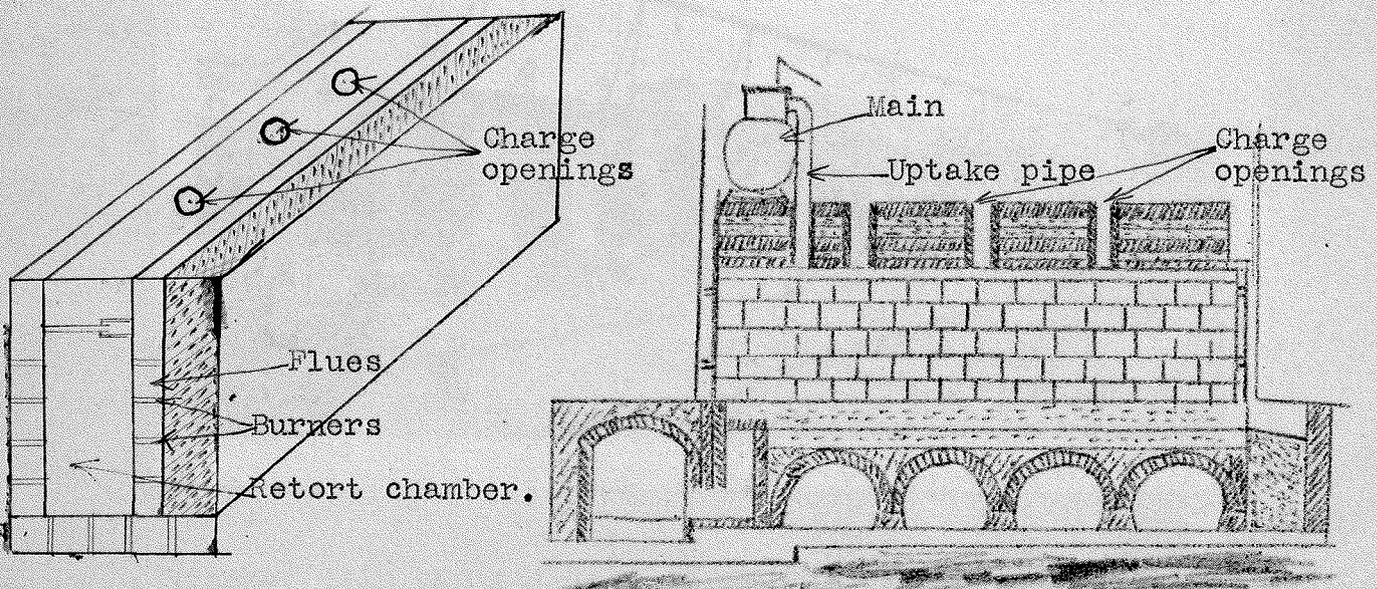
A hundred years of development have passed since the streets of the city of London were first lighted with coal gas. This beginning of preparing coal gas by the distillation of coal has been expanded and developed into our modern great by-products recovery industries. The history of these years plainly shows how the proper utilization of by-products can revolutionize an industry. No attention was given to the recovery of by-products of coal as a factor in reducing the cost of production, when coal gas was produced first by the distillation of coal. Special laws were enacted in England at one time to prevent the contamination of streams and lakes with tar. We are now beginning to realize how wasteful our methods of coking coal have been and how necessary it is to conserve our supplies of fuel.

The recovery of the by-products--tar, ammonia liquor, ammonium sulphate, light oil, and naphthalene--from the gases evolved in the coking process of a modern by-product coke oven plant is a rather broad subject, and I shall endeavor to confine myself in this paper to how this is done and to a description of the Semet-Solvay plant at Holt, Alabama.

The Semet-Solvay company with central offices and plant at Syracuse New York was incorporated July 8, 1895, and from a small beginning of about twelve ovens, it has grown to be one of the

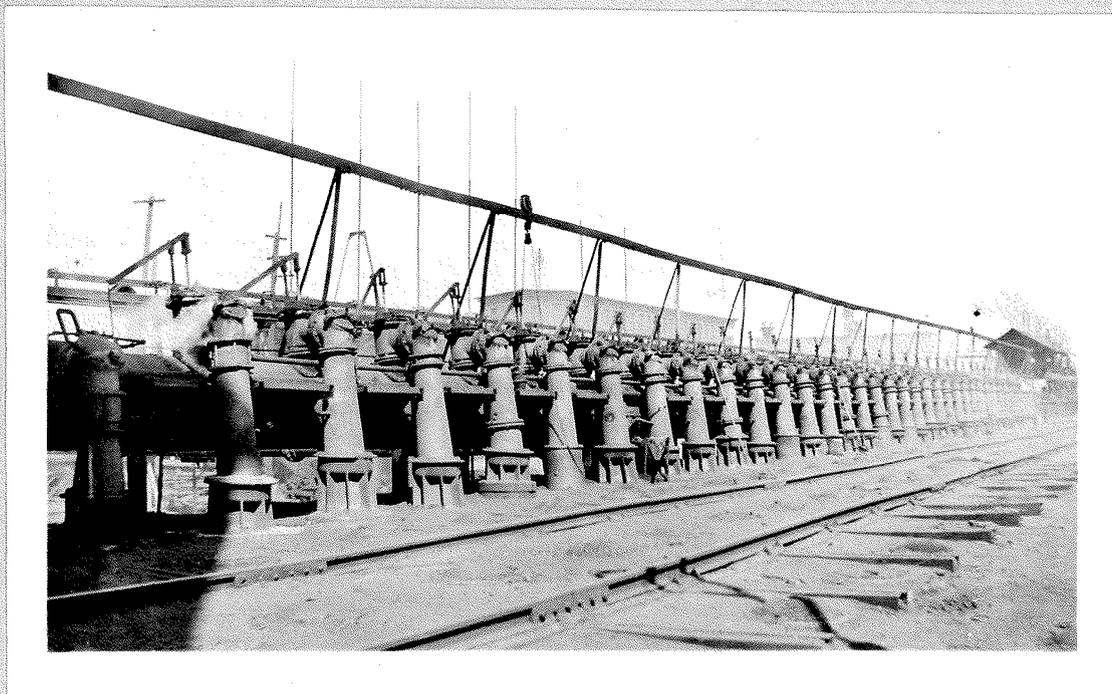
largest producers of <sup>The</sup> products from the distillation <sup>of</sup> coal in the world. The plant at Holt is one of a chain of plants owned and operated by this company.

The plant at Holt ~~##~~ consist of sixty ovens and equipment and apparatus to take care of the gas from these ovens. There are forty ovens in one block operated on the indirect system, and twenty in another operated on the direct plan. The ovens are of the recuperative type, and the retort chambers in which the coal is distilled are about thirty feet long, 6 1/2 feet high, and 21 inches wide. They are about one inch broader at the back side than at the front so as to facilitate the pushing of the coke. The ovens are lined with fire-proof silica brick. The walls are provided with verticle or horizontal internal flues heated with the gas produced by the distillation of the coal after the gas has passed through the plant, and the by-products have been removed.



Figs. 1 & 2, Sections of Semet-Solvay by-products coke oven.

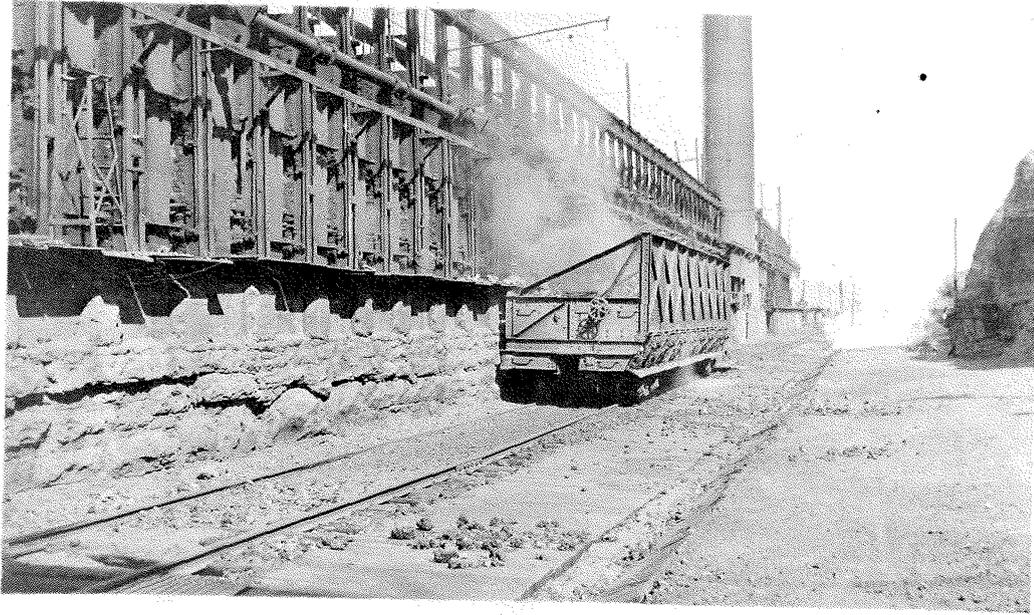
The ends of the retorts are closed with iron doors lined with fire brick. These doors fit very closely and are sealed with clay-lime mortar. The tops of the retorts are fitted with three openings through which the coal is charged and uptake pipes through which the evolved gases pass to the gas collecting main which extends along and over the top of the ovens. Large iron lids fit over these openings, and they are sealed air tight by means of fine coal dust. When the coke is pushed, the oven which is being pushed is cut off from the main by means of a lever and automatic cut off valve. A fairly good idea of how these valves work may be obtained from the picture given below of the main and the uptake pipes.



