Acme Coke
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By-Product Operation Course
For Battery Operators
June 1996

ACME STEEL COMPANY

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COKE PLANT OVERVIEW

[illegible] simplified schematic of the coke oven and by-product plant to illustrate the main [illegible] plant operation at Acme Steel. Highlights include the following items:

- [illegible] the coke ovens is to take raw coal and heat it in an air-free atmosphere to produce [illegible] the blast furnace.

- [illegible] lity of the coke is one of the key factors [illegible] blast furnace productivity and [illegible] formance at Acme Steel.

- The [illegible] e ovens produce gas which is called coke [illegible] uct. T[illegible] coke [illegible] en gas is used as fuel to underfire the ov[illegible] plant. [illegible] coke oven gas also contains tar, light oils and a[illegible] l and so [illegible]

- The coke ovens and by-product plant operations [illegible] ourse [illegible] er. Each [illegible] provides a key feed stock to the other.

The purpose of this course is to introduce the coke oven ope[illegible] to the by[illegible] uct process. [illegible] hoped that a basic understanding will help the operators run the coke ovens [illegible] manner which [illegible] improve by-products operation. This, in turn, will allow the by-products operation to provide a higher quality, more consistent COG to improve and stabilize coke oven operation.

Nitr

COMPONENTS OF COKE OVEN GAS

[illegible] atile baked out during the coking process are collected as four major by-product groups - [illegible] es (COG), coal tar, ammonium sulfate and light oil. COG contains numerous compounds [illegible] in order of concentrations, hydrogen, methane, nitrogen, carbon monoxide, carbon dio[illegible] illuminates and oxygen. COG also contains numerous impurities such as ammonia, hy[illegible] fo[illegible], hydrogen cyanide and naphthalene.

T[illegible] al COG composition ranges at Acme Steel [illegible] the major chemical compounds are as fo[illegible]

Coke Oven Gas Dry Composition (Normal 30 MMSCF

Hydrogen	38 -	58%
Methane	27 -	32%
Illuminates	2.0 -	4.0%
Carbon Monoxide	4.0 -	6.0%
Light Oil	0.8 -	1.3%
Carbon Dioxide	0.5 -	2.0%
Oxygen	0.3 -	3.0%
Nitrogen	3.0 -	12.0%
Hydrogen Sulfide	300 -	400 grains/100 SCF
Hydrogen Cyanide	50 -	150 grains/100 SCF
Ammonia	250 -	350 grains/100 SCF (dry)
Naphthalene	100 -	120 grains/100 SCF (before light oil)

A short description of each of these compounds follows for the readers enlightenment.

Hydrogen

Hydrogen is the simplest and lightest element. Hydrogen is a colorless, odorless, tasteless gas. Hydrogen burns with oxygen to form water and is very explosive when exposed to a flame or spark. The hydrogen in COG is one of the main energy sources that makes COG a valuable fuel for steel plant use. Hydrogen is used commercially to manufacture ammonia, petroleum products and methanol.

Methane

Methane is the primary constituent of natural gas. Methane is odorless, colorless and lighter than air. Methane burns with oxygen to form water and carbon dioxide. It is very explosive. Methane has a high heating value and is the largest energy source in COG even though it normally has a lower volume concentration than hydrogen.

Nitr[illegible]

[illegible]ge[illegible] is a colorless, odorless, tasteless, non-toxic gas. Nitrogen is the major component of the a[illegible] itrogen is very inert and will not react under normal conditions. Nitrogen has no fuel value and act[illegible] diluent in COG. Commercially, the main uses of nitrogen are in fertilizer manufacturing and the pr[illegible]uction of nitric acid.

Carbon M[illegible]xide

Carb[illegible] monoxide is a colorless, odorless gas which is very toxic to humans. Carbon monoxide has a gr[illegible] affinity for blood hemoglobin. It ties up the hemoglobin, which restricts its ability to carry oxy[illegible] through the body, causing death at excessive conc[illegible]trations. Carbon monoxide is the product of imperfect combustion of fossil fuels. It is the cul[illegible] mos[illegible]ar and home asphyxiations. Carbon monoxide is an effective reducing agent and is th[illegible] d in the blast furnace. Carbon monoxide will burn with oxygen to form carbon [illegible] i[illegible]t fuel constituent of COG.

Carbon Dioxide

Carbon dioxide is the main product of fossil fuel combustion. It [illegible]orless, odorless and non-toxic gas. Although non-toxic, the gas can cause suffocation due to [illegible]k of ample oxygen.

Carbon dioxide is used to provide carbonation for soft drinks, in its solid form as dry ice, in fire extinguishers and as a raw material for numerous chemical manufacturing processes. In COG, carbon dioxide has no heating value and acts as a diluent.

Ethylene

Ethylene is a colorless, flammable gas. Ethylene is the simplest double bonded carbon compound. Ethylene has no direct end users, but it is the most important petrochemical feed stock. The two most important derivative products are polyethylene for plastics manufacture and ethylene glycol for anti-freeze use.

Ethylene burns quite readily with oxygen. Its value to COG is as a fuel.

Illuminates

Illuminates is the general name for the low molecular weight hydrocarbons (ethane, propane, butane) found in COG. These materials all have high heating values and readily burn. These constituents contribute to the fuel value of the gas.

[illegible]

O[illegible] the most abundant element found in the earth's crust. Nearly all known species of living th[illegible]quire oxygen to survive. The earth's air is 21% oxygen. Oxygen is also required for all fuel co[illegible]stion processes.

Ox[illegible]n's main commercial use is for combustion and it can be supplied whether via air or refined pure oxygen. The BOF process uses pure oxygen to remove the carbon from the hot metal. The combustion of COG, whether for underfiring of the battery or for steam production in the boilers, requires oxygen from the combustion air.

Unwanted burning and/or explosions are always a concern with COG or any other fuel. Air leaks into the by-product plant must be prevented. It must be noted that COG normally does contain small amounts of oxygen but at levels too low to support combustion.

Oxygen is also a key culprit in corrosion of the COG lines. Corrosion [illegible] occur at about .5% oxygen and becomes a problem at 1%. The rate of corrosion increases ra[illegible]y as more oxygen, higher temperatures and higher pressures occur.

Ammonia

Ammonia is the second largest chemical in tonnage and the first chemical in value of production. The largest uses for ammonia are in fertilizer applications. Other uses are for intermediates in fiber and plastics manufacture.

It must be noted that ammonia is removed from coal gas not only to recover a useful by-product but because even moderate amounts of ammonia in the COG distributed through the steel plant can be very corrosive to the gas mains, meters and nozzles.

Hydrogen Sulfide

Hydrogen sulfide is a colorless gas having the offensive odor of rotten eggs. It is flammable and may explode upon ignition. It is also highly toxic at higher concentrations. Upon burning, it forms SO_2 which is a problem pollutant. In the atmosphere, it reacts to form sulfuric acid which produces "acid rain", which affects plant growth.

Commercially, hydrogen sulfide is used to prepare sulfides and sulfur containing organic compounds. It is a precipitating agent for the removal of copper, cadmium and titanium from spent catalysts. It is used for the production of extreme pressure oils and lubricants. It is also used to manufacture rare-earth phosphors for color TV tubes.

Oxygen

Hydrocyanic acid (HCN), also commonly called hydrogen cyanide or prussic acid, occurs in all high temperature carbonization coal gas. Hydrogen cyanide is very poisonous and is used in the lethal gas chambers for capital punishment. The gas is also used in fumigation. In addition, hydrogen cyanide gas contributes to corrosion in COG gas mains.

The amount of hydrogen cyanide in the crude COG varies from .10 to .25% by volume. Hydrogen cyanide is soluble in water and most of the cyanide is absorbed by the water it contacts in the by-product plant. This hydrogen cyanide must be removed by Acme Steel before the plant waste water can be sent to the city water treatment plant.

Naphthalene

Naphthalene is formed in large quantities during high temperature carbonization of coal. Naphthalene is a colorless, crystalline flaked solid with the familiar odor of moth balls. The largest use of naphthalene is as a component to produce phthalic anhydride which is used in alkyd resin paints and dye manufacture. The largest historical use of naphthalene had been as an insect repellent for clothing (i.e. moth balls). Use of naphthalene as an insect repellent has dwindled in recent years as other materials have replaced it.

Large amounts of naphthalene are present in the raw COG but most is condensed in the tar. Tar contains in the order of 10% naphthalene. The most serious effect of naphthalene in COG is its tendency to deposit as crystals of solid naphthalene in the gas distribution system. Solid deposits may gradually grow in size until gas pipes all filled at certain points and stoppage of gas flow may result. Excess naphthalene levels in the tar can lead to pluggage in the primary cooler plate and frame heat exchangers which can greatly upset by-product performance.

Naphthalene production in the coke oven is accelerated by higher temperatures. Overheating can cause excessive naphthalene generation leading to the previously described adverse effects in the by-product plant and COG distribution system.

Tar

Coal tar constitutes the major part of the liquid condensed from the COG. A number of years ago, coal tar was the primary, if not the sole, source of hundreds of important organic chemicals. In the last 40 years, synthetic processes for the production of these materials have been developed. These processes have pushed coal tar into the background and lowered its market value. Despite these happenings, tar still remains an important by-product revenue to the coke plant.

tains hundreds of materials. Some of the most important are summarized below:

- Solvent Naphtha - The lower boiling fraction of tar is a very powerful solvent, particularly for coatings containing coal tar and pitch. Product resins are also useful in the manufacture of inexpensive floor tiles and coatings.

- Naphthalene - Is the most abundant single material in coal tar. It is separated by distillation. The properties and uses of naphthalene are described in the previous section.

- Topped Tar - The residue from the topping operation which produces the lower boiling distillates. The principal use of topped tar is in road materials. Road tar has excellent weather and skid resistance.

- Creosote - A mixture of a great number of cyclic structure compounds. The principal use of creosote is for the preservation of wood. Railroad ties, poles, fence posts, marine pilings, and lumber for outside use are impregnated with creosote. If properly treated, the life of the wood is greatly extended.

- Pitch - The residue from the processing of coal tar. Pitch constitutes over 50% of the crude tar. Coal tar pitch is a black, shiny material which is solid and brittle at low temperatures and liquid at high temperatures. Total U.S. production of coal tar pitch is over 2 million tons per year. The main categories of pitch are summarized below,

    - Carbon Pitch - Pitch mixed with coke, pressed into a suitable shape, and then baked to 2000°F. The pitch forms a very strong binder coke which holds the shape and imports strength and good electrical conductivity. These carbon electrodes are used in the production of aluminum.

    - Graphite - Additional heat treatment of carbon electrodes to 4500-5000°F, after further impregnation with hot pitch for greater density, produces graphite. Graphite is a very dense and very pure form of carbon. Graphite is used in a variety of shapes, ranging from giant electrodes used in electric arc steelmaking furnaces and carbon brushes for electric motors. Graphite is also used in seals, bearings, acid-resistant construction materials, and in various nuclear and spare applications.

    - Refractory Pitch - The pores of BOF and BF refractories are filled with pitch either by hot impregnation or hot pressing. The pitch is carbonized during heating and the pitch coke aids in retarding the penetration of molten slag and iron into the refractory thus prolonging the life of the brick lining.

- Roofing Pitch - A substantial amount of pitch is used as a covering medium on flat roofs of industrial plants, large office and apartment buildings, parking garages and similar structures.

I ls

Th t oil fraction of the COG is a general name for a series of aromatic (i.e. benzene ring d es) compounds which can be condensed into liquid form and sold as a by-product. The m ht oil components are found in these approximate quantities in the COG - benzene, 66%; t c 13%; xylene, .05%. The yields are approximately (in gallons per ton of coal) - benzene, 1.85 g ton; toluene, .45 gal/ton; xylene, .30 gal/ton.

Light oil production at one time was a major money maker for the coke plant. However, today over 95% of the benzene, xylene and toluene produced comes form petroleum sources. This fact, coupled with the added complexity of separating the three main products from COG light oil, have greatly depressed the market value of these items.

Benzene, toluene and xylene are all colorless, highly flammable liquids. The liquids are very poisonous with a small glassful quantity being fatal. They have relatively low boiling points (170°F - 230°F) which means that vapors are present at normal temperatures. The vapors can cause long term health affects. Because of this, Acme Steel has installed a COG blanketing system in the by-product area to capture all the light oil vapors and return them to the COG.

Benzene is used as a building block for hundreds of industrial compounds. Toluene is used to produce many products such as industrial solvents, explosives (TNT is trinitrotoluene), saccharin and antiseptics.

BY-PRODUCTS PLANT OVERVIEW

shows a simplified schematic of the by-product plant to illustrate the main aspects of the Highlights of the process include the following (specific unit operation details follow in later):

The hot COG coming from the coke ovens is covered with flushing liquor as it enters the ollecting main to cool it. The cooled COG (~180°F), flushing liquor, condensed tar, and water from the COG are taken from the coke ovens to the by-product plant.

