

by Dr. Walter H. Oppelt

The light oil, which results from the carbonization of coal and which is extracted from the coal gas, requires further refining before it can be commercially used.

The composition of the crude light oil depends on the nature of the coal gas applied and on the efficiency and type of the absorption system. It is evident that the nature of the coal gas is determined by the properties of the carbonized coal, the temperatures of carbonization employed and the rate of cracking to which the coal gas was subjected. There is a difference in the composition of crude light oils depending on the applied carbonization temperature. Light oils originating from low temperature carbonization of coal contain more aliphatic, phenolic and unsaturated compounds and less aromatic ones than a high temperature light oil. The chief aromatic compounds of high temperature light oil are benzene, toluene, and xylene. The higher the temperature to which the gases were subjected, the lower the toluene and xylene content. Similar to American practice, the following fractions are obtained from crude coke-oven light-oil:

	American	Nomenclature	German
I	Forerunnings		Forerunnings
II	Crude benzol		Crude benzol
III	Crude toluol		Crude toluol
IV	Crude light solvent		Solvent naphtha or solvent benzol
V	Crude heavy solvent		Solvent naphtha or solvent benzol
VI	Wash oil		Wash oil

A typical example of the composition of a light oil is as follows:

Forerunnings	3% vol
Crude benzol	67 "
Crude toluol	8 "
Crude light solvent	6 "
Crude heavy solvent	10 "
Wash oil	6 "

The Engler analysis of a crude light oil was as follows:

Boiling point	81.2°C
85°C -	6% vol
90 " -	30 "
95 " -	51 "
100 " -	61 "
110 " -	71 "
115 " -	74 "
120 " -	77 "
125 " -	79 "
130 " -	81 "
135 " -	82 "
140 " -	84 "
145 " -	85 "
150 " -	86 "
155 " -	87 "
160 " -	88.5 "
165 " -	89 "
170 " -	91 "
175 " -	92 "
180 " -	92.5 "
185 " -	93 "

190°C	-	93.5% vo
195 "	-	94.5 "
200 "	-	95 "

450

At least two thirds of the crude light oil consists of the crude benzol fraction, whereas toluol and xylenol represent but 1/5 of the total light oil volume.

The difference between light oils originating from either high or low temperature carbonization can be shown by treating the respective light oils with fuming sulfuric acid. A high temperature light oil contains approximately 2% paraffinic compounds which are insoluble in the acid, whereas 40-60% of a low temperature light oil is not affected by the acid.

The crude light oil is almost never commercially used, some kind of refining by distillation or chemical treatment is necessary. Unlike in U.S.A. the light oil originating from the carbonization of coal was the basic fuel for Otto engines. However, it was blended with benzine hydrocarbons, ethylalcohol or methylalcohol. A widely used mixture called "Aral" was composed of approximately 60% benzine and alcohol and 40% benzol.

In this connection it is interesting to compare the combustion properties of the various types of hydrocarbons which are present in a commercially used gasoline. Such a computation shows that prejudices, which are sometimes uttered by the driver of a car against one or the other type of hydrocarbons, are not justified with respect to the heat units furnished by the combustion of the hydrocarbon-air-mixture in the cylinder of an engine.

A given air volume is mixed with such a quantity of fuel as can be completely burned by the oxygen of the air. The quantity of fuel which can be burned by a certain volume of air differs with the chemical composition of the hydrocarbons. The following Table No. 1 contains the results of such computations which were carried out for various typical hydrocarbons.

Column 1-4 contains the higher heating as well as the lower heating value of typical hydrocarbons expressed in kcal per kg and Btu per pound. There exists a big difference between the heating values of aromatic and paraffinic hydrocarbons and the alcohols. It seems quite obvious that methylalcohol, due to its much lower heating value, when burned in the cylinder of an engine cannot furnish the same heat units as benzene or hexane. Columns 5 and 6 represent the volume of air which is required for the theoretical combustion of the respective hydrocarbons. The air volumes are expressed in  $\text{Nm}^3$  per kg and cu ft per pound. We see now, that ethylalcohol and methylalcohol require much less air for the combustion than the other hydrocarbons. Since the volume of a cylinder depends on the bore and the stroke and is constant for a given cylinder, it is evident that a larger quantity of ethyl - or methylalcohol can be burned by an equal volume of air. We are therefore allowed to compute the heat which is furnished by the combustion of such a quantity of fuel as can be admixed to a certain volume of air under conditions of complete combustion. Columns 7-10 contain the results of the respective computations, expressed in the somewhat unusual manner as higher or lower heating value of 1  $\text{Nm}^3$  or 1 cu ft of air. Since the exhaust gases are discharged with such a temperature that no condensation of the water vapors, originating from the combustion, takes place, the figures of Column 9 and 10 represent the heat units which are liberated per  $\text{Nm}^3$  or per cu ft of air if burned under theoretical conditions in the cylinder of an engine. We see now that, regardless of the type of fuel employed, the heat evolution is equal. Each cycle of the engine furnishes the same heat units, whether it is operated with benzene, hexane, or methylalcohol.