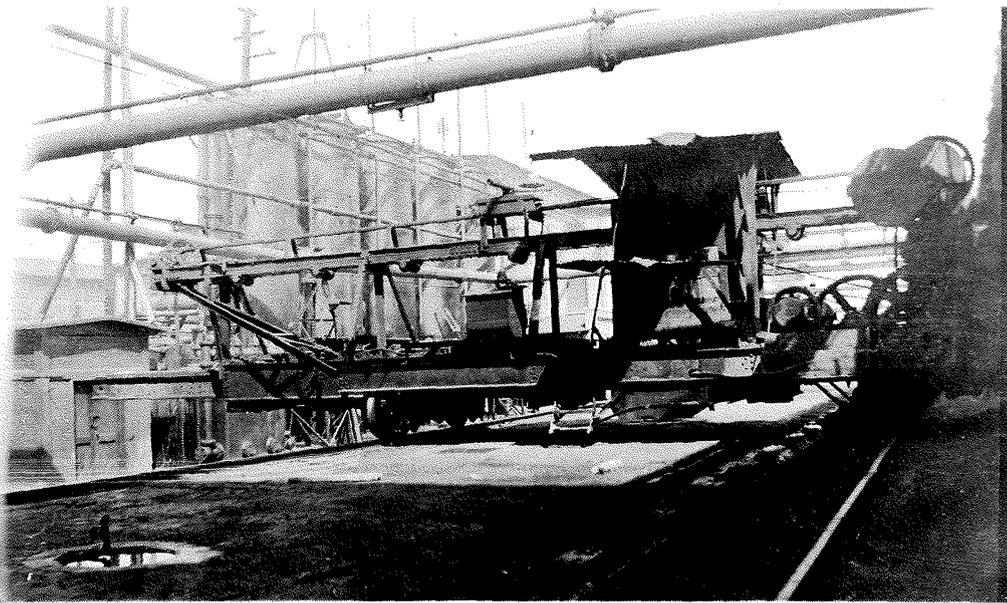
View of main and off-take pipes as seen on top of ovens.

The coke is pushed by a large, strong mechanical device or machine, and it is watered as it comes out and falls into the car. The coal is leveled in the ovens also by means of this machine. One view included with this paper shows this machine in action.

The time required for the complete coking of the coal and for all the volatile matter to pass off is from sixteen to eighteen hours. The longer period seems to give a higher percentage of ammonia. The whole process is under control and can be regulated. The yield of by-products is dependent on the working of the ovens and can be regulated to a certain extent at the option of the operator. The quality of the coke can be sacrificed for a better quality and <sup>an</sup> increased yield of gas and by-products; or the latter may be sacrificed somewhat for better coke. The manipulation of the ovens depends in a large degree upon what product is more desired. Uniformity is the main thing desired. Uniform heating produces uniform coke ~~##~~ through out the charge and reduces the time of burning. Uneven heating causes the points of higher heat to coke more rapidly, thus making a non-uniform product, and lengthens the time required for burning, and, perhaps, reduces the yield of coke from the coal. When the ovens are being operated at full operation, the average is about an eighty oven# push per twenty-four hours. Theoretically, <sup>this</sup> should give 560 tons of coke. It will be readily understood that the nature of the products as well as their relative amounts depend on the kind of coal distilled;



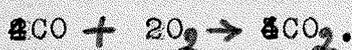
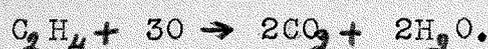
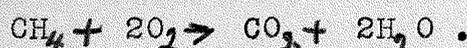
Flaming coke tumbling out of an oven into the car.



The pusher in action.

and they depend, more over, in a very marked degree on the general conditions under which the distillation of the <sup>coal</sup> is carried out, for example, temperature, size, and shape of retort. Each oven, when charged, holds about 10 tons of coal, and this amount is supposed to yield about 3 tons of by-products and 7 tons of coke. However, these proportions will vary, since they are dependent upon the volatile matter of the coal.

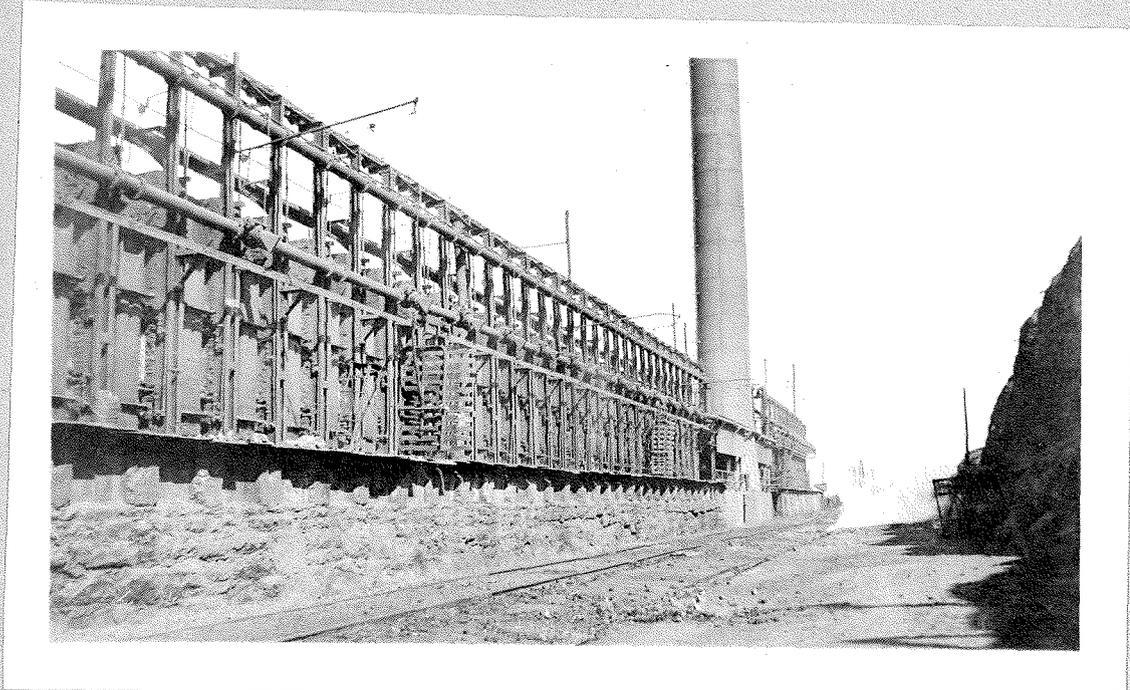
Since these ovens are of the recuperative type, the gas after the by-products have been removed is used for producing the steam needed for the operation of the plant and to produce the heat with which the coal is distilled. The gas is burned in flues at the sides and under the bottom of the retort# chambers. Air is admitted in order that <sup>t</sup>he carbon of the gas may be completely oxidized.



In the regenerative type of ovens the gas is used to preheat the air which is admitted, instead of producing steam. The steam necessary for the operation of the plant in a regenerative system is produced by burning coal in funaces separate and apart from the ovens.

For a while after the introduction of by-product coke there was a strong prejudice among the iron-makers against this coke, as it was thought--- not, at first, without reason--- that by-product coke was inferior to that produced in the old bee-hive ovens. But, the information that I have obtained from all the authorities examined on this point is that this prejudice has been ~~proved~~ proved groundless, and that by-product coke is not inferior to beehive coke for metallurgical purposes. The coke which is produced by this plant is used with very satisfactory results in the blast furnace of the Central Coal and Iron Company, which is located just around on the opposite side of the by-products plant from the ovens.