- The stream of liquid is drawn off the bottom of the collecting main and sent to the tar decanters. Gravity separation occurs in the decanters. The heavier tars sink to the bottom and they are removed. The water (flushing liquor) is returned to the collecting main to cool the COG.
- The COG is sent to the primary cooler where it is sprayed with cold circulating liquid or liquor. The COG is cooled from 180°F to 100°F. Excess water and tar condense out. The now heated circulating liquor is cooled with plate and frame heat exchangers before being sent back to the primary cooler.
- The cooled COG then passes through the exhauster. The exhauster is a large compressor which pulls the gas from the ovens and pushes it through the rest of the by-product plant.
- After the exhauster, the COG is pushed through the electrostatic precipitators where tar particles are removed. The collected tar is pumped to the tar decanters for further treatment.
- The COG is then sent to the ammonia absorber where it is sprayed with a 4% sulfuric acid solution. The sulfiric acid reacts with ammonia to produce ammonium sulfate which is sold as a fertilizer. The market value of ammonium sulfate is not very high but ammonia must be removed because it is very corrosive to the COG piping system.
- The temperature of the COG is raised considerably (to about 140°F) in the ammonia absorber due to heat given off by the ammonium sulfate production reaction. The COG is, therefore, sent through the secondary cooler where it is cooled to 85°F by cold recirculating liquor. The liquor contains water and tar. Naphthalene condenses from the COG in the secondary cooler as a solid due to the low temperature. Tar is added as it dissolves the naphthalene and eventually carries it to the decanter for removal from the system. The heated recirculating water is cooled by a wet surface area cooler and sent back to the secondary cooler.

last step in the COG treatment is light oil removal. Light oil is a combination of benzene, lene and toluene. The COG is sprayed with wash oil which absorbs the light oils from the OG. The benzolized wash oil, rich in absorbed light oils, is sent to a still where steam eating is used to strip off the light oils. The light oils are collected and sold. The de-enzolized wash oil is then sent back to the light oil scrubber.

The processed COG is now ready for use. Some of the COG (approximately 40% of produced volume) is sent directly to the coke ovens for underfiring. The remainder is sent to gas boosters where the pressure is raised to allow transport to the boiler house, blast furnace or outside sales.

Condensate water from the COG collection leads to a system buildup of water. This excess flushing liquor is pumped to weak ammonia liquor storage tanks. From there, it is sent to the ammonia stills and cyanide plant for treatment before discharge to the city sewer system.

The weak ammonia liquor is heated with steam to 215°F at 2 psig in the ammonia stills. This heating drives off the free ammonia (not chemically attached as a salt). A caustic solution is used to convert the fixed ammonia to free ammonia which is then driven off by heat. The ammonia vapors are sent back to the COG piping at the inlet of the ammonia absorber.

The low ammonia liquor waste stream is then sent to the cyanide plant. Sulfuric acid and ferric sulfate are used to convert all of the free cyanides to stable complex iron cyanide compounds. The purified waste water stream can then be sent to the city waste water treatment plant.

All tanks and vessels in the plant have been modified to meet the US EPA Benzene NESHAP. The Benzene NESHAP requires that benzene emissions be reduced by 95% from previous levels. Therefore, all vessels and lines containing benzene are sealed preventing discharge to the atmosphere. Acme Steel met this requirement by replacing tar tanks, light oil tanks and weak ammonia liquor tanks. All remaining vessels were upgraded.

INDIVIDUAL BY-PRODUCT UNIT OPERATIONS

on of Volatile Products in the Coke Oven Collecting and Suction Mains

llection system for the recovery of the volatile products from coal, the first operation reduces
erature of these products, which are generally referred to as foul gas. This takes place in
of gas mains through which the foul gas passes.

The foul gas passes out of the oven chamber through a refractory-lined ascension pipe and into a gooseneck which connects into the collecting main through a damper valve. The collecting main serves an entire battery of ovens, running parallel with the battery and extending above it on one side or on both sides depending on whether it is a single or double collecting main operation.

The gas and vapors ordinarily leave the oven at temperatures in the range 1100-1300°F and are shock-cooled by spraying with flushing liquor in the goosenecks and further cooled by spraying again with flushing liquor at different points along the collecting main. The cooling is effected by the evaporation of a portion of the water from the flushing liquor which removes some of the sensible heat from the gas and condenses some of the vapors with the resultant condensation of heavy tar from the gas.

The gas and remaining vapors pass from the collecting main through one or more cross-over mains into the suction main. A pressure-regulating valve, automatically controlled, is located in each cross-over main. After the gas and vapors have passed this control valve their temperature drops to a range of 175 to 212°F as a result of atmospheric cooling and further evaporation of the flushing liquor.

The flushing liquor, used for cooling in the spray system, is liquor which has been condensed in the mains, collected and recirculated, amounting to 800 to 1,200 gallons per ton of coal carbonized on coke-oven batteries with a single collecting main and up to 2,000 gallons on those with two mains. The flushing liquor, which cools and condenses various vapors in the gas, provides a carrying medium for the condensable tars and other compounds formed in the operations. These liquid materials flow from the collecting main through a seal into a downcomer and are delivered through the return flushing liquor lines to a collecting unit called a flushing-liquor decanter, Figure 3.

The uniform flow of gas and vapors into the system is accomplished by the charging of coal into the ovens at regularly prescribed intervals and the withdrawal of the evolved gases at a constant rate. This constant rate of removal of the gas is controlled by varying the speeds of the exhausters which pull the gas away from the ovens and by automatic pressure regulators in the cross-oven main. This pressures regulator provides a slight pressure of about one millimeter of water at the base of the oven prior to pushing. This control of pressure is for the purpose of eliminating the infiltration of atmospheric air or gases from the heating system into the oven, which would have a deleterious effect on the quality and quantity of the coke and coal chemicals.

quence of this practice, the pressure on the collecting main is about eight to twelve of water with a variable suction of about two to three hundred millimeters of water in the main after the regulating valve.

ssure differentials are maintained by the use of exhausters designed to remove the gases s at a controlled rate.

nters

ing-liquor decanter tank serves a two-fold purpose in the processing of the liquid densates and recirculating liquor in the primary liquid system.

- It provides a settling basin in which the velocity of the tar and liquor is reduced to permit separation of the tar and liquor by the difference in specific gravity.
- It serves as the first settling point for carbonaceous and other finely divided material that is carried along with tar and liquor from the collecting main.

The two tar decanters are rectangular vessels 12' wide by 10'6" long and approximately 10' high. The ar decanters have a nominal capacity of 30,000 gallons each. Figure 3 shows a sketch of a decanter.

lushing liquor enters the decanter at one end and flows towards the discharge at the opposite end. The heavier tar settles to the bottom. The liquor level above the tar is normally maintained at 28-30". Tar is pumped from the bottom of the decanter to the tar collector. Flushing liquor overflows a fixed veir at the other end of the tank and is pumped from the upper portion of the decanter to the flushing iquor tank. From there it is pumped back to the coke oven collecting main.

One end of the decanter inclines out at a 45° angle to allow the use of a conveyor belt for tar sludge emoval. The conveyor belt runs along the bottom of the tank and up the inclined wall. The belt has addles to drag the heavy tar sludge from the bottom of the tar to an external sludge collector buggy.

Tar Storage Tanks and Handling System

The Tar Processing System consists of two 500,000 gallon tar storage tanks and a tar shipping tank of approximately 125,000 gallons. These tar tanks are heated with steam fed, roof-mounted bayonet eaters. The tanks have draw-off manifolds and piping interconnections, permitting the transfer of naterial within the system or to other designated tanks within the by-products area. A sketch of the ar handling system is shown in Figure 4.

The total tar storage within the plant is 73 days at maximum battery operating conditions. The tar hipping tank is also used for tar processing and quality control. The plant uses this tank to blend tar qualities (Q.I.'s) and to permit additional tar water separation. Tar quality specification of 5% or less moisture is achieved in this manner.

ge tanks also contribute to the separation of tar and water. Piping connections to the
rmit the plant to return this separated water from the tar processing area to the plant
em. The production tar from the coke facility is drawn off the decanters to a tar
In this tank, the tar product, containing as much as 30% water, is heated by
ers and tar water separation is permitted. The tar is then pumped from that tar
to one of the two new tar storage tanks. Water separated and collected at the tar
is returned to the weak liquor system.

ar storage tanks is permitted to stand. Solids (Q.I.'s) settle to the bottom and water
floats on top of the tar. The tar is kept hot by a steam fed immersion heater. The
courages the separation of water tar emulsions. The water is decanted and returned to
quor system. The final tar recovered from the flushing liquor contains 2-5% water.

nsferred from storage to the tar shipping tank. Tar from either storage tank or directly
iction can be fed to the shipping tank. Here the tar can be further settled to remove
olids. Operating in this way, the plant can provide for shipment of consistent high-
tar.

asures the portion of tar that is insoluble in quinoline. This test is used to establish the
y of tar in the manufacture of pitch for the production of electric furnace electrodes. Low
eeded to produce good quality electrode pitch.

Q.I. insolubles are carbon particles and inorganics (ash).

High oven temperatures, particularly in the tunnel head, cause cracking (breakdown) of hydrocarbons contained in the COG which produces carbon particles that are absorbed by the tar in the collecting main. High aspiration levels carry over coal and ash particles during charging and the collecting main and these particles also are absorbed by the collecting main tar. Tar Q.I. effectively measures two different oven conditions - high temperatures that produce carbon particles and high aspiration levels that carry over ash.

Excess coal pulverization is also a factor in Tar Q.I. The excess fines generation leads to more carryover from the oven which leads to more ash and particles in the tar.

High tar Q.I. levels also have a severe negative impact on the by-product plant operation. The solids increase the tar viscosity which causes the tar to coat the surfaces of the primary cooler plate and frame coolers. This reduces heat removal efficiency. In addition, the higher viscosity fluids cause a reduction in the flow rate through the coolers which also reduces heat removal capability.

These [illegible]ctions in heat removal cause the COG temperature from the primary cooler to rise. This high [illegible]erature transfers through the entire by-product plant resulting in poor product recoveries, ammonia, light oil, naphthalene and cyanide removal efficiencies which cause problems throughout the plant COG system, and higher steam and water consumption in the by-product plant.

The plate and frame cooler flow rates are finally reduced so far that the coolers must be taken off line for steam cleaning. The by-product operators sometimes have to charge the plate and frame coolers 4-8 times per day. This becomes quite labor intensive and upsetting to the by-product plant operation. The coke battery operators must cut back on the battery charging to reduce COG generation during this period. Eventually, the coolers become so plugged that they must be sent out of the plant to be rehabilitated.

The by-product plant operators can extend the time between cooler changes by running at higher primary cooler temperatures but this has negative consequences on the gas cleaning performance as discussed previously.

Primary Cooler

The non-condensed gas and vapors leaving the collecting and suction mains at a temperature of 167-176°F require further cooling to 95°F to remove additional tar and a major portion of the water [illegible] reduce both volume and temperature of the gas before its admission to the exhausters. suitabili[illegible] Q.I. is [illegible]imary cooler, Figure 5, is utilized at Acme Steel. It consists of a cylindrical scrubbing [illegible]op portion is equipped with a series of spray nozzles and the lower section contains a chamb[illegible] llect the liquor and condensate.

The gas enters the bottom of the tower and the cooling liquor is pumped into the top of the tower through the spray system to provide a downward flow of cooling liquor in counter-current flow to the gas stream. This direct contact between the gas and liquor provides for exchange of heat which is transferred from the hot gas to the cold liquor. This heat is removed from the liquor by direct heat exchange, through plate and frame heat exchangers with circulating water. As a result of this cooling, 20-25% of the total tar recovered is condensed along with a considerable quantity of weak liquor containing ammonia. These condensates are processed in conjunction with the tar and liquor condensates from the collecting main.

The plate and frame heat exchangers are susceptible to plugging for naphthalene and tar. Heat transfer efficiency decreases as coating and plugging begins. This results in higher exit COG temperatures which negatively impacts all downstream removal operations in the by-product plant. The plugging accelerates once it begins and eventually the plate and frame heat exchanger must be removed from service. The exchanger is steamed out to allow the tar and naphthalene to flow. The procedure usually requires 20 minutes. During this time, there is no primary heat removal and the downstream processes are seriously impacted. Charging must be stopped at the battery to reduce the COG generation rate. This causes lost production and lower coke quality; both of these items have major impacts on the battery's bottom line.

ration at higher temperatures has a significant impact on naphthalene production as n a later section. Standard operating practices must be followed to minimize these ns. These heat-ups are occurring 2-8 times per day.

COG temperatures, caused by improper battery cooling, also have a negative impact. The d moisture content in the COG is exponentially proportional to the temperature. An increase G temperature can overload the primary cooler heat removal capacity leading to higher m temperatures and the subsequent decreased removal efficiencies.

tic Tar Precipitator

s leaving the primary coolers still contains small amounts of tar that would cause difficulty in e operation of subsequent units in the by-product plant. The method used for removal of this entrained tar is through electrostatic precipitation. The electrostatic precipitators are placed after the exhausters. The preferred location is after compression of the gas (following the exhausters) to prevent infiltration of air into the precipitator. A schematic drawing of the electrostatic precipitator is shown in Figure 6. In the electrostatic precipitator, removal of tar fog from gas is achieved by passing the gas between electrodes having a high electrical potential. The discharge electrode is of small cross section, such as a wire or a series of points, in order to develop the high-intensity electrical field at its surface which is required for ionization of gas. The collection electrode has a large cross section and serves as a collector for the suspended particles which are ionized and transferred to this electrode.