Table 1 Combustion Properties of Hydrocarbons

Type of hydrocarbons	1 L.H.V. kcal/kg	2 L.H.V. kcal/kg	3 H.H.V. P.t.u./lb	4 L.H.V. Btu/lb	5 Air requ. for theor. comb. Nm/kg	6 Cuft/lb	7 H.H.V. kcal/Nm <sup>3</sup>	8 H.H.V. of the air Btu/cuft	9 L.H.V. kcal/Nm <sup>3</sup>	10 L.H.V. of the air Btu/cuft
benzene C <sub>6</sub> H <sub>6</sub>	10,030	9,310	18,000	16,750	10.255	164.2	973	109.5	908	102
toluene C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>	10,150	9,730	18,250	17,540	10.43	167	971	109	931	104.8
naphthalene C <sub>10</sub> H <sub>8</sub>	9,629	9,310	17,300	16,730	10.00	160	963	108.3	931	104.8
hexane C <sub>6</sub> H <sub>14</sub>	11,510	10,620	20,750	19,100	11.78	188.2	978	110	903	101.5
hexylene C <sub>6</sub> H <sub>12</sub>	11,340	10,700	20,400	19,250	11.43	183	991	111.3	910	102.2
heptane C <sub>7</sub> H <sub>16</sub>	11,499	10,710	20,650	19,300	11.73	188	980	110.2	913	102.8
ethylalcohol C <sub>2</sub> H <sub>5</sub> OH	7,110	6,340	12,800	11,420	6.95	111.2	1020	114.8	912	102.5
methylalcohol CH <sub>3</sub> OH	5,330	4,730	9,600	8,500	5.00	80.1	1070	120.3	947	106.4

Another question is the quantity of the fuel which is consumed in order to furnish the heat units recorded in column 9 and 10 of Table 1.

The following Table 2 contains the amounts of fuel, which are consumed, per Nm<sup>3</sup> or cu ft of air.

Table 2

## Fuel Consumption

Type of Fuel	Kg per Nm <sup>3</sup>	Pound per cu ft.
Benzene	0.0975	0.0061
Toluene	0.0957	0.00597
Naphthalene	0.1000	0.006
Hexane	0.085	0.0053
Hexylene	0.0851	0.00531
Heptane	0.0852	0.00532
Ethylalcohol	0.144	0.009
Methylalcohol	0.200	0.0125

The table indicates very clearly that the fuel consumption depends on the heating value of the respective fuel and that we obtain a higher mileage from a pound of benzene than from a pound of methylalcohol.

Since the consumer buys the fuel per volume and not by weight he is interested to know the heat content of a gallon of the respective fuel.

The following Table 3 represents the lower heating value of 1 gallon of the various fuels.

Table 3

## Heat Content of Liquid Fuels (Heat Units per Gallon)

Type of fuel	density	kg per gallon	kcal per gallon	B.t.u. per gal.
Benzene	0.8794	3.320	30,900	122,600
Toluene	0.866	3.270	31,800	126,000
Naphthalene	1.1	4.16	38,700	153,000
Hexane	0.6603	2.5	26,700	106,000
Hexylene	0.6732	2.54	27,200	108,000
Heptane	0.684	2.58	27,600	109,000
Ethylalcohol	0.7893	2.98	18,900	75,100
Methylalcohol	0.7928	2.99	14,150	56,100