In the coking process the volatile matter of the coal, in the form of mixed vapors and fixed gases, leaves the by-product ovens through offtake pipes and enters what is called the hydraulic main, which is about 18 or 20 inches in diameter and is located above the ovens. This vapor-gas mixture, as it enters the hydraulic main, contains all the residuals of the volatile matter of the coal, and the method of their recovery in later stages of the process is simply the method of their separation.



A battery of sixty ovens viewed from the back side.



Charging the ovens.

The vapor mixture as it leaves the ovens and enters the main is generally at a temperature of 500 to 600 degrees Centigrade. On entering the main it is sprayed with a weak ammonia solution circulated continually for the purpose of cooling the gas and condensing the tar. The temperature drops down to about 70 or 80 degrees C., and in falling through this wide range of temperature the high boiling tar vapors are condensed out. The tar and ammonia liquor then flow along the main and away with the outgoing gases. When the liquors reach, along with the gas, the first series of coolers, the liquor and gas are there separated, the gas rising through a vertical pipe into the coolers, the tar and ammonia liquor going down into a decanter where they are separated. The tar being heavier than the <sup>liquor</sup> ~~###~~ goes to the bottom of the decanter, and each is then drawn off into separate collecting reservoirs. The liquor is picked up by a pump and thrown back again through the main for more cooling and condensing work. The decanter must be watched and not allowed to be filled with tar and empty of circulation liquor. If this should happen serious consequences would result in the loss of tar and by-products in the main.

The gas, still around 80 degrees C., and carrying a heavy volume of water vapor obtained from the circulation liquor, is

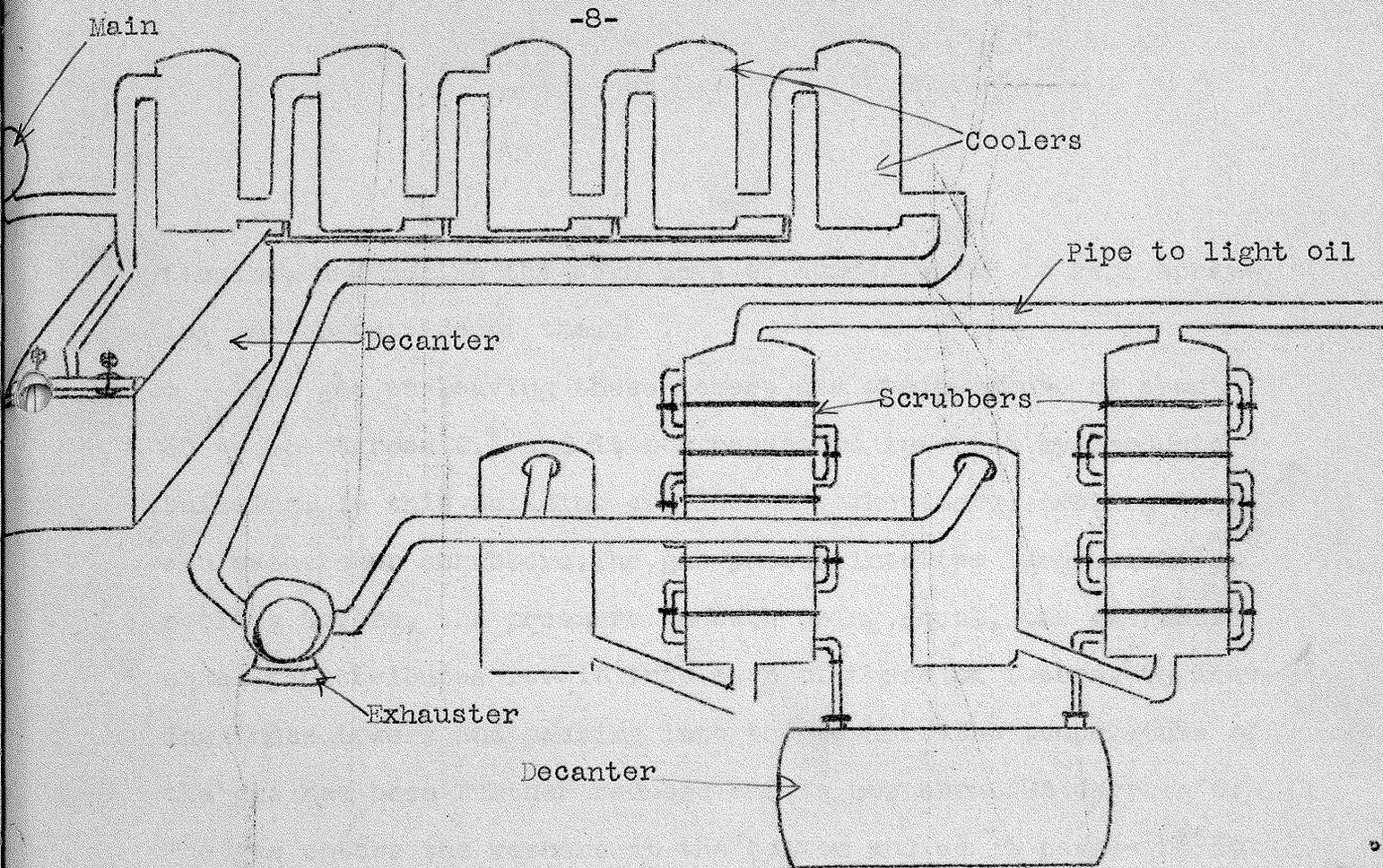


Fig. 3, Coolers and washers used in the indirect system.

now drawn under suction through a series of cooling towers, shown above in Fig. 3, which have for their object the reduction of the gas temperature to as low a point as possible, for the purpose desired. There are five towers in this series located on the outside of what is called the by-products building. A little tar and ammonia liquor fall down here, and they are drained off into the decanter which is shown above. Pipes and valves are so arranged that it is possible to cut out any one or number of these towers that you may desire and by-pass the gas around them. There are tubes on the inside of these towers through which cold water is

flowing, and during the warm days of summer water is kept spraying on the outside of them.

The gas on leaving these towers has a temperature of about 30 to 35 degrees C., and it now passes on into the by-products building. In this building are located exhausters, cooling tanks, and washers or scrubbers. The gas passes into two large ~~cooling~~ cooling towers, the pressure in each being equal, the gas about equally distributes itself into each of these ~~of~~ towers. On leaving these towers and passing into the washers the temperature of the gas has been further reduced and is now about 25 degrees C. The gas enters the washers at the bottom and as it passes up ~~##~~ through them meets a cool spray of water coming down.

The removal of ammonia depends upon its solubility in water, and at ordinary temperature and pressure water will absorb about 700 times its volume of ammonia gas, the absorption increasing with the decrease in temperature, providing the pressure of the ammonia is equal to the atmosphere, and if the gas carries no tar burden. So in passing through the above mentioned cooling towers an appreciable portion of the ammonia is dissolved in the water condensed by the cooling process, and the resulting ammonia liquor is drawn off for further treatment.

Some ammonia still remains in the gas leaving the coolers; so the exhausters force the gas through the above mentioned series

of scrubbers or washers, which remove the last traces of the ammonia content of the gas. The weak resulting ammonia liquor and tar which is removed pass into a decanter and are separated. The ammonia liquor is sent to a collecting tank and from there is sent to the concentrating apparatus, where a pure concentrated solution of ammonia liquor is produced, or the ammonia gas is sent from the concentrating apparatus to the sulphate plant and recovered in the form of ammonium sulphate.

#### THE CONCENTRATING PLANT.

The apparatus for concentrating the weak ammonia liquor which has been recovered is shown in Fig. # 4, and it consists of stills (A,B,D), liming section (C), overhead supply tank (I), and coolers (E,F,G,H).