In this operation, the electrostatic precipitator, in addition to its function as a collecting unit for dispersoids, also serves to catalyze the formation of vapor-phase gums formed by oxides of nitrogen and unsaturated hydrocarbons. These reactions can be minimized by reducing air entrainment as discussed previously. These gums cause serious plugging problems in the battery under[illegible]g orifices.

Ammonia Removal

A schematic of an ammonia absorber is provided in Figure 7. The coke oven gas enter s the ammonia absorber near the bottom and leaves near the top. The COG is sprayed with dilute (4%) sulfuric acid as it rises to the top of the absorber. The ammonia in the gas reacts with the sulfuric acid to form ammonium sulfate. The reaction is very rapid and the COG ammonia concentration is reduced to the range of 6-10 gr/100 SCF. It must be noted that the term dilute acid is misleading because the 4% sulfuric acid has a pH below 1 which is very corrosive and dangerous.

The ammonium sulfate product is a crystal but is very soluble in water. The water/sulfuric acid solution used in the absorber can keep ammonium sulfate in solution in concentrations up to 42%. A constant flow of sulfuric acid is added to the ammonia absorber to replace the acid neutralized by the ammonia in the COG.

The secocoke plants, the solution is circulated until it becomes super-saturated. Solution is drawn off thick be[illegible]tals of ammonium sulfate are precipitated in crystallizer. The crystals are then dried and the of the oduct is a dry, crystalline powder product.

arrang

the ga Steel, however, utilizes a unique process. The circulation solution is never allowed to become saturated. This is done by running a semi-continuous batch process using multiple circulation Th[illegible] The first tank on line starts with a fresh water/4% sulfuric acid solution. The solution is circ[illegible]d (for approximately 16 hours) until the ammonium sulfate concentration builds up to near its [illegible]ation point. Sulfuric acid is added continuously to maintain concentration as previously ment[illegible]ned. The tank is taken off line when it nears the saturation tank and a fresh one put on line.

The finished circulation tank has a 40-42% ammonium sulfate concentration but cannot be sold as a fertilizer because of the 4% sulfuric acid. The tank is neutralized with a liquid water/ammonia solution (called aqua ammonia and having an ammonia concentration of 27%). Similar to the absorber reaction, the ammonia reacts with the sulfuric acid to form ammonium sulfate. The final product is a near-saturated ammonium sulfate solution.

Ammonium sulfate is used as a fertilizer. Ammonium sulfate production at one time was a profitable activity for steel plants. However, the tremendous quantities generated from the various synthetic basic ammonia processes have depressed the price. Production is now a money loser as the sulfuric acid costs much more than the ammonium sulfate can be sold for. However, ammonia removal is critical due to its corrosiveness to gas pipelines.

Battery operations which increase ammonia production are detrimental because the increased removal costs are significant. High battery temperatures and excessive steam aspiration are the main culprits as discussed later.

The Acme Steel ammonia removal is very sensitive to problems from excess naphthalene and tar. Naphthalene plugs the circulation tank vent and overflow pipes; this has been a main culprit in the tank pressure problems seen recently. Tar is not acceptable in the ammonium sulfate product. The system has tar filters in the ammonium sulfate loadout line but excessive levels have resulted in carryover to the product loadout tanks. Battery practices causing excessive tar and naphthalene production must be minimized.

Secondary Cooler

Further cooling of the COG, as required for naphthalene and light oil removal and processing, is accomplished in the secondary cooler. Incoming COG is cooled to a temperature of 86°F or less with recycled or "circulating" liquor. The heated circulating liquor is then cooled by passing it through the tubes of a wet surface air cooler.

A sketch of the secondary cooler is shown in Figure 8. A sketch of the wet surface air cooler is shown in Figure 9.

The secondary cooler is a 9'3" diameter by 67'3" high cylindrical carbon steel vessel, containing a 3' thick bed of pall ring packing plus distributor plates and expanded metal packing sections. Utilization of the special expanded metal packing combined with the high efficiency gas/liquor distribution arrangement provides excellent contact between the gas and liquor. This makes it possible to cool the gas to the required temperature with a very low pressure drop.

The wet surface air cooler consists of 8 multi-pass split tube bundles mounted on a concrete structure approximately 40' wide by 50' long. The cooler is separated into a hot well and a cold well. Two fans move air over the surface of wetted bundles for rapid evaporative cooling.

Operation of the wet surface air cooler is carefully controlled to maintain the temperature of the recycled liquor. The liquor temperature must be kept higher than that at which tar could condense on the cold tube surfaces and risk plugging the tube bundles.

A small amount of additional tar is continuously added to the circulating liquor to maintain all the absorbed naphthalene from the COG. A controlled amount of liquor stripped of free ammonia (from the middle of the still) is also added to serve as a carrying medium for the accumulated naphthalene dissolved in tar.

The recirculating liquor and gas condensate, along with the tar and naphthalene, are continuously removed or "blown down" from the recirculating loop to the COG suction main.

Plugging with naphthalene and tar is also a problem in the secondary cooler. Heat transfer efficiency decreases as coating and plugging of the wet surface air cooler tubes occurs. The pressure drop in the secondary cooler increases as the naphthalene and tar coat the secondary cooler packing. Eventually, the pressure builds up high enough to cause flow problems. At that time, the secondary cooler must be taken off line and the deposits steamed out. The COG temperature to the light oil scrubbers raises from 86°F to the 150-160°F range and light oil recovery drops dramatically. Battery overheating must be minimized to reduce naphthalene generation as discussed in the primary cooler section.

Light Oil Scrubber and Stripper

The gas leaving the ammonia absorbers contains light oil. This oil is a clear, yellow-brown oil with a specific gravity of about 0.88. It is a mixture of all those products of coal gas with boiling points mostly ranging from 32°F to 390°F, containing well over a hundred constituents. Most of these are present in such low concentrations that their recovery is seldom practicable. The principal usable constituents are benzene (60-85%), toluene (6-17%), xylene (1-7%), and solvent naphtha (0.5-0.3 %). Light oil constitutes approximately one percent of the coal carbonized.

The first step in the recovery of light oil is its absorption in the liquid petroleum wash oil. The gas comes in direct contact with the wash oil in one or more tall scrubbing towers containing packing and interlocking sprays. The gas passes from the first tower to the last in series and the wash oil travels from the last tower to the first in reverse series. The flow of gas and wash oil is counter-current in each tower. The steel towers are approximately 15 to 22 feet in diameter and 100 feet in height.

A schematic of a light oil scrubber is shown in Figure 10. Contact between the gas and absorption oil is accomplished by the use of single conical sprays placed at three different elevations within the tower. Absorption oil pumped through the top pressure spray is collected by steel plate umbrellas, and passed through second and third spray nozzles of the gravity-flow type. Baffles direct the flow of gas toward the spray in every pass and horizontal angles restore correct distribution above each umbrella collector. Restrictions to gas flow by accumulations of residues commonly found in packed scrubbers are minimized or eliminated in scrubbers of this design.

From 80-95% of the light oil content of the gas is recovered in this operation. The wash oil, after being cooled, passes through a large decanting tank which acts as a settling compartment for the emulsified and resinous materials present in the wash oil. This material accumulates in the bottom of the tank, and the wash oil decants off at a higher level to a small receiving tank, from which it is pumped to the top of the first scrubbing tower in the series. Generally, two decanting and two receiving tanks are provided to permit cleaning the residue from the tanks periodically.

In the debenzolization step, the light oil (2-3%) in the benzolized wash oil is separated by steam distillation. The carryover of absorbing oil into the light oil is kept to about 5% and the debenzolized absorbing oil product contains 0.2% light oil.

In the straight steam-distillation process at atmospheric pressure, the benzolized wash oil is preheated to approximately 212°F with a vapor-to-oil and an oil-to-oil heat exchanger. Heating is continued to 295°F with an indirect preheater of the shell- and tube-type, with the oil flowing through the tubes, using steam as the heating medium on the shell side. The preheated oil is introduced near the top into a multi-plate bubble-cap fractionating column leaving several plates above the feed to keep entrainment of wash oil to a minimum. The benzolized wash oil flows down the column countercurrent to upward flow of live steam, which is introduced in the base of the still column. The debenzolized wash oil leaving the base of the column through a sealed outlet at a temperature of 290-300°F passes through the oil-to-oil heat exchanger in which it is cooled to 212°F giving up its heat to the incoming benzolized wash oil. Water separates out at this point and is drained off. The wash oil passes through a pumping tank and is pumped at 212°F (100°C) to cooling coils for cooling prior to begin used again as an absorbent for the light oil in the scrubber towers.

The mixture of steam and light oil vapors leaving the top of the column flows through the tubular vapor-to-oil heat exchanger which recovers heat and also acts as a partial condenser. Sufficient heat is imparted to the incoming benzolized oil to raise its temperature and, at the same time, the vapors are cooled to cause a portion of the steam and high-boiling constituents of light oil to condense (the condensate of which caries along some of the wash oil which was carried over the top of the column as entrainment). The mixture of oil and water is separated in a gravity separator tank, the water flowing to the sump system and the oil being returned to the debenzolized oil streams. The mixture of steam and light oil vapors leaving the vapor-to-oil heat exchanger passes to a water-cooled condenser, which is of a multi-pass design, with the vapor and water flowing countercurrent to each other. The condensate flows to a gravity separator effecting a separation of the light oil and water, the light oil flowing to storage and the water to the sump system. Figure 11 shows a schematic of the Acme Steel light oil storage and loadout facility.

The boiling point of the wash oil is well above 390°F so as to permit an effective separation of light oil from wash oil in debenzolization. The oil should not thicken and should have a low viscosity to permit its distribution in the scrubbing towers. It should not deteriorate readily but maintain its initial properties as long as possible to keep makeup oil at a minimum. It must be especially stable with respect to the repeated heating which takes place in the recycling of the oil in the process. Its absorptive capacity should be very high and it should not react with or contaminate the coal gas. The specific gravity should be low enough to permit effective separation of wash oil and water in the processing and keep emulsification of the two to a minimum. The specific heat should be low because the oil is subjected to repeated heating and cooling as it is recycled in the process.

Weak Ammonia Liquor Settling and Storage Tanks

There are two weak ammonia liquor storage tanks. The tanks are 40' diameter by 32' high carbon steel tanks. Nominal capacity is 300,000 gallons. A schematic drawing is provided in Figure 12.

In the first tank, the liquor is permitted to stand in order to settle out tar, which would foul the valve trays in the distillation column. Liquor is fed to the tanks through a dip pipe with a discharge point near the bottom of the tank. The liquor rises slowly to the top of the tank while tar particles separate and settle to the bottom. Liquor overflows near the top of the first tank and enters the second tank. Only a minimum volume is retained in the second tank during normal operation so that most of the tank volume represents surge capacity available for liquor inventory during upset or emergency conditions. The liquor is pumped from the second tank to the ammonia stills. Tar is periodically pumped from the bottom of the first tank to the tar decanter for recovery.

Ammonia Stills

The ammonia stills are cylindrical distillation columns fabricated from carbon steel. The stills are 4' in diameter and 73' high. The bottom 25' is a base shell. The upper 48' section contains 22 valve trays and one blank tray. A sketch of the ammonia stills is shown in Figure 13.

One still is in operation and the other is in reserve under normal operating conditions. Both free and fixed ammonia are steam stripped from the weak ammonia liquor. Caustic is added to the column to liberate the fixed ammonia. Steam is fed to the bottom and the middle of the column via submerged perforated tubes called spargers. The stripped ammonia leaves the top of the column as vapor which is returned to the COG piping upstream of the existing ammonia absorber.

Steam usage for the stills is reduced by the use of a steam ejector to recover heat from the still bottoms. The ejector acts as a heat pump by recovering energy from the still effluent as steam.

Several problems effect the still operation. Excess water infiltration, either from the battery or by-product plant, requires that more steam be consumed in the still. Tar and naphthalene deposits eventually plug the valve trays. The result is lower ammonia removal which is unacceptable for waste water discharge. The still must be taken off line for a 1-2 week clean out. Excess service water infiltration, with the inherent hardness, causes scaling of the valve trays. Excess scaling has the same net affect as excess tar and naphthalene deposits.

Cyanide Treatment Plant

Free cyanide levels are normally reduced to 10 ppm in the ammonia still. Acme is now required to reduce free cyanides to below 5 ppm. A new facility was started up last year for this purpose.

The still effluent is treated with iron sulfate and sulfuric acid in the cyanide treatment plant. The iron combines with the free cyanide to form complex ferrocyanides which can be discharged to the city waste water treatment plant.

Excess cyanide formation, due to high battery operating temperatures, requires extra sulfuric acid and iron sulfate consumption which increases operating costs. In addition, free cyanide levels can normally be reduced only to a certain concentrations. Extra plant water levels lead to higher cyanide out flows at a fixed concentration.

EFFECT OF BATTERY OPERATIONS ON THE BY-PRODUCT PLANT

The preceding by-product plant discussions have touched on battery operation impacts as they relate to individual units. This section will attempt to tie all these items together to highlight the impacts from various battery operating practices.