The weak ammonia liquor which is collected in a tank from the washers, as stated above, is pumped to an overhead supply tank and fed to the still (A). The crude liquor enters at the top of the still and flows down from section ~~of the~~ top section of the still, steam being admitted at the bottom. The liquor on entering this still contains around 4 grams <sup>of ammonia</sup> to the liter; on leaving, it contains around 8 grams to the liter and has a temperature of about 90 degrees C. Some waste gases, principally sulphur dioxide, escape

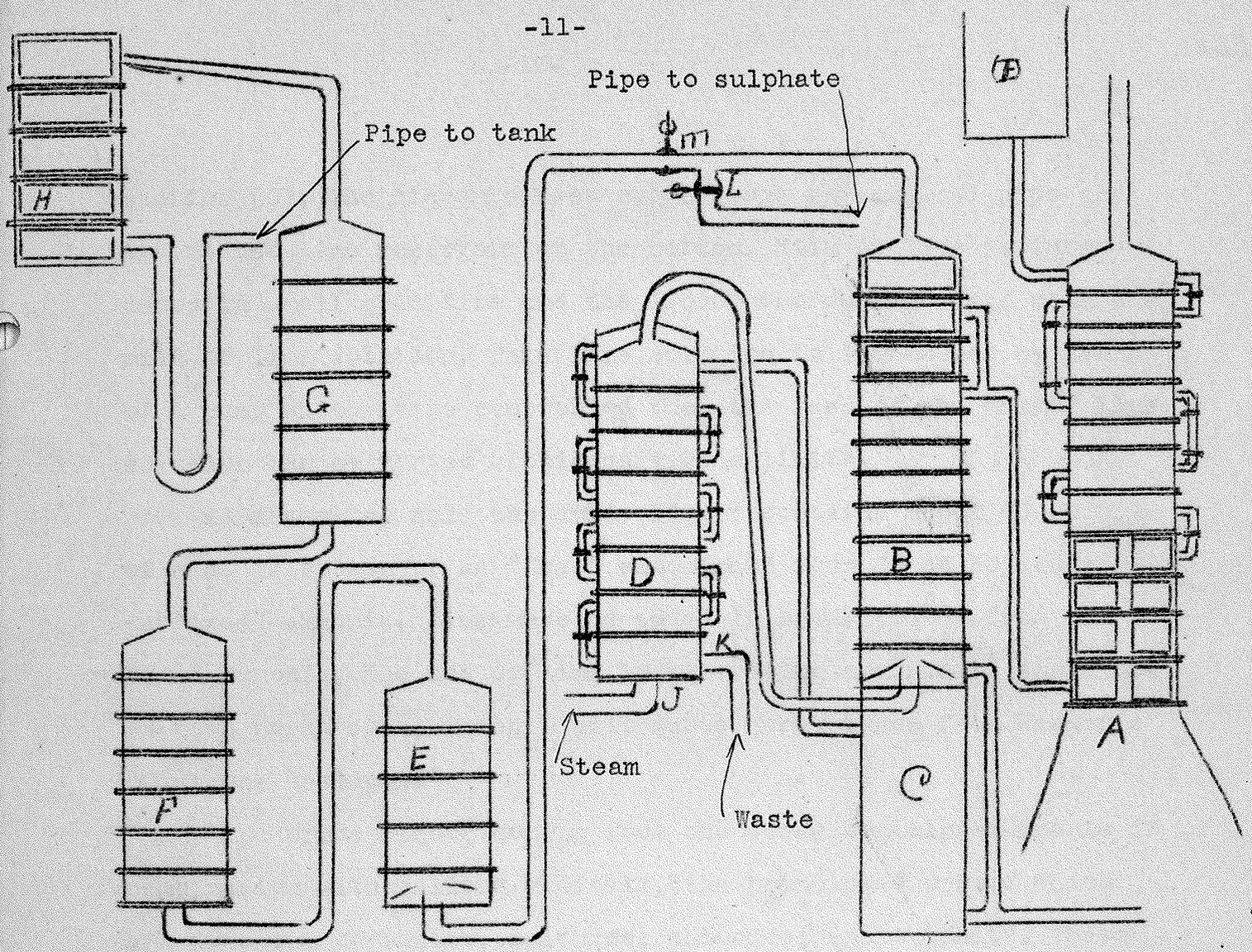


Fig. 4 THE CONCENTRATION PLANT.

into the air at the top of the still, conducted off by a pipe extending to the outside and above the building.

The liquor at a temperature of about 90 degrees and under high pressure now leaves the bottom section of (A), passes over and enters the fourth section, from the top, of (B). Each section or ring has a seal of liquor, but internal overflows are provided; so the liquor flows down from section to section until the last one is reached. Below this last one is a ten foot liming

section (C). The liquor passes out through an external pipe and enters the lime reservoir at the bottom. Milk of lime is introduced in small quantities and the liquor thoroughly mixed with the milk of lime solution. This lime solution is introduced by means of a pump which is so controlled that the feed of the milk of lime solution can be varied within very wide limits.

As a general rule the crude liquor contains about 70 to 80% of what is spoken of as "free" ammonia and from 25 to 30% known as "fixed" ammonia. Lime must be added in order to set free the fixed ammonia. The use of lime in liberating ammonia is explained in two paragraphs, which I will quote here, taken from Wagner's "Coal Gas Residuals".

"The crude liquor coming from the works contains ammonia in combination with various radicals, the principal ones of which are ammonium carbonate, sulphide, chloride, and sulphate. These salts may be grouped into classes in accordance with their conduct during the process of boiling the crude liquor."

Carbonates of ammonia as well as sulphides of ammonia below the boiling point of the liquor, decomposes into carbonic acid, hydrogen sulphide, and ammonia, and these are completely freed at the boiling point and are classed as 'free' ammonia compounds. On the other hand, ammonia combined as chloride and sulphate can only be liberated by the addition of some stronger alkali, lime in the form of the milk of lime being usually introduced into the solution for this purpose."

The liquor leaves the top portion of the lime section and enters the still (D) at the top. As the liquor goes down through (D) it meets a counter current of steam introduced at the bottom through pipe (J). A final boiling of the liquor in the lower sections of this still completely liberates all of the fixed ammonia. The ammonia gas rises up to the top of the still, and the liquor passes out at the bottom and is conducted off to the sewer. The stills should be so operated that the waste leaving at the bottom will not contain more ~~0.01~~ than from 0.01 to 0.02 grams per liter of ammonia and not over 1 gram per liter of lime.

The ammonia gas which rises to the top of the still is carried back and again introduced into the bottom section of (B). Each section has a liquor seal on it. The vapors rise through the tubes in the bottoms of the sections, being baffled by a kind of hood like device located over the tubes, while the raw liquor gradually flows through the external overflow tubes from one section to another. The <sup>repetition</sup> of this cycle produces ammonia vapors of high strength.

The last three sections at the top of (B) are fitted with aluminium tubes, about 4 or 6 inches in diameter, through which cold water circulates. The ammonia is conducted off through the series of coolers (E, F, G, H) where it is condensed and dissolved in water. The ammonia gas leaves (B) and enters (E) at a temper-

ature of about 90 degrees. The rings of (E), (F) and (G) are lined with lead and contain lead coils of pipe through which cool water flows. From 1/2 to 1 1/2 liters of pure water are admitted in (G) per minute, and from 2 to #3 1/2 liters of water, depending upon what strength of ammonia solution is desired, are admitted per minute in (H). The # liquid when it leaves (H) is a strong ammonia solution, averaging from 25% to 28% pure ammonia, and is sent to the storage tank, from which it is sold and shipped for commercial purposes. The liquor when it enters# the still (A) of this concentrating apparatus contains about 4 grams per liter of ammonia, but when it leaves (H) it contains about 240 grams per liter. If it is desirable to produce ammonium sulphate instead of ammonia liquor, the ammonia gas is not sent through the series of coolers (E,F,G,H), but is cut off and sent to the sulphate plant by closing the valve (M) and opening (L), as shown in Fig. 6 .

This account so far, considering that there is no production of ammonia liquor, is a description of the method and treatment of the gas from 40 ovens, block 1, and is what is called the "indirect recovery process". The gas from 20 ovens is treated somewhat different from this and is what is called the "direct recovery process".

In the "direct recovery process" the scrubbing of the ammonia is avoided by passing the gases direct to the sulphuric acid

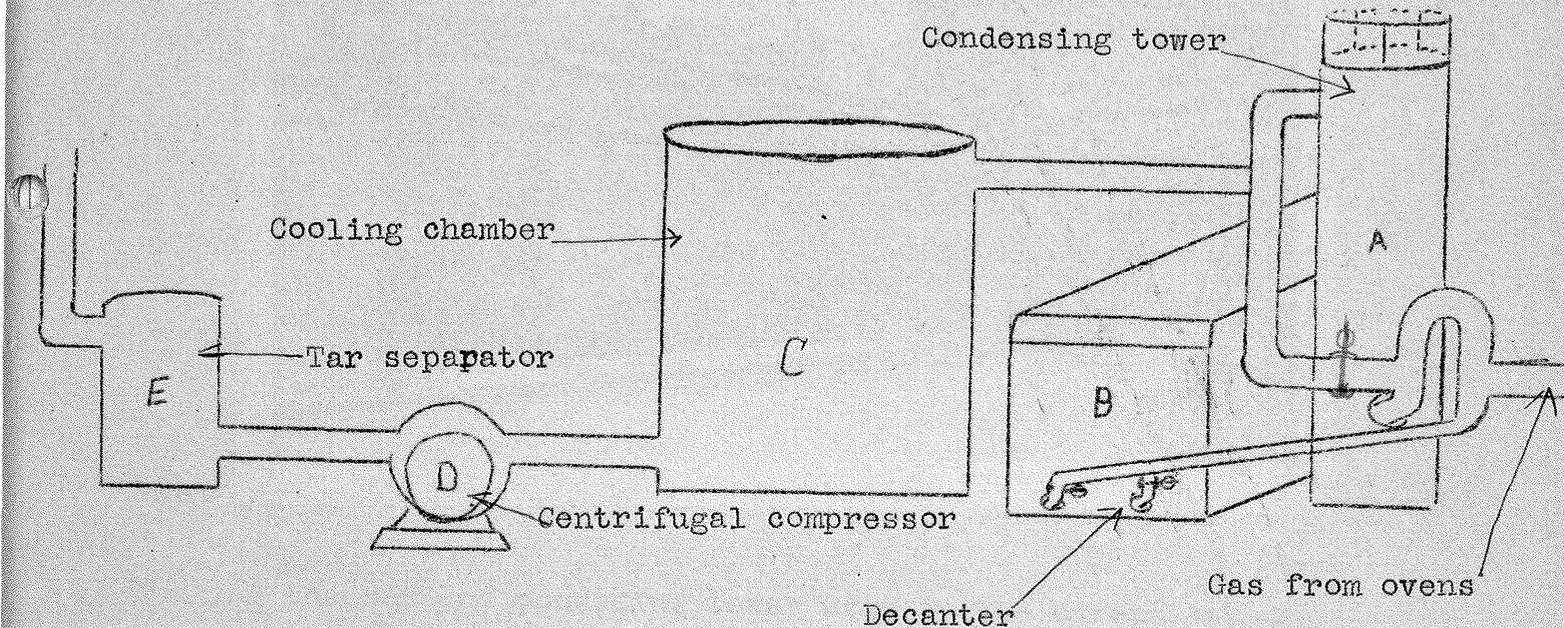
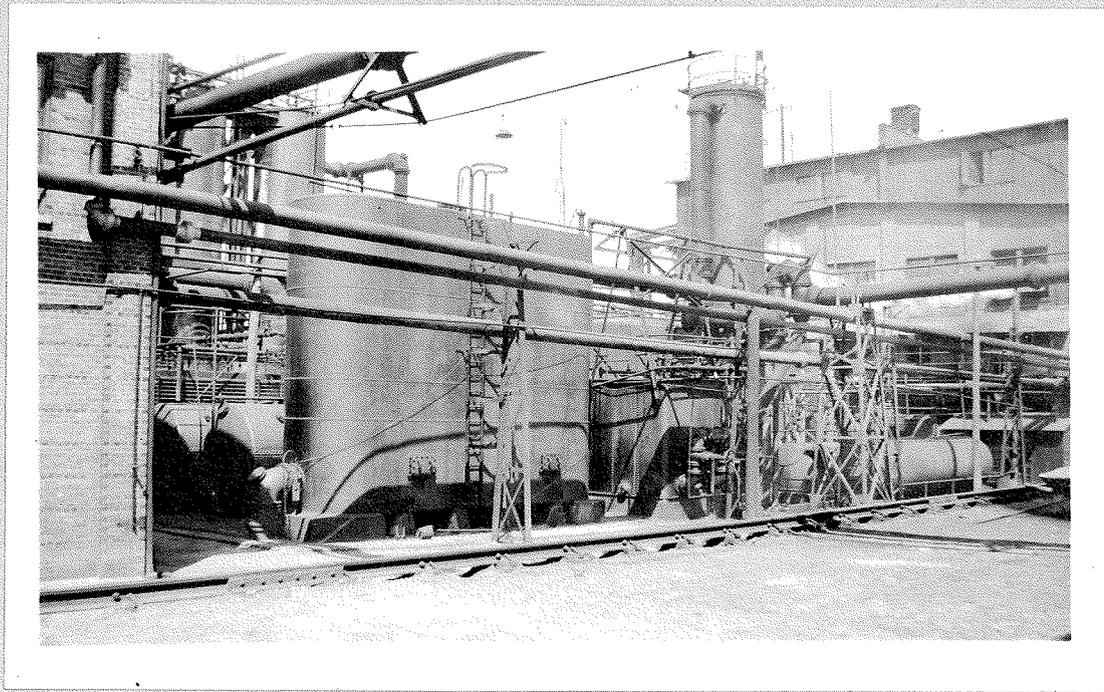


Fig. 5, Tar condensing apparatus used for the direct system.

saturator after the removal of the tar has been accomplished.

Fig. 5 is a sketch of the apparatus employed in the removal of the tar from the gases that come from 20 Ovens, block 2. A cool weak solution of ammonia liquor is kept spraying out into the main for the purpose of cooling the gas and condensing the tar, just as in the case of the indirect method. The gas enters at the bottom a tall tower (A), Fig. 4, and meets a down coming spray of cooled ammonia liquor, which is very weak, with the result that on entering the exhauster the temperature is very close to that of the cooling water. The hot liquor and tar enter the decanter (B), and the liquor is decanted off into a reservoir near by. Some of this liquor then is picked up by a pump and forced



Cooling chamber and condensing tower used in the direct system.

through cooling coils, cooled and then put back through the tower (A). Another pump picks up some of this liquor without carrying it through the cooling coils and throws it back through the main over the ovens for more cooling and condensing work. The tar is pumped over into a reservoir or cooker and united with the tar which has been removed <sup>from</sup> block 1.

The gas passes on into a very large cooling chamber (C). The superintendent said that this chamber was put in more as an experiment than anything else. The idea was to slow up the gas and allow it to cool slowly, and that in doing so, fine particles or globules of tar held in suspension would be removed. The opinion of the superintendent is that it is not worth very much. From here the gas passes through a centrifugal compressor (D) which slings out

practically all of the remaining tar and forces it on through a small tar separator (E), where the last trace of tar is removed. The gas is now ready to go directly to the sulphate plant. However, if it<sup>is</sup> desirable to recover the ammonia in the form of a concentrated liquor, which sometimes is the case, and not as ammonium sulphate, this may be done very easily by opening and closing a few valves, when the gas will be sent through the coolers and scrubbers in the by-products' building and treated just as in the case of the gas in the indirect method.

#### THE SULPHATE PLANT.

This plant, a sketch of which is shown in Fig. 6, consist of an acid saturator (A), and acid tank (B), a circulation liquor tank (C), two separators (D) for catching liquor from out flowing gas, a vat (E), an open tank (F), and a rotary drying apparatus (G). All of these containers and pipes are lined with lead.

The tar washed gas from the second set of ovens and the ammonia gas produced by treating with lime and steam in a still the weak ammonia liquor recovered from the first set of ovens pass through a gas main to the sulphuric acid saturator. Here neutralization of the ammonia occurs with the formation of ammonium sulphate.  $2\text{NH}_3 + \text{H}_2\text{SO} \rightarrow (\text{NH}_4)_2\text{SO}_4.$

Every little while the operator opens a valve with a hand lever at the bottom of the saturator in order that the liquor and salt