The following breakdown attempts to show some major battery operation categories and the by-product impacts which can be caused by improper operation.

Heating Practices

- Cyanide Production
- Tar Q.I.
- Primary Cooler Plate and Frame Plugging
- Naphthalene Production
- Ammonia Production
- COG Consumption
- Coke Quality

Aspiration Practices

- Tar Q.I.
- Primary Cooler Plate and Frame Plugging
- Ammonia Production
- COG Steam/Water Load
- Excess COG Oxygen Levels
- Steam Cost

Pulverization Practices

- Coke Quality
- Tar Q.I.
- Primary Cooler Plate and Frame Plugging

Charging/Pushing Schedules

- COG Volume Variations
- COG Composition Variations
- Coke Quality

Flushing Liquor Water Additions

- By-Product Plant Water Load
- Hardness Problems

Heating Practices

Heating practices are critical to the production of high quality coke for blast furnace operation. Low flue temperatures cause under-coked or "green" pushes. Underheating of the coal blend also results in a product with low CSR and coke stability (a 1 point reduction in CSR or stability can raise blast furnace coke rates by 4-5 lb/NTHM which corresponds to $225,000 - $300,000/year on a 2,500 NTPD furnace). Overheating the coal blend does not improve coke stability and can hurt CSR. In addition, overheating can decrease coke yield due to excessive fines production (a .1% loss in coke yield can cost Acme Steel $80,000 - $100,000/year).

Heating practices can have significant impacts on the by-product plant operation. Some of the major items are as follows:

- **Cyanide Formation**

  Carbonization temperature is the most significant variable in the production of nitrogen compounds that are found in by-product gases and liquids. Carbonization at 1100°F results in virtually all of the coal nitrogen remaining in the coke or conversely virtually no formation of ammonia or cyanide in the exit gases. At 2200°F, however, approximately 50% of the coal nitrogen remains in the coke while the rest exits the oven in the gases and ends up in the tar, flushing liquor, and coke oven gas. Gases driven off earlier in the coking cycle (at lower temperature) do not contain significant amounts of cyanide and ammonia. Therefore, the length of the soak time influences cyanide formation.

  Cyanides may also be generated by the reaction of ammonia with carbon in the roof area. This reaction occurs at high temperature and, therefore, only becomes significant when both roof carbon and high tunnel head temperatures exist.

  The level of operation determines the carbonization temperature. When overheating occurs as a result of fouling or other means, quick remedy of the problem will reduce cyanide production.

  Certain events have had adverse effects on the cyanide levels at Acme Steel. These events include:

    - The plant began advanced stage charging on or about November 15, 1993, to maintain compliance with the Clean Air Act on emissions. This event caused a number of detrimental operating procedures such as:

- Extended charging rates. This procedural change increases the time to fill the coke oven with coal. With the additional time that the oven is open, an excess amount of air is allowed into the oven. In this time period, temperatures in the open oven space above the coal line (the tunnel head) can approach 2500°F. This combination of high temperature and excess air will cause the nitrogen in the air to crack and form cyanide with any carbon that is present. This could be in the form of roof carbon or in the volatile matter that is beginning to be driven off from the coal that was just charged. In addition, the oxide box reaction will take place downstream of the oven in the collecting main or in the piping to the by-products. The oxide box reaction occurs when iron oxide reacts with hydrogen sulfide and generates elemental sulfur. The sulfur contributes to plugging of the oven underfiring piping.

- Increased coking temperatures. Temperatures were raised to reduce pushing emissions. However, due to nozzle pluggage and depositions in the fuel gas main, even more heat can be applied to the ovens. Localized hot spots can occur which contribute to cyanide formation.

The above items all illustrate the importance of minimizing battery temperatures to reduce the amount of cyanide formed. As discussed previously, cyanide removal costs are directly proportional to the cyanide production levels.

- **Tar Quality**

High oven temperatures, particularly in the tunnel head, cause cracking of hydrocarbons in the COG. This produces carbon particles which are absorbed by the tar in the collecting main. These particles increase the tar Q.I. index which lowers the tar's price and marketability.

The increased ash and solids level in the tar leads to increased plugging in the primary cooler plate and frame heat exchangers. This upsets operations in both the by-product plant and the battery.

- **Naphthalene Production**

The quality of naphthalene produced increases as carbonization temperatures increase. Naphthalene plugging throughout the by-product plant and the battery heating system is a serious problem at Acme Steel. The primary cooler plate and frame heat exchangers have been requiring 2-8 heat-ups per day for cleaning. Every heat-up causes downstream removal problems in the by-product plant and charging upsets at the battery. Likewise, the secondary cooler has been exhibiting excessive high pressure drop pressures which require 2-4 heat-ups per day. These periods provide hotter gas out of the secondary cooler leading to decreased light oil removal performance. The overall high COG temperatures, which result from poorer primary and secondary cooler performance, results in more naphthalene carryover in the COG and more plugging problems in the battery heating system.

The higher plant naphthalene levels have been a problem at the ammonium sulfate circulation tanks. The tank vents and overflow pipes have exhibited severe plugging during the last year. The plugging has caused excessive downtime which has affected ammonia removal. It is also likely that this plugging has been a factor in the recent circulation tank failures.

- **Ammonia Generation**

Increased oven temperatures also lead to increased ammonia levels. The higher ammonia production leads to higher ammonia removal costs in the ammonium sulfate plant.

- **COG Consumption**

Oven overheating uses extra COG. COG is a valuable fuel to Acme Steel and any waste directly affects the plant's operation costs.

Aspiration

Steam aspiration is used during charging to reduce emissions. The steam flow to the assist oven is used to suck air into the charge oven and to prevent charging emissions.

Acme Steel has developed an aspirating steam ramping control program to control the rate of air volume drown into the oven during charging. Battery operators are aware that this is important because the air volume change can be so great that it increases collector main back pressure which has a negative impact on door seals. However, steam aspiration practices affect the by-product operation as well. Some of these impacts are discussed below.

The operator must always aim to meet the steam aspiration guidelines.

- The amount of steam aspiration must be enough to meet environmental requirements. However, excess steam usage has many detrimental effects.
- Excess steam usage causes excessive amounts of air to be drown into the oven. This excessive air can lead to the following problems:
  - High oxygen levels can lead to an explosive mixture of COG oxygen. The lower explosion limit for COG is only 4% oxygen. The combination of an explosive mixture and a spark could lead to a catastrophe result.

  - Corrosion of gas handling equipment is directly attributed to air in the gas. Corrosion begins to be seen at about .5% oxygen and becomes a problem at 1%. The rate of corrosion and the bulk of corrosion products in the equipment increases rapidly as more oxygen, higher temperatures and higher pressures occur.
  - Air in the gas detrimentally lowers the Btu value of the gas. The underfiring gas systems were not designed for low Btu values and if the batteries are taken up to a fast coking rate the piping will not be large enough to handle the needed volume of a low heating value gas.
  - Air can oxidize some of the gums and resins in the COG. These oxidized products grow to form large, sticky particles which can plug up the smaller orifices in the battery heating system.
  - The excess air volume adds to the load on the exhauster. This extra load can reduce the COG pressure which has negative impacts on the COG distribution system. It also increases the steam or electric demand at the exhauster.

- Excess steam consumption causes excess amounts of water to be drown into the by-product plant. These excessive amounts of water and steam causes the following problems:
  - The energy contained in the extra steam must be removed in the primary and secondary coolers. This is a particular problem at the primary cooler which is hampered by the plate and frame heat exchanger problems previously discussed.
  - The additional energy removal requires additional cooling water which is a cost to Acme Steel.
  - The additional water load results in greater waste water loads that must be treated before release to the city treatment system. The result is greater steam consumption in the ammonia stills, which also brings more water into the system, and reagent usage in the cyanide treatment plant.
  - The additional steam can also have a cost to Acme Steel depending on the current boiler operation and gas flaring conditions.

- Excess aspiration can have a significant impact on tar quality. High aspiration levels can cause coal and ash particles to be sucked into the collecting main during charging. These particles are absorbed by the tar in the collecting main. These particles increase the tar Q.I. index which has an adverse impact on the tar's marketability and price.

  The higher ash and particle levels in the tar also make the tar more sticky. The tar has a greater tendency to stick to the surfaces in the primary cooler plate and frame heat exchanger and the secondary cooler. This causes significant problems as previously discussed. The stickier tar can also clog the ammonium sulfate loadout filters causing pumping problems.

- Excess aspiration also affects ammonia generation. The presence of excess steam reduces the rate of decomposition of ammonia to hydrogen and nitrogen. The result is more ammonia production, which causes additional removal costs, and less hydrogen, which lowers the COG heating value.

Pulverization

The level of pulverization is a critical factor in coke quality. Optimum pulverization levels are normally in the 80-85% minus ⅛" depending on the particular coal blend. The amount of fines should be minimal with a maximum of 10-15% minus 100 mesh. The quality of the product coke is lowered if the pulverization level is below optimum conditions due to the detrimental effect of larger coal particles during the coking process. However, coke quality is not improved by pulverization beyond optimum conditions. In addition, battery and by-product plant operations are hurt by the excess fines created when the coal blend is over pulverized.

Excess fines levels can cause problems at the battery such as plugged standpipes and goosenecks. The excess fines which reach the collecting main become tied up with tar. As discussed previously, the tar becomes stickier and reduces the plate and frame heat exchangers operating periods between cleaning. The tar Q.I. also decreases which affects price and marketability.

Although it is uncommon, fines can sometimes make it through the by-product plant and be returned to the battery via the COG used for underfiring. The fines can plug the nozzles and cause heating problems.

Pushing Charging Schedules

Any chemical plant, such as the by-product plant, performs best when operated in a steady manner. Variations in gas flow rates cause upsets at the various unit operations. These upsets cause removal efficiencies to be reduced. The reduced removal efficiencies hurt the plant economics and cause further problems down the line.

A constant pushing and charging schedule allows the by-product plant to see a constant COG flow rate which allows optimum performance. In addition, the exhauster can run steady and minimize surges. A net effect of these items is delivery of a constant quality fuel to the battery for underfiring.

Fluctuating oven cycle times, and the resulting heating variations, can also affect the basic composition of the gas. Non-steady state operation can, therefore, change the gas quality which upsets underfiring control.

Flushing Liquor Water Additions

The flushing liquor system is critical to control of temperatures in the collecting main at the battery. It is obviously important to maintain flushing liquor to the battery. Makeup service water must occasionally be sued when adequate flushing liquor volumes are not available. However, this practice is detrimental to the by-product operation and should be minimized.

As discussed in the steam aspiration section, the additional water load results in greater amounts of water which must be processed in the by-product plant before release to the city waste water plant. Greater ammonia still steam usages are one result (which also add to the system water load).

An additional problem is the hardness of the service water at Acme Steel. The minerals in the water, especially calcium, tend to drop out and form scale in many areas causing increased pressure drop and flow losses. The valve trays in the ammonia still are sensitive to scale formation. Increased service water use will cause the still to be taken off line on a more frequent basis for clean out.

It is, therefore, important that service water additions at the battery, whether made on purpose or via leaks, be minimized.

Coke Quenching

Coke quenching practices have no impact on by-product operations but they are very important to the blast furnace. From the coke plant standpoint, the main concern is to quench the coke far enough to prevent heat damage on the coke conveyor belts and screening station. However, the blast furnace has much more stringent requirements. Blast furnace concerns include both the coke moisture level and variability.

Moisture in the coke will be driven off in the top of the blast furnace; however, this requires energy. Each 1% moisture increases the blast furnace coke rate by 5 lb/NTHM; this corresponds to $300,000 year on a 2,500 NTPD furnace. Low coke moistures are desirable but too low (< 3-4%) moistures cause excessive dusting in the stockhouse. The coke plant should, therefore, aim for a 4-6% coke moisture.

Variability in coke moisture is a problem because it greatly upsets blast furnace heat level control. The coke moisture gauges correct for moisture variations to maintain a constant dry coke charge weight, but they don't correct for the energy balance changes due to the changing coke moisture. The coke plant must maintain constant moisture levels.

Communications

One of the most important, but often overlooked, items in the battery/by-product interaction is frequent and open communication. As this course has tried to illustrate, the operation in both areas is highly dependent on the product from the other area. The by-product plant depends on COG from battery, and the battery depends on flushing liquor and underfire COG from by-product plant. Operational changes, whether planned or resulting from upsets, can have drastic and immediate impacts on the sister unit. The operators must keep their co-workers aware of problems and operational changes in a consistent and timely manner.

SUMMARY

The daily operation at the coke battery has a direct impact on the by-product plant performance. Battery standard operating practices must be followed on a consistent basis not only to maximize oven life and plant profitability, but to insure the same thing at the by-product plant. Smooth and steady battery operation will stabilize the by-product plant operation. This, in turn, will led to a steady flow of clean COG for underfiring which will further help the battery stability.

The operator must always keep in mind that his actions to develop a steady battery operation do not only benefit the by-product plant, they make his unit function better, also.