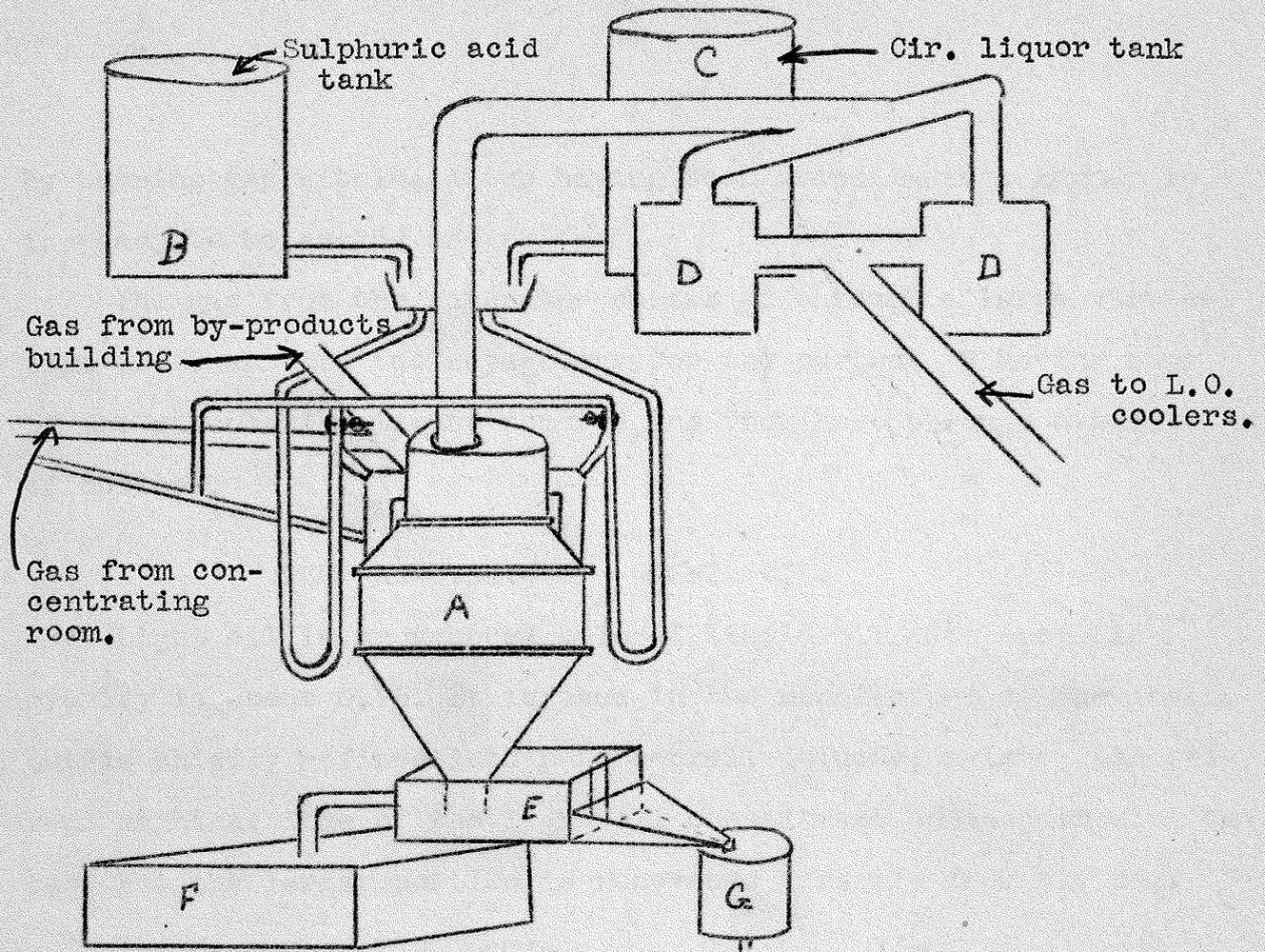


Fig..6, Sulphate Plant.

may flow out into a vat, where the salt settles out as a precipitate. The liquor is drawn off into an open tank (F), and is picked up from there by a pump and thrown up into the circulation liquor tank (C) to be mixed with pure concentrated sulphuric acid from the tank (B) and used over again. The salt is then pushed out by hand with large paddles into a round, cylinder-like machine which rotates very fast and dries the salt. It is then taken out by hand, carried in small cars to a room where it is further dried by passing through a cylindrical stove like arrangement kept hot

by burning gas within. After having been dried in this manner it is ready to be sacked and shipped.

The gas from the saturator passes up through a large vertical pipe and then into two separators, for the purpose of having some of the circulation liquor removed, and from here through a series of coolers.

#### THE RECOVERY OF LIGHT OIL.

Light oil is an amber~~ed~~ colored limpid oil. Its specific gravity is about 0.75. It is used in the manufacture of chemicals, but is chiefly refined into pure benzol, toluene, xylene, and solvent naphtha. Some of the light oil constituent comes down with the tar, but the larger portion is recovered directly from the gas.

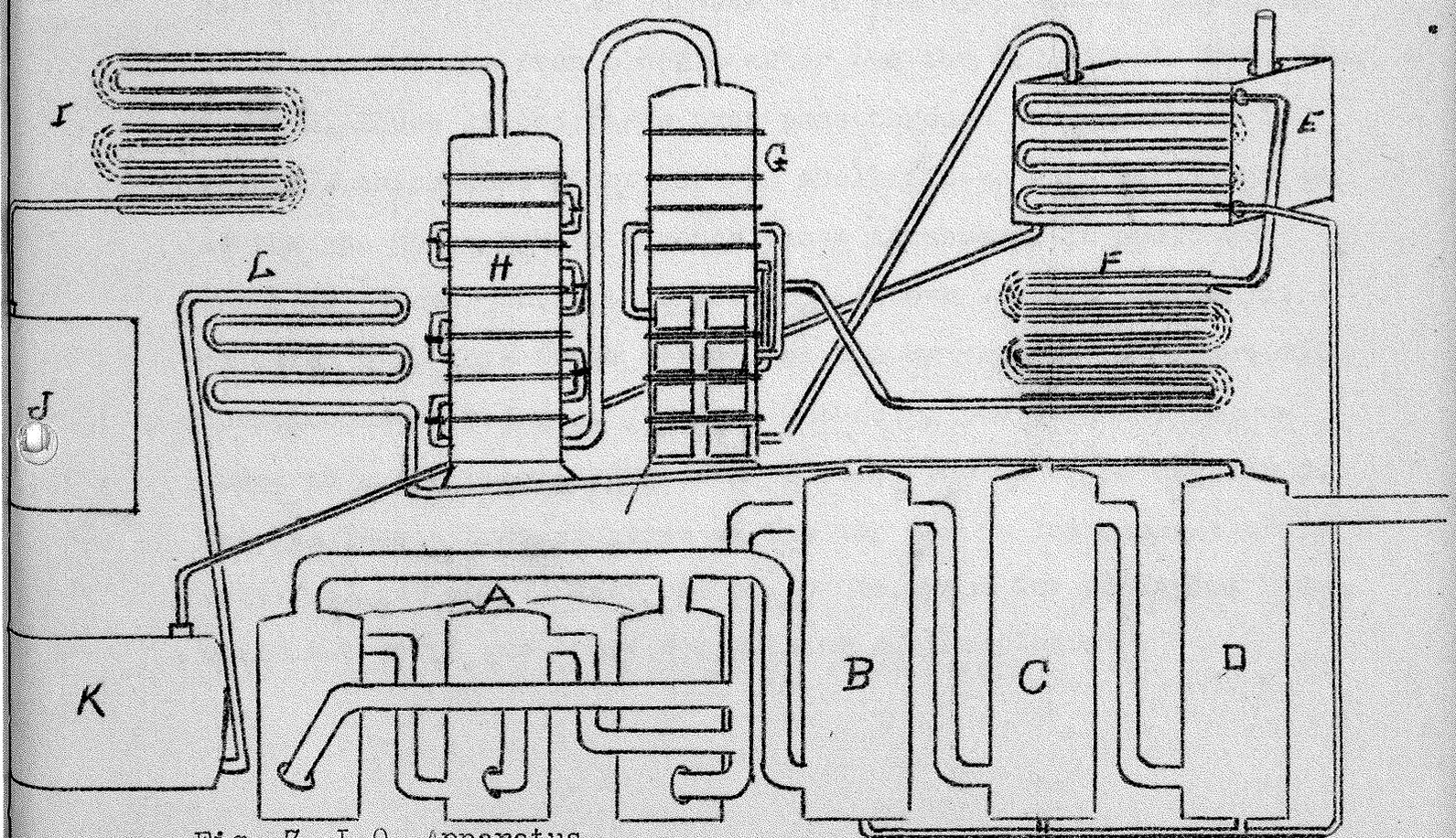


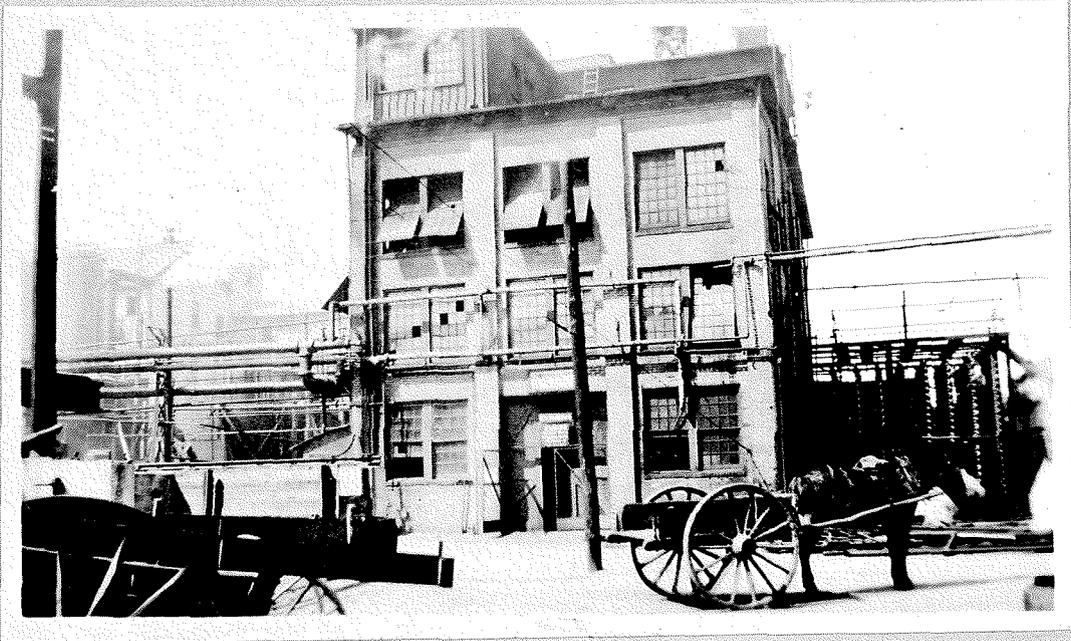
Fig. 7. L.O. Apparatus.

The light oil recovery plant as shown in Fig:7 consist of the following apparatus: a series of coolers (A), scrubbers (B?C,D) coils (E& F), still (G), cooler (H), coils of pipe (I), collecting tanks (J &K), coil (L), and a set of pumps not shown in the figure.

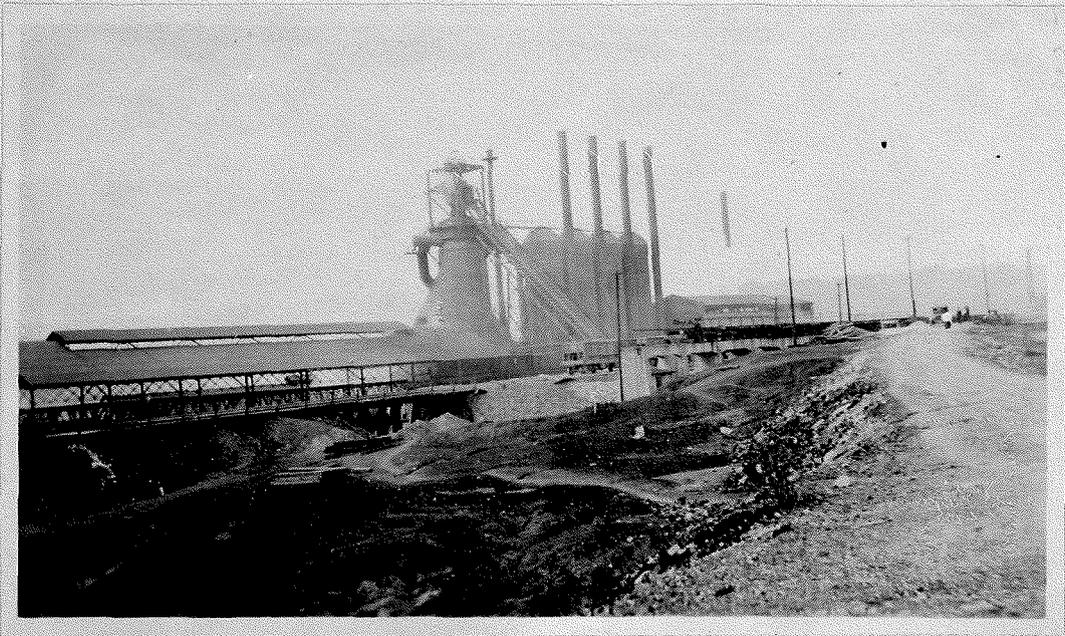
The gas coming over from the sulphate plant, being at a higher temperature than is desired, is sent first through the series of coolers (A). These coolers are so connected that any combination of them may be used. In order that they may be kept clean and in perfect working order, at least, one is idle all the time, alternating between them. After having passed through these coolers, this gas which comes from the sulphate plant is united with the gas which comes from the scrubbers in the by-products' building, or rather the gas from block 1 after the tar and ammonia have been removed. These united gases then pass through the scrubbers (B,C,D). which consist of an iron shell fitted with wooden grids. As the gas moves upward through these scrubbers, it meets a spray or counter current of wash oil, known as straw oil or circulation oil. This straw oil washes out or absorbs the light oil constituent of the gas. The temperature of the wash oil is reduced to a low point ~~---~~ down to about ~~###~~ 16 or 30 degrees C. The gas leaves the scrubbers at the top and is now used as ordinary fuel gas and is sent either to the ovens for producing heat or to the large gas container outside of the plant.

The oil leaves at the bottom of the towers and is now pumped over through the two sets of coils (E & F) to the still (G). The coils (E) are fitted in a closed rectangular box, and the hot straw oil which comes over from the still (G) after having been separated from the light oil, and which is now at a temperature of about 110 degrees C., is poured into this box over the coils. The oil from the scrubbers leaves (E) and enters coils (F) at a temperature of about 60 degrees C. The coils (F) consist of a coil within a coil. The inner coil contains the oil, and the outer coil around the oil pipe contains steam. The oil is thus pre-heated before entering the still.

The oil from (F) at a temperature of about 90 to 100 degrees enters the still (G). Steam is admitted in the bottom rings, which heats the oil up to a temperature sufficient to vaporize the light oil constituent that was taken up by the straw oil in the scrubbers. The light oil constituent which is now a gas passes out at the top of (G) and through the cooler (H) and on through a set of cooling ~~#####~~ coils (I). These coils are constructed like those of (F). Cold water circulates in the outer pipe and completely condenses the light oil, which flows into the collecting tank (J). The straw or circulation oil leaves the still at the bottom, goes out and is poured over the coils of pipe in (E). The straw oil from this collecting box goes to collecting tank (K), and



The light oil building.



Blast furnace of the Central Coal and Iron Company where the coke is used.

from there is pumped back to the scrubbers. On the way back to the scrubbers it is forced through a series of coils over which cold water is flowing so as to reduce the temperature to the desired point before entering the scrubbers.

#### RECOVERY OF NAPHTHALENE.

Naphthalene comes down with the tar and is recovered from the tar by fractional distillation, the tar being heated up to the proper temperature at which the naphthalene is evolved as a gas. Naphthalene is a source of a lot of operating trouble, owing to its formation as a solid in the mains or apparatus. A small amount of very crude naphthalene is recovered directly from the gas which is managed by the direct system.

As to the cause of the naphthalene being present in the gas after the tar has been removed the following is quoted from Wagner's "Coal Gas Residuals". "The presence of naphthalene in the gas is probably due to the high heats employed in present-day carbonization, and it is presumed that these high heats cause a partial distillation of the tar with the consequent formation of naphthalene. The greater portion of the naphthalene produced, especially with high distillation or carbonization temperatures goes over into the tar, the gas containing only a portion of the naphthalene vapor, its maximum content being dependent upon saturation at various temperatures, but outside of the temperature