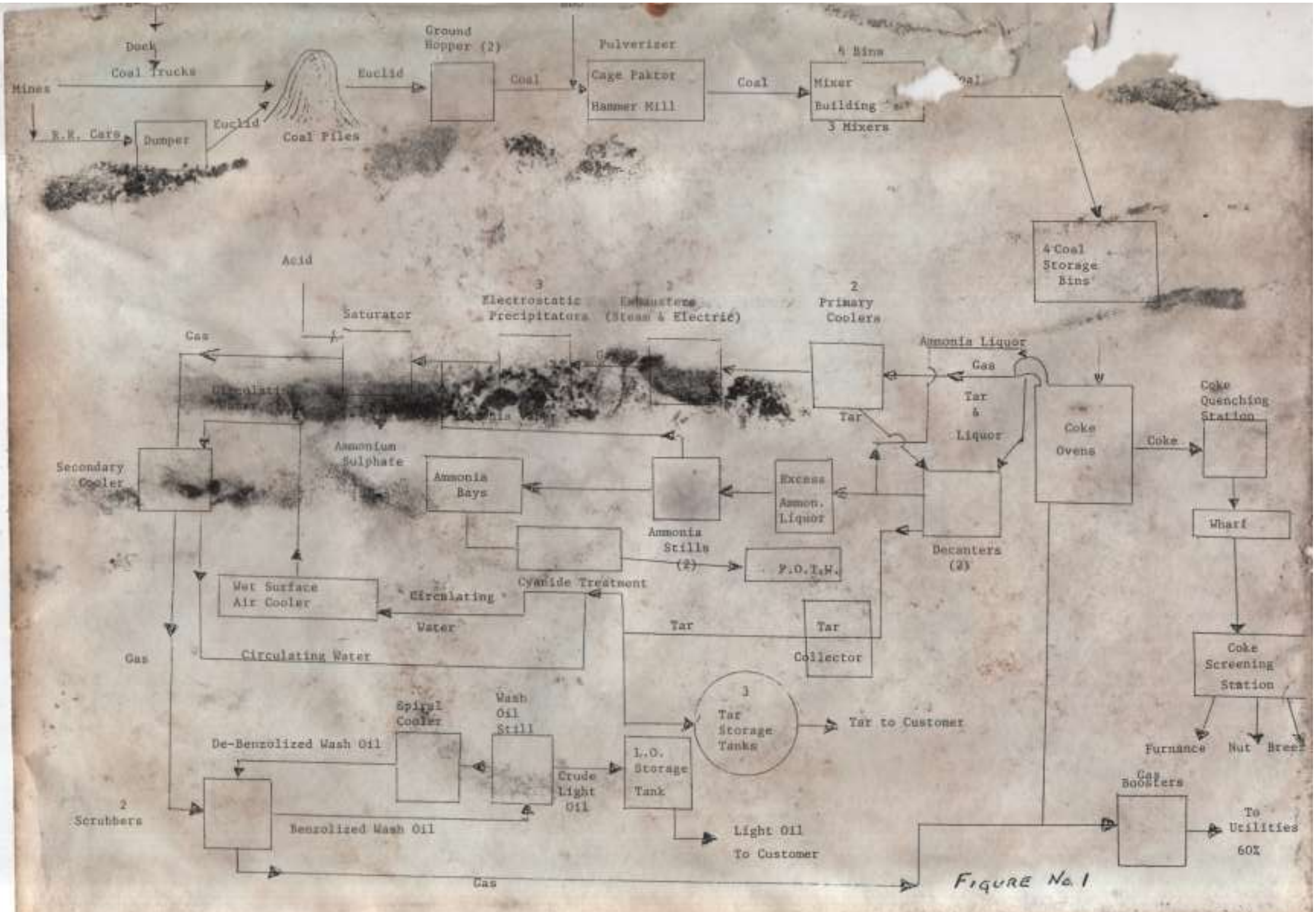

Mines
Dock
Coal Trucks
R.R. Cars
Dumper
Euclid
Coal Piles
Euclid
Ground Hopper (2)
Coal
Pulverizer
Cage Paktor
Hammer Mill
Coal
4 Bins
Mixer
Building
3 Mixers
oal
4 Coal Storage Bins
Acid
Saturator
Gas
3 Electrostatic Precipitators
2 Exhausters (Steam & Electric)
2 Primary Coolers
Ammonia Liquor
Gas
Tar & Liquor
Tar
Coke Ovens
Coke
Coke Quenching Station
Wharf
Coke Screening Station
Furnance
Nut
Bree
Secondary Cooler
Ammonium Sulphate
Ammonia Bays
Ammonia Stills (2)
Excess Ammon. Liquor
Decanters (2)
P.O.T.W.
Cyanide Treatment
Wet Surface Air Cooler
Circulating
Water
Circulating Water
Tar
Tar Collector
Gas
3 Tar Storage Tanks
Tar to Customer
Spiral Cooler
Wash Oil Still
De-Benzolized Wash Oil
Crude Light Oil
L.O. Storage Tank
2 Scrubbers
Benzolized Wash Oil
Light Oil To Customer
Gas
Gas Boosters
To Utilities 60%

FIGURE No. 1

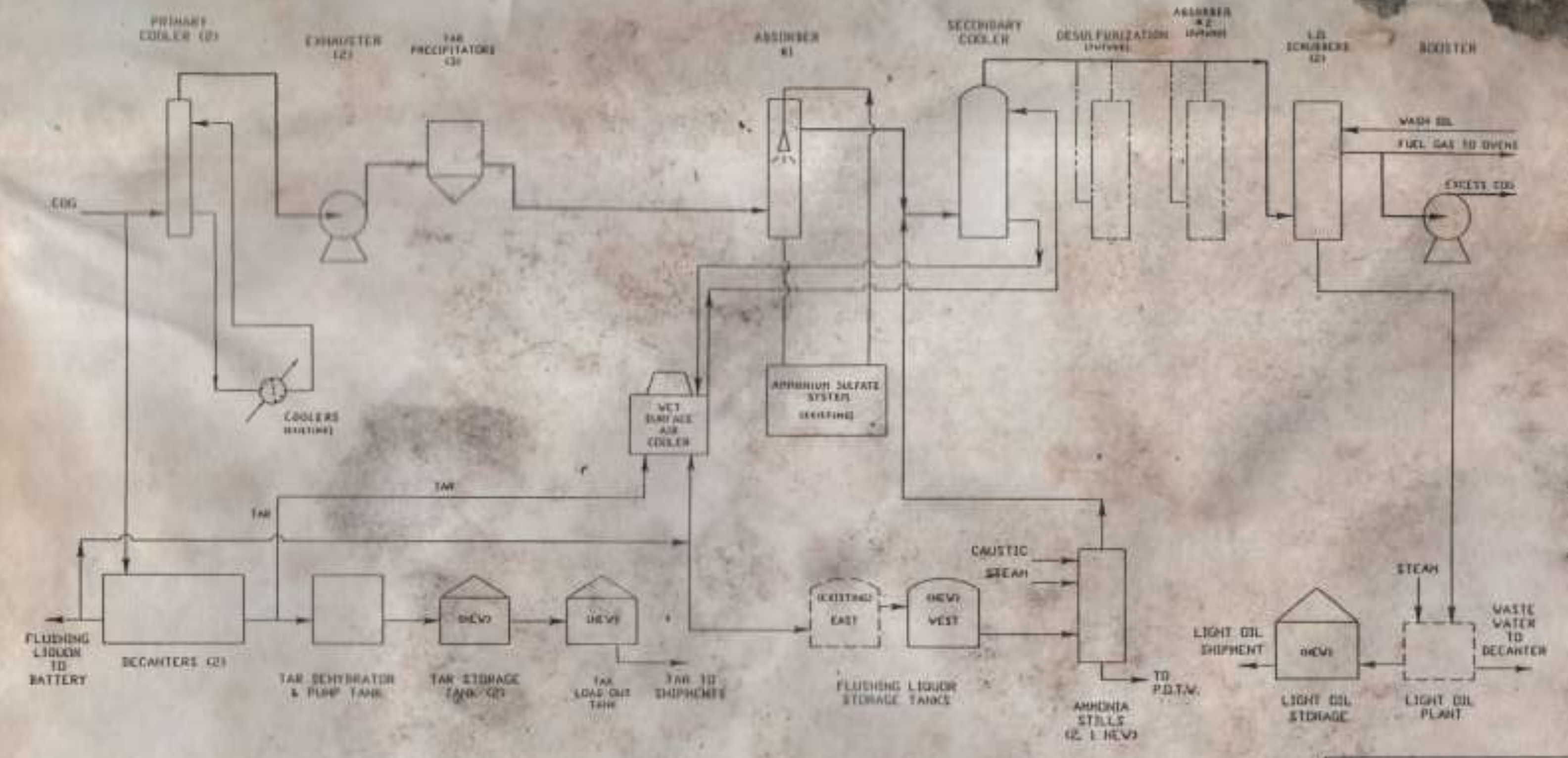


FIGURE No. 2

REFERENCE DRAWINGS LISTED ABOVE

ACME STEEL COMPANY

BYPRODUCT PLANT
CONFIGURATION
(PROPOSED)

FAI SKETCH'S

5

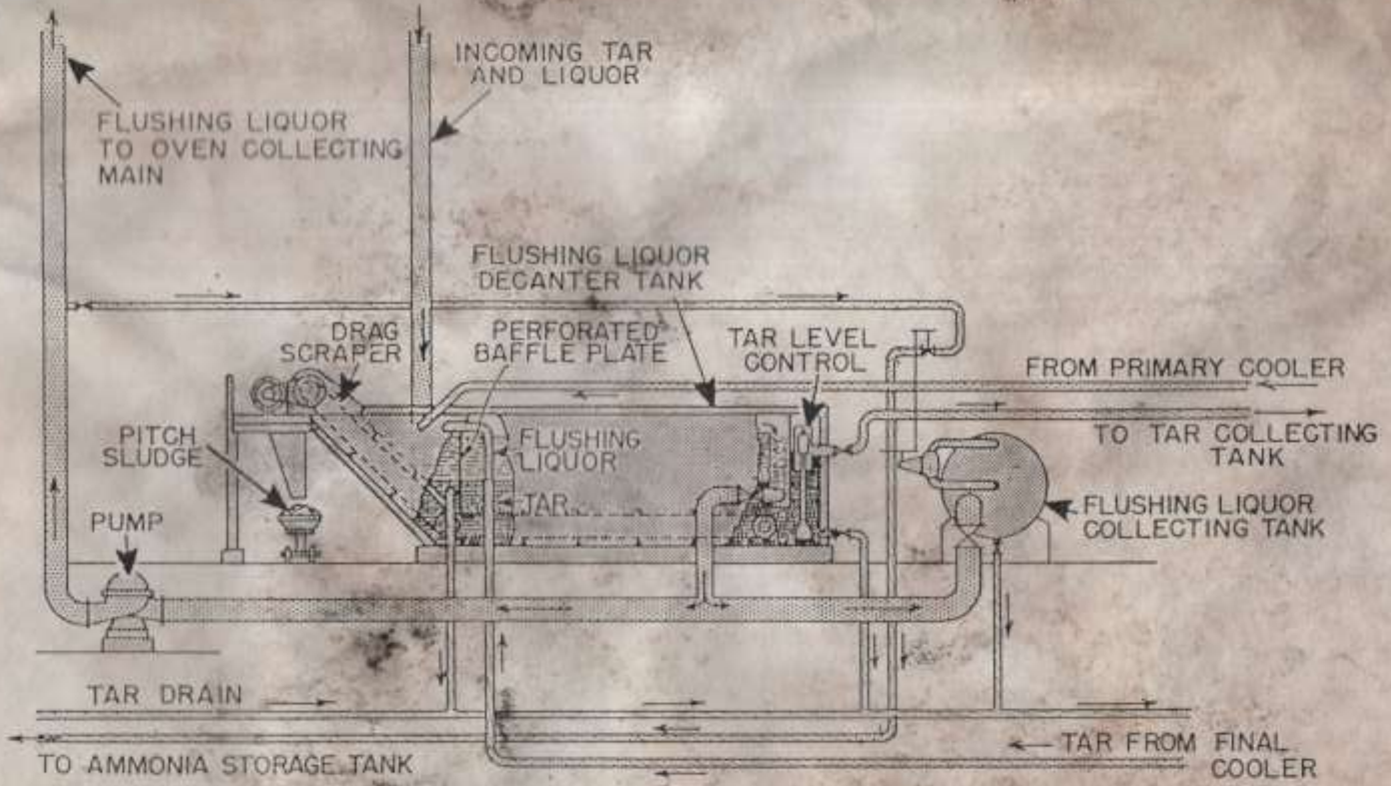
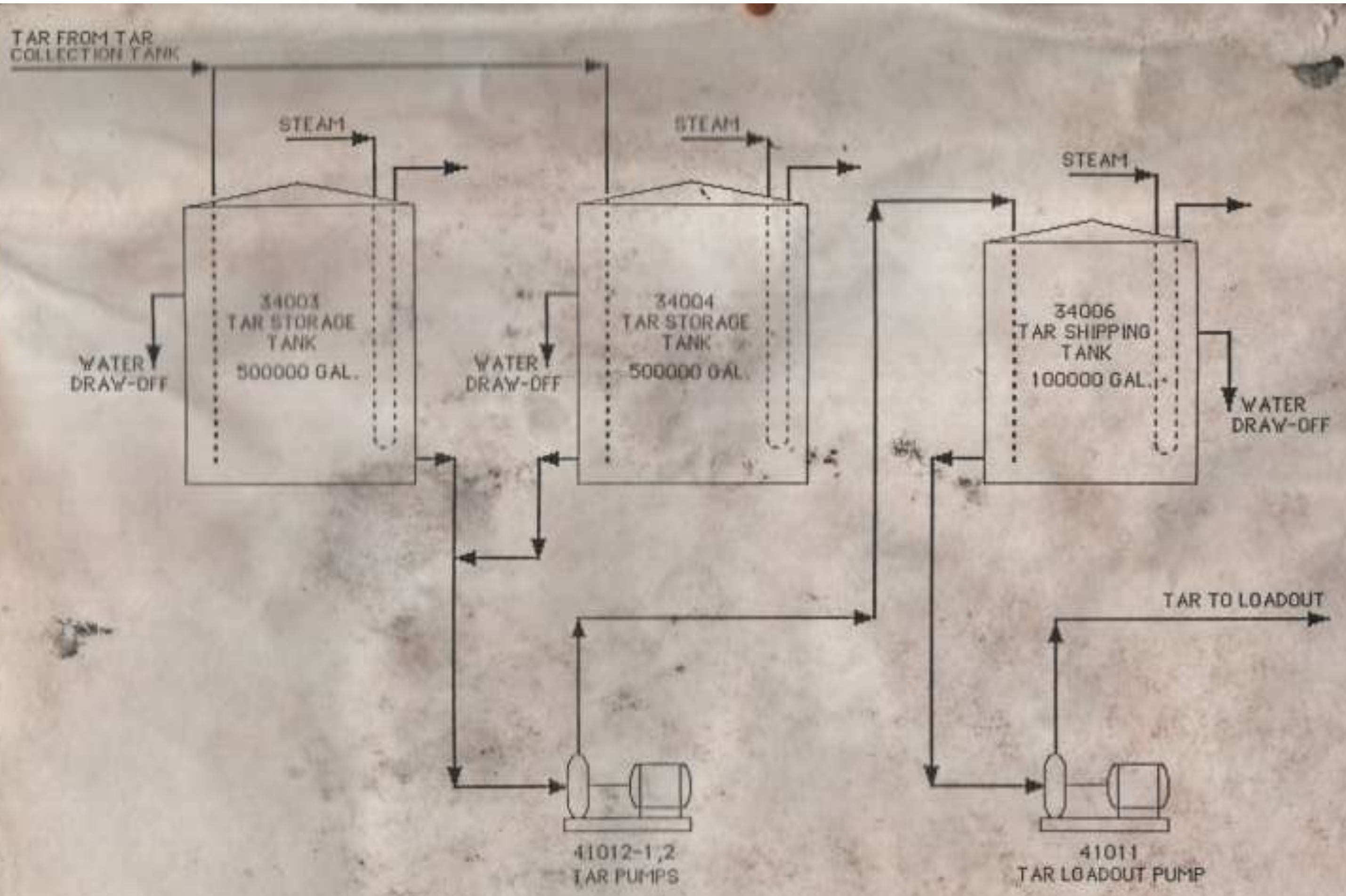