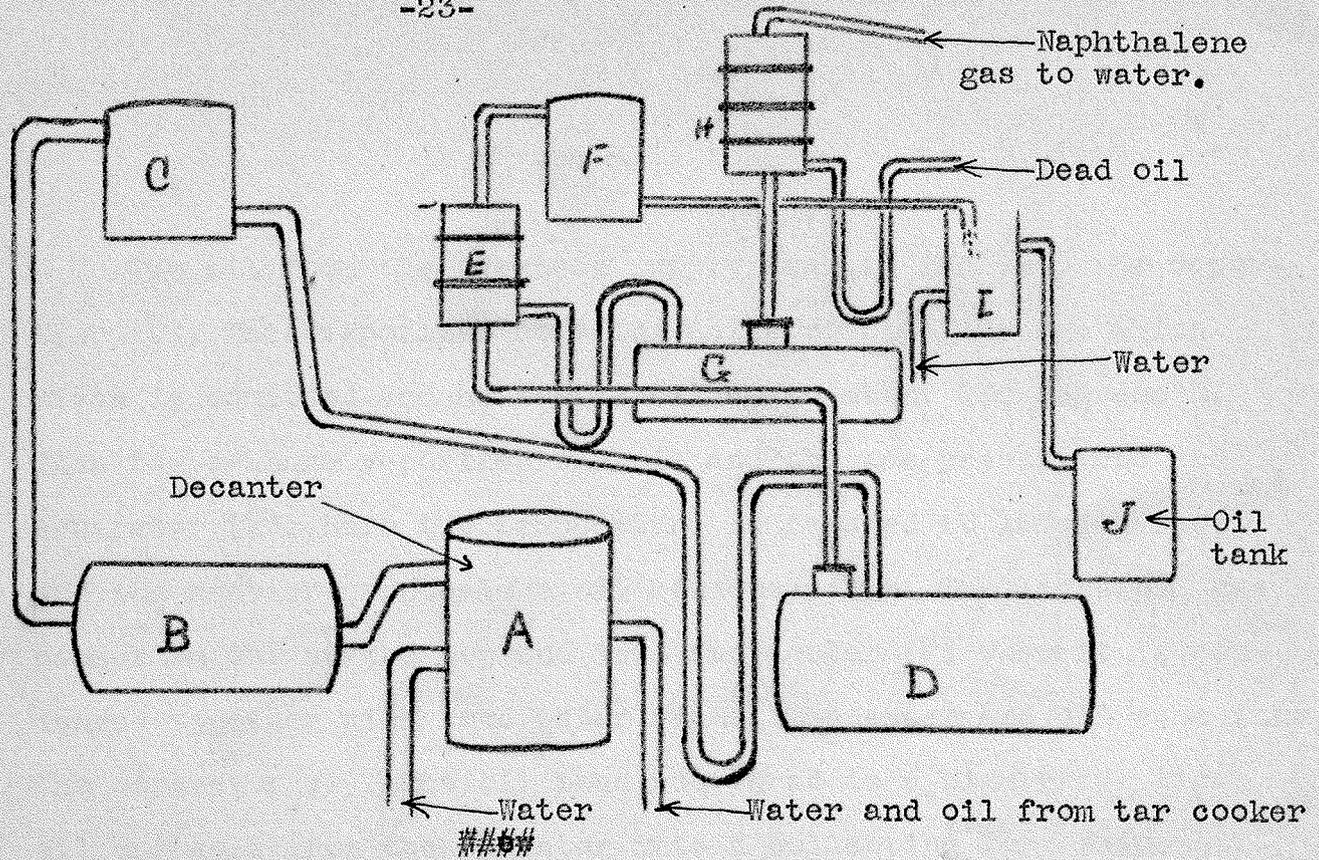


Fig. 8 Part of the naphthalene apparatus.

of carbonization the amount of naphthalene present in the gas is also due to the character of the coal used, and upon the time of contact <sup>between</sup> the gas and hot coke and hot retort walls."

Part of the apparatus for the refining of the naphthalene is shown in Fig. 8. The tar in the cooker is heated up to the proper temperature to vaporize the naphthalene. The naphthalene gas and water vapor which are evolved by this distillation are cooled, condensed, and collected in the decanter (A). The oil being lighter than water rises to the top and flows over into the retainer (B) and is pumped from there to the overhead supply tank (C).

Some light oil is recovered with the tar and comes off with the ~~###~~ naphthalene oil. This oil is said to be of a higher grade than that recovered from the gas, as has already been explained.

The oil from the overhead supply tank is fed into the vaporizer (D). This vaporizer contains coils of pipe through which steam is admitted and heats the oil up to about 160 degrees C. This temperature vaporizes the oil and the gas passes into the separator (E). Here the temperature is reduced to 105 degrees, and the heavier naphthalene oil condenses out. The light oil gas passes on out at the top and into the cooler (F) where it is condensed together with some water vapor. The water and oil pass into the separator (I). The oil thus recovered is a high grade light oil and goes from the separator into a collecting <sup>tank</sup> for shipment.

The heavy naphthalene oil from the separator (E) passes into a second vaporizer (G). Here it is again vaporized. The vaporized naphthalene gas passes into a kind of separator (H) where a heavy oil condenses out and is known as "dead oil". From here the naphthalene gas passes over and meets a cold stream of water and falls down as a precipitate as soon as it strikes the cold water. It is carried off by the water to a pit where it collects on top of the water. The water is filtered off, leaving the crude naphthalene in the pit. This crude naphthalene is then carted over to what is known as the naphthalene house and revaporized. The naphthalene vapor passes up into a long horizontal box like device, about 50 or 60 feet long, with compartments separated by hanging curtains of burlap. Cool air at atmospheric pressure is admitted to this

long cooling box through tubes at the bottom side of it. The gas comes up and strikes this cooling chamber and sublimes in a beautiful white crystalline form, looking as it falls very much like snow. It is then taken out at the bottom and packed in barrels ready for shipment.

CAPACITY OF PLANT.

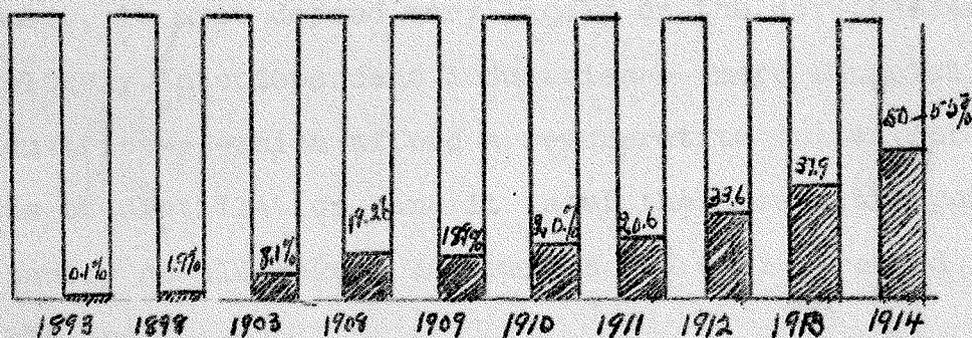
This plant when running on full operation produces about 560 tons of coke per day. The surplus above what it takes to supply the blast furnace of the Central Coal and Iron Co. is sold and shipped. The average amount of tar recovered per day is 500 gallons, and that of refined oil 200 gallons.

The normal or average amount of sulphate produced per ton of coal is 25 pounds. It quite frequently runs up to 28 pounds, the theoretical amount. Assuming 2 percent ~~## ##~~ of coal to be nitrogen and that 15% of this nitrogen is converted into ammonia, the amount of nitrogen present in a ton of coal will be  $2000 \times .02 = 40$  pounds,  $40 \times .15 = 6$  pounds of nitrogen per ton of coal to react with hydrogen to form ammonia. Ammonia is a compound consisting of 14 parts of nitrogen and 3 parts of hydrogen; so the amount of ammonia per ton of coal would be  $\frac{77 \times 6}{14} = 7.28$  pounds.

In the reaction,  $2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$ , 34 parts of ammonia by weight react with 98 parts of sulphuric acid forming 132 parts of ammonium sulphate. Then  $\frac{132 \times 7.28}{34} = 28.25$ , the theoretical amount of ammonium sulphate obtained per ton of coal.

Taking an average of 25 pounds per ton of coal and of a 80 oven push per day, the amount of ammonium sulphate produced per day would be  $80 \times 10 \times 25 = 16000$  pounds.

The increase in by-product coke and the ratio of by-product coke to beehive coke since 1893 may be seen below from the diagram taken from an article in the Scientific American, April 24, 1915 .  
The shaded portions represent the by-product coke.



From the same paper mentioned above I quote the following. "Enough benzol to run 200,000 automobiles per year, enough ammonium sulphate to supply all of the farmers for a period of two years was thrown away by the beehive coke ovens in the U.S. during the year 1912. The value of the by-products thus wasted was \$80,000,000, and the amount of coke burned up and destroyed by the beehive ovens was 6,800,000 tons."

It is said that there was an increase of beehive coke production <sup>in Ala.</sup> in 1918; but this increase was due to strenuous effort to secure coke, and one should not conclude that the wasteful bee-

hive oven has reasserted its sway in permanent form. When the three new plants now building are completed more than half of the coke produced in the state will be by-product# coke. We welcome the preponderance of the by-product oven because it conserves otherwise wasted material and converts it into valuable and staple articles of commerce.

In the future, it seems, if the coking industry, with recovery of the by-products, is to reach its highest and most successful development, it must depend very largely on the development of all those closely interdependent industries----more especially chemical industries----which afford a remunerative outlet for the by-products of distillation, and it is of the greatest importance that this country should make a determined and well directed effort toward this end.

BIBLIOGRAPHY.

There is very little to be given as a bibliography to this paper. The main basis of this paper is the result of my own work and study of the Holt plant itself, with the help and explanations given by the superintendent and employees of the plant. I wish to say that the superintendent was very kind in making explanations ## and in allowing me the privilege of studying the plant.

However in connection with my study the following were read:

"Coal Gas Residuals" by F. H. Wagner.

"Coal and Its Scientific Uses chs. 15,16,17 by W. A. Bone.

Metallurgical Coke (Bulletin U.S. Bureau of Mines) by A.W.Belden.

By-products of the Modern Coke Oven by C. A. ~~M~~weissner,

Scientific American Nov. 8, 1913.