Fig. 3 Schematic representation of a flushing-liquor decanter tank or hot-tar drain tank.



TAR STORAGE AND HANDLING SYSTEM

FIGURE No. 4

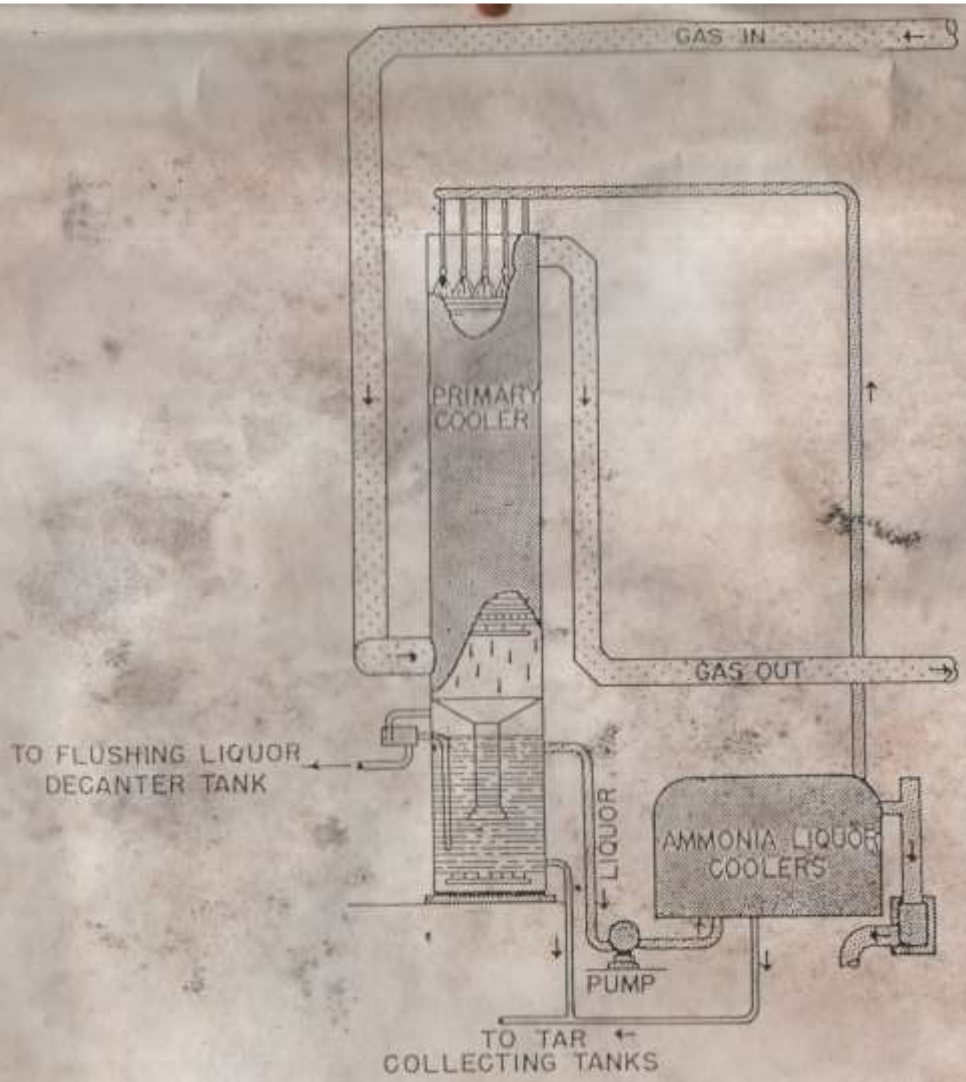


FIG. 5 Schematic diagram of a direct primary cooler.

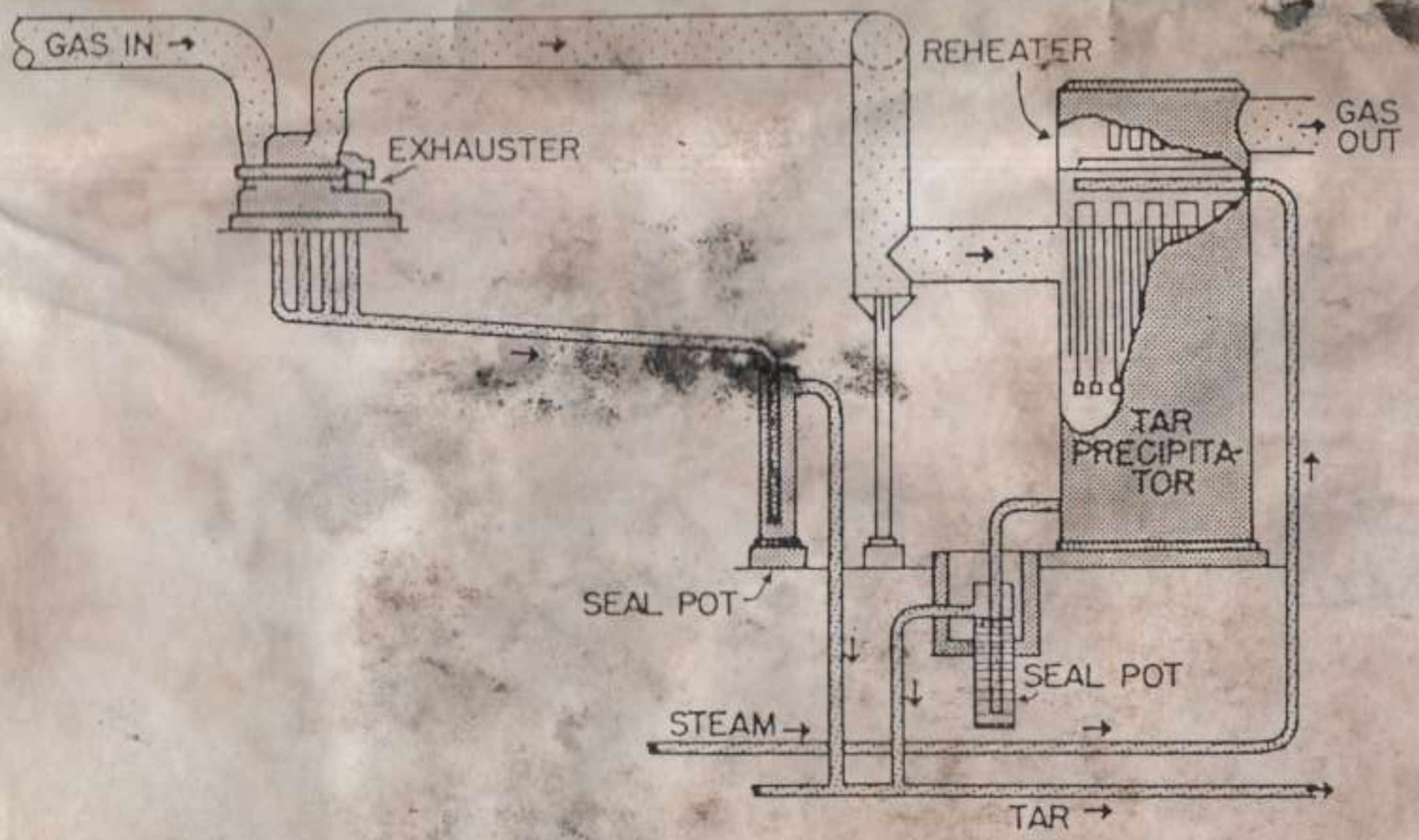


FIG. No. 6 Diagrammatic representation of an electrostatic precipitator for precipitation of tar from raw coke-oven gases.

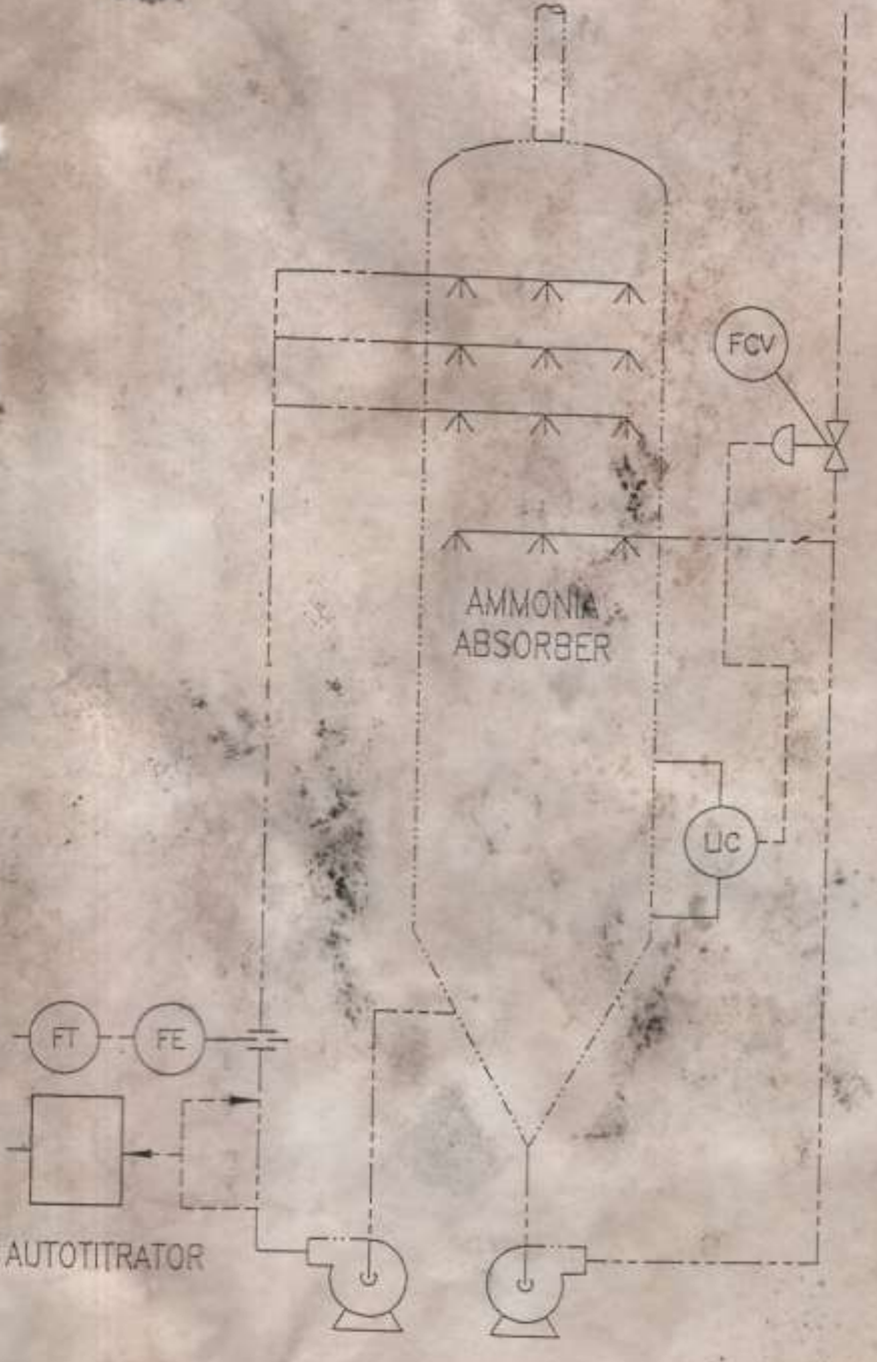
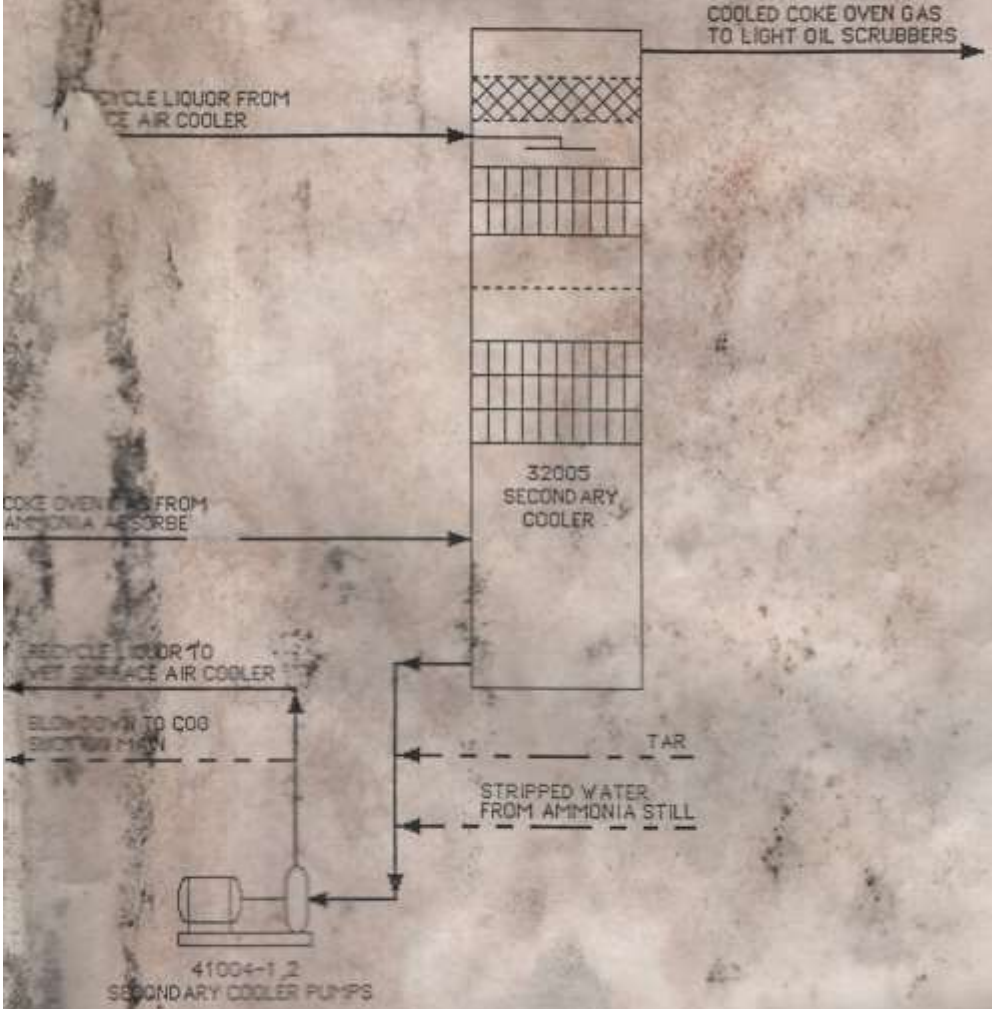
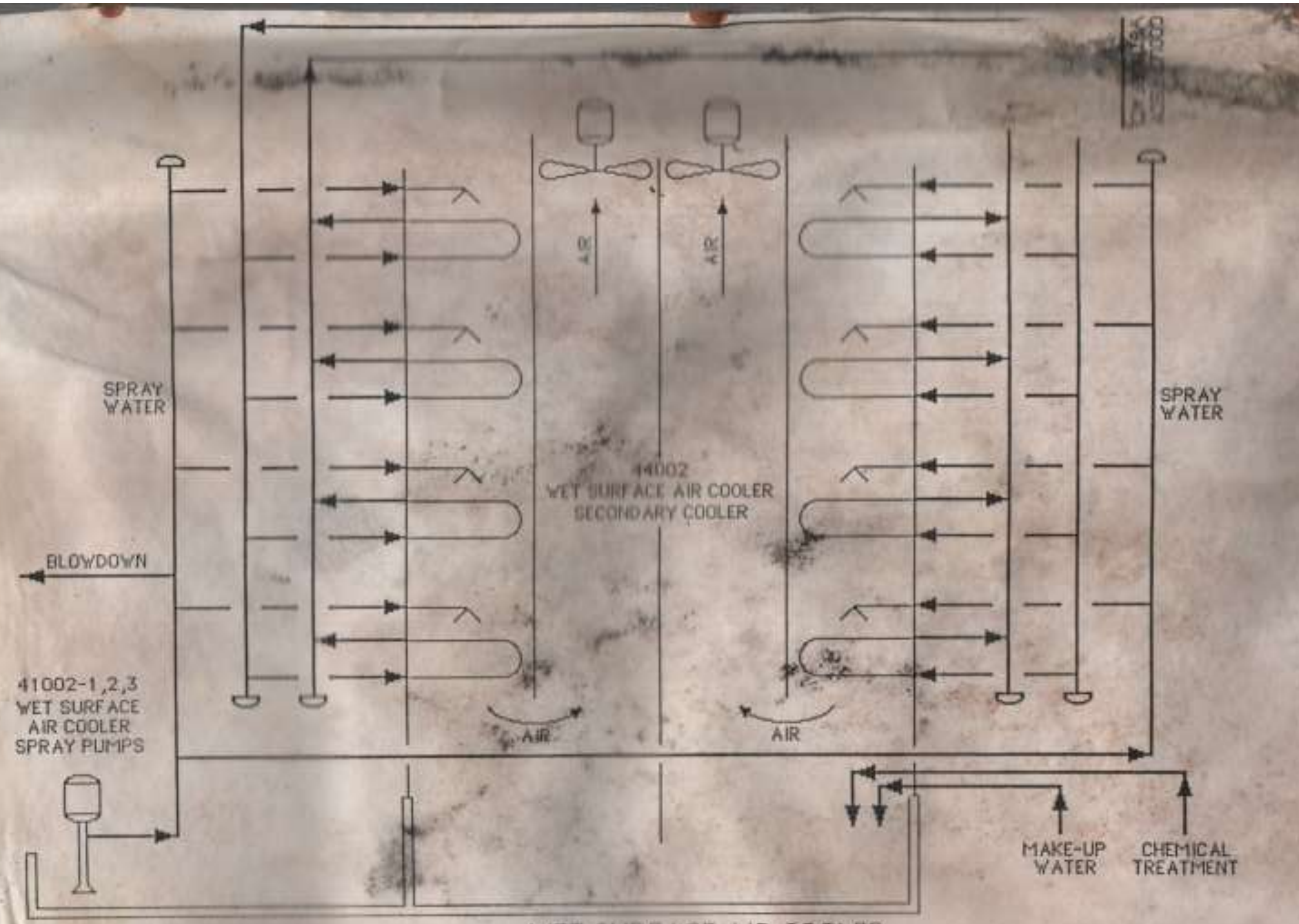


FIGURE No. 7



SECONDARY COOLING

FIGURE No. 8



WET SURFACE AIR COOLER

FIGURE No. 9

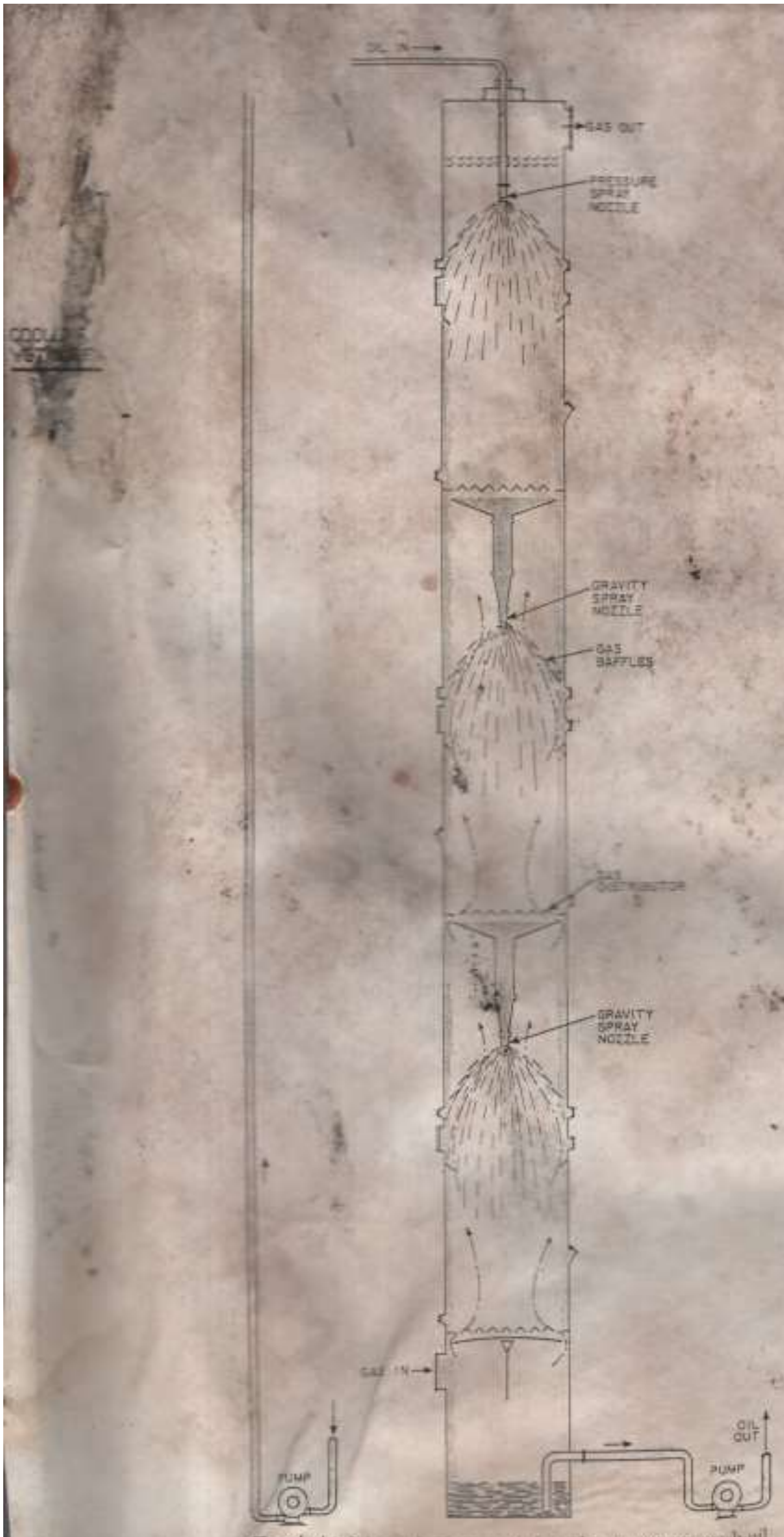
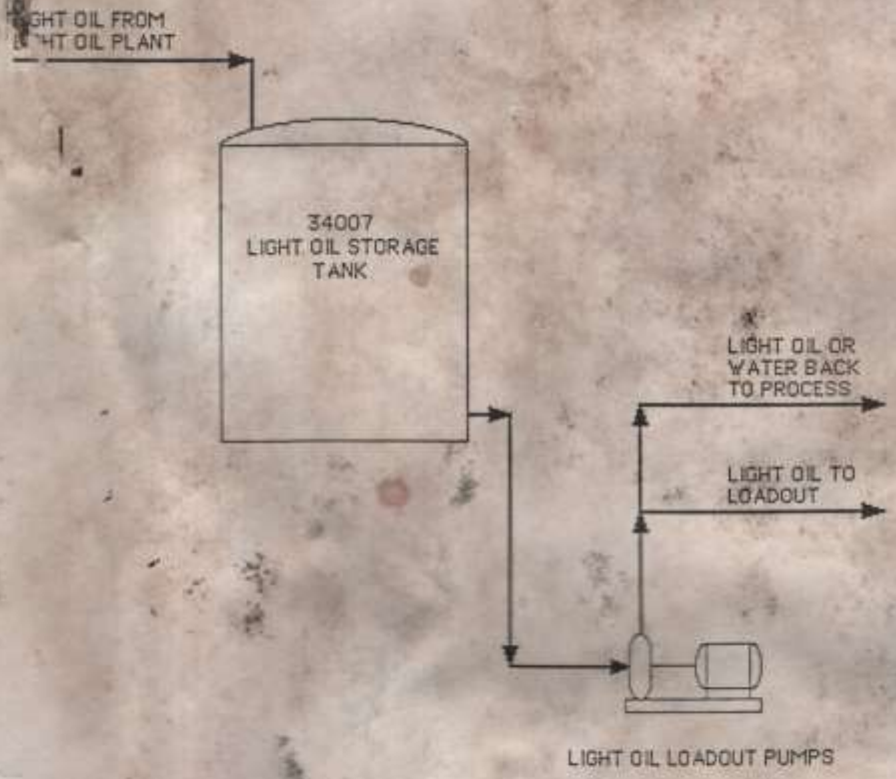
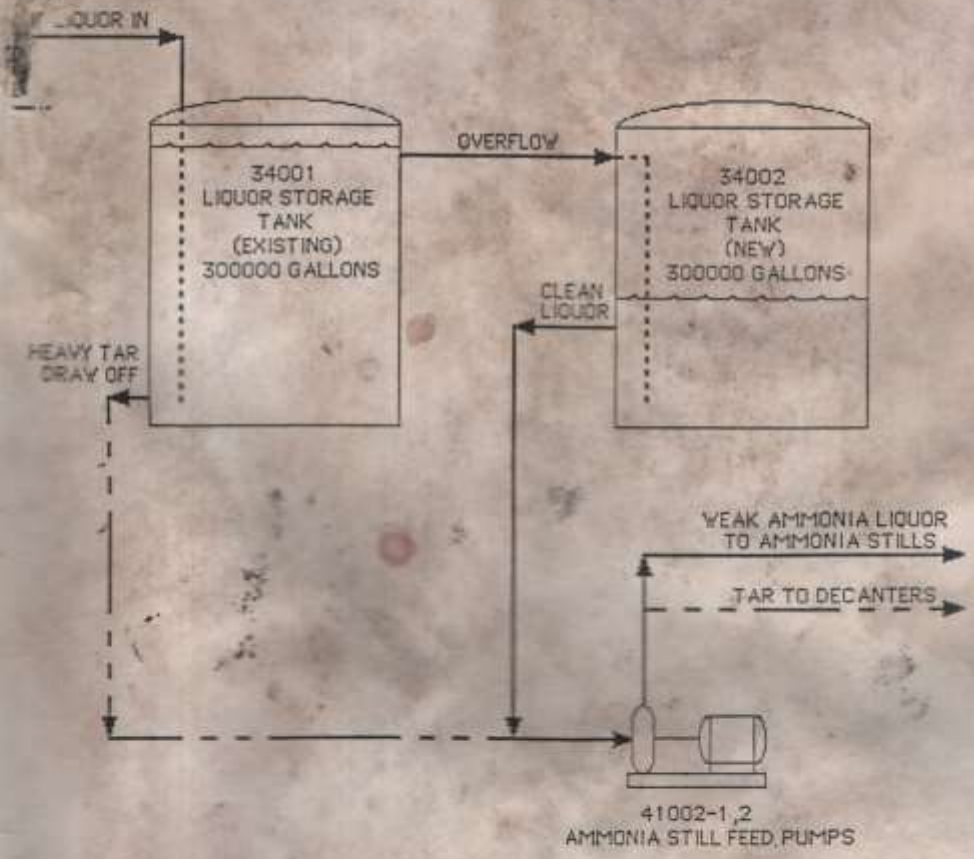


Fig No. 10 Schematic representation of a spray-type wash-oil scrubber.



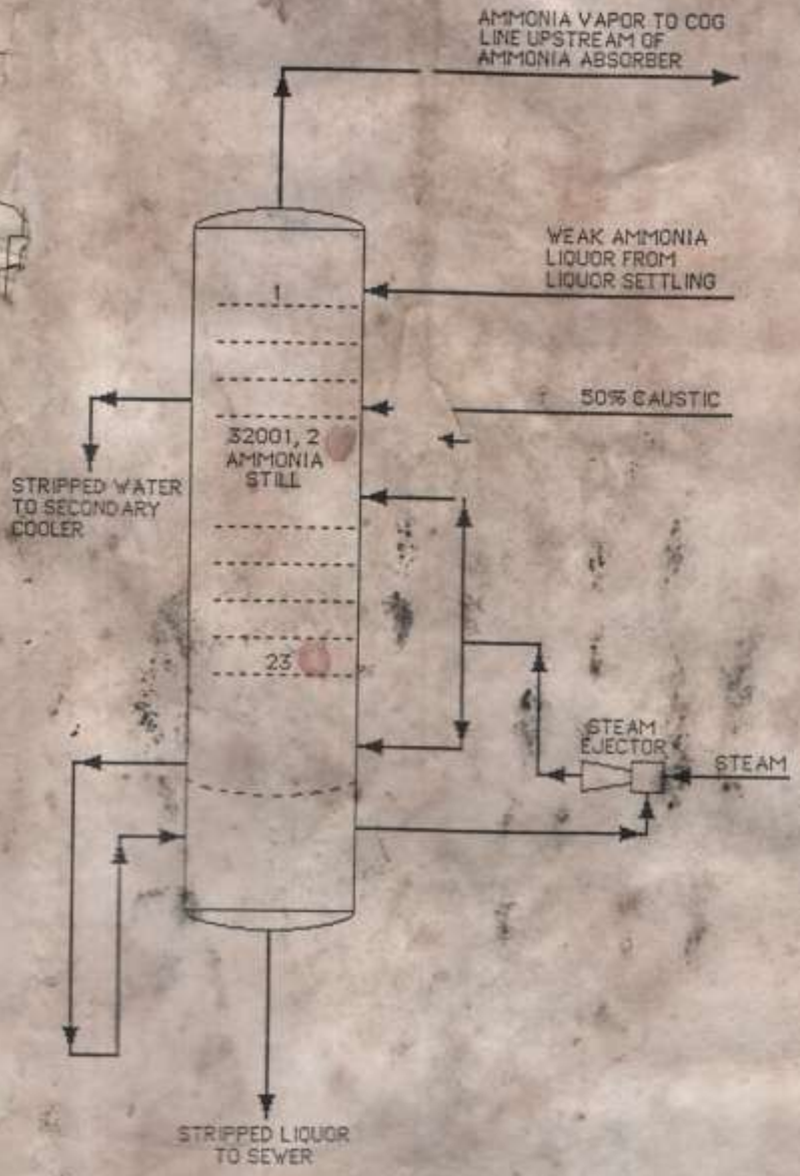
LIGHT OIL STORAGE TANK

FIGURE No. 11



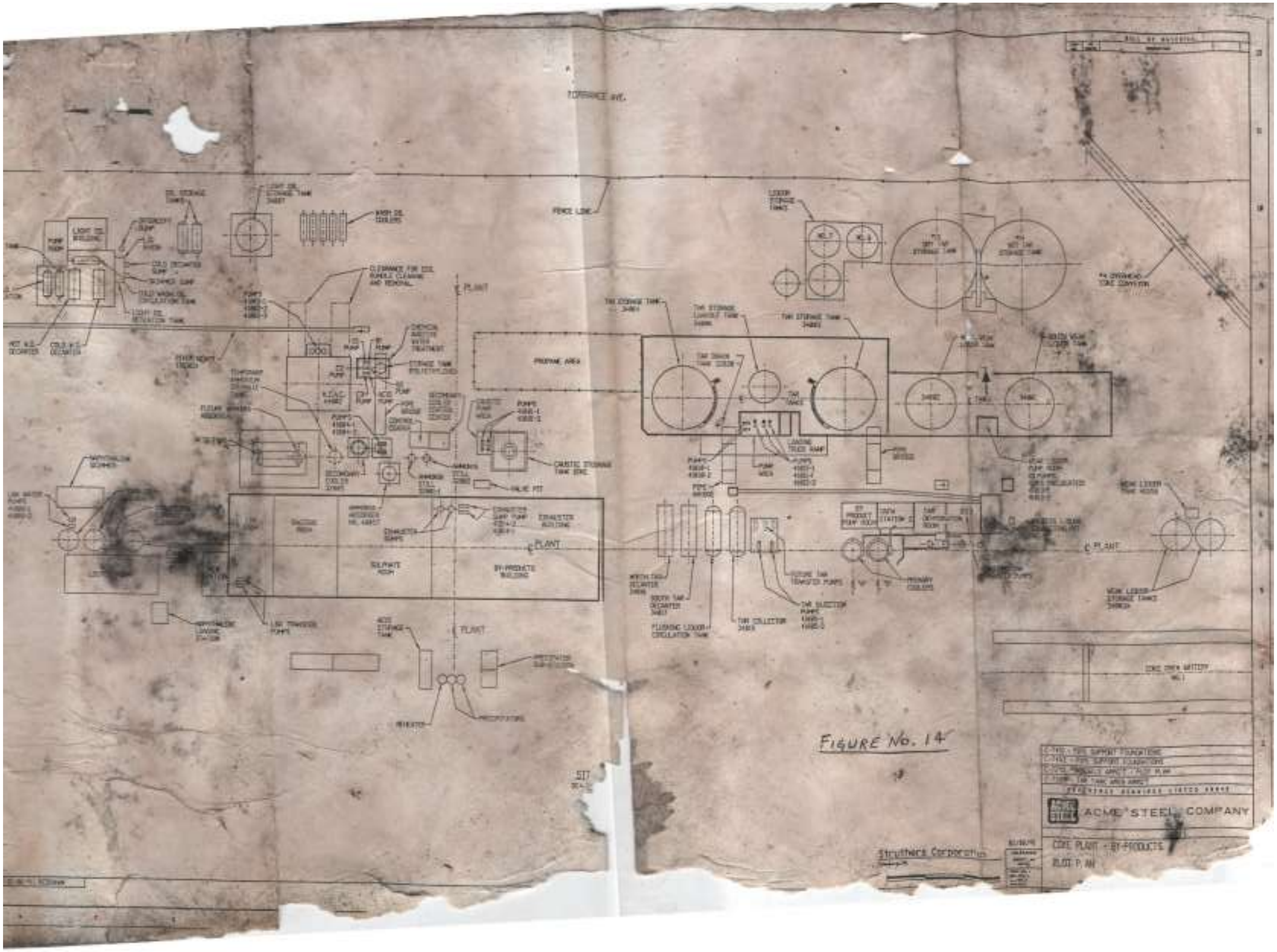
WEAK AMMONIA LIQUOR SETTLING
AND STORAGE TANKS

FIGURE No. 12



AMMONIA STILL

FIGURE No. 13


TORRANCE AVE.
FENCE LINE
OIL STORAGE TANKS
LIGHT OIL STORAGE TANK
WASH OIL COOLERS
LIGHT OIL BUILDING
PUMP ROOM
COLD DECANTER SUMP
SKIMMER SUMP
COLD WASH OIL CIRCULATION TANK
LIGHT OIL RETENTION TANK
HOT W.O. DECANTER
COLD W.O. DECANTER
CLEARANCE FOR COIL BUNDLE CLEANING AND REMOVAL
℄ PLANT
CHEMICAL WATER TREATMENT
STORAGE TANK
PROPANE AREA
CAUSTIC STORAGE TANK
VALVE PIT
NAPHTHALENE SKIMMER
LOW WATER PUMPS
AMMONIA ABSORBER
EXHAUSTER PUMPS
EXHAUSTER BUILDING
SULPHATE ROOM
BY-PRODUCTS BUILDING
NAPHTHALENE LOADING STATION
LOW TRANSFER PUMPS
ACID STORAGE TANK
REHEATER
PRECIPITATORS
TAR STORAGE TANK
TAR STORAGE TANK
TAR TANKS
LOADING TRUCK RAMP
PUMPS
PIPE BRIDGE
NORTH TAR DECANTER
SOUTH TAR DECANTER
FLUSHING LIQUOR CIRCULATION TANK
TAR COLLECTOR
FUTURE TAR TRANSFER PUMPS
TAR SUCTION PUMPS
PRIMARY COOLERS
BY PRODUCT PUMP ROOM
TAR DEHYDRATION ROOM
WEAK LIQUOR STORAGE TANKS
#4 OVERHEAD COKE CONVEYOR
COKE OVEN BATTERY
FIGURE No. 14
PIPE SUPPORT FOUNDATIONS
PIPE SUPPORT FOUNDATIONS
TAR TANK AREA ARRGT.
REFERENCE DRAWINGS LISTED ABOVE
ACME STEEL COMPANY
COKE PLANT - BY-PRODUCTS
PLOT PLAN
Struthers Corporation