Table 4  
Composition of Flue Gases and Their Dew Point for Water Vapors

Type of Fuel	CO <sub>2</sub> % vol.	H <sub>2</sub> O% vol.	N <sub>2</sub> % vol.	Dew Point for Water Vapors °C	Dew Point for Water Vapors °F
Benzene	16.15	8.07	75.78	41.5-42	106.7-107.6
Toluene	15.65	8.93	75.42	44	111.2
Naphthalene	16.90	6.77	76.33	39	102.2
Hexane	12.32	14.38	73.30	52.5-53	126.5-127.4
Hexylene	13.12	13.12	73.76	51	123.8
Heptane	12.42	14.20	73.38	53	127.4
Ethylalcohol	12.28	18.42	69.30	58	136.4
Methylalcohol	11.58	23.16	65.26	63	145.4

Objections can be made against operating the engine with methylalcohol, due to the high dew point for water vapors of the flue gases. The water vapors are condensed at relatively high temperatures. Corrosion troubles can be expected especially in cold weather and when frequent stops are made. The most favorable conditions are offered by the use of aromatic hydrocarbons.

When the air is passing through the carburetor the liquid fuel is vaporized and the air, due to the heat of vaporization of the liquid is cooled. In order to get the maximum amount of fuel into the cylinder the air should be as cold as possible because not the volume of oxygen but its weight which is present in the cylinder is what counts.

The following table contains some computations which have been made with respect to the heat of vaporization of the various fuels.

Table 5  
Heat of Vaporization

Type of Fuel	Heat of kcal/kg fuel	Vaporization kcal/Nm <sup>3</sup> air	Theoretical temperature drop of the air in the carburetor	
			°C	°F
Benzene	94.3	9.2	29.7	53.4
Toluene	84.0	8.0	25.8	46.5
Naphthalene	75.5	7.55	24.4	43.9
Hexane	79.4	6.75	21.8	39.2
Hexylene	92.7	7.88	25.4	45.7
Heptane	77.8	6.62	21.3	38.4
Ethylal	204	29.4	94.8	171
Methylalcohol	262.8	52.6	170	306

There is not much difference in case of the aromatic and paraffinic hydrocarbons, however the alcohols show an appreciable higher heat of vaporization, which results in a higher temperature drop of the air. It is obvious that such a considerable temperature drop will never occur in practice due to the influence of the radiant heat of the engine, however, under equal conditions the air will be cooled to a greater extent if alcohols are vaporized. In practice, the combustion of the fuel in the cylinder takes another course. The exhaust gases besides CO<sub>2</sub>, H<sub>2</sub>O and N<sub>2</sub> contain CO and H<sub>2</sub> which indicates that the combustion is not complete in the cylinder and that besides the heat loss due to the sensible heat of the flue gases additional losses occur owing to the chemical heat content of the flue gases, resulting in the fact, that during practical operation the theoretical considerations may be changed. To come back to the refining of light oil we must distinguish between such refined products which are used as chemicals and such which serve as liquid fuel for engines.

All products which are used as chemicals, such as pure benzene, toluene or xylenes require a treatment with concentrated (66° Be') sulfuric acid in order to remove the unwanted compounds. Up to the present time no better process



has been found, although the process is unsatisfactory in so far as it removes the unsaturated hydrocarbons by destructing them. The acid sludge, far from being a valuable product, must be disposed of. The refining procedure follows closely that of motor benzol and shall be discussed later. The chemically treated product is redistilled whereby the batch distillation prevails. Since the big companies operated centralized refining plants, they tried to employ continuously operated plants too, however the development was just in the beginning. The pure products must be cut very closely because 95% of the product must distill within  $0.5^{\circ}\text{C}$ . Under those conditions it is more easy for the operator to supervise a batch still than a continuous process. The chemical treatment of the hydrocarbons to be refined was carried out batchwise in so called "agitators". A continuous process was not applied,

While the refining procedure of pure benzene, toluene etc. was rather conservative, many attempts have been made in order to improve the refining methods of motor benzol.

For a long time, due to the rigid specifications of the German Benzol Association, the motor benzol had to be refined by means of concentrated sulfuric acid too, despite the great refining losses which resulted from the treatment with the concentrated acid. Depending on the chemical nature of light oil the losses were as high as 10 - 12%. In addition to the diolefines which are responsible for the formation of polymerized products, the olefines, which represent valuable hydrocarbons with respect to their utilization in the motor, are removed too under the influence of concentrated sulfuric acid. After long deliberations the specifications with respect to the properties of motor benzol were changed. While formerly the refined motor benzol, when vigorously shaken with concentrated sulfuric acid should produce but a light yellow color, the gum test was now introduced. Oxygen was passed through the boiling refined motor benzol, the benzol was then vaporized and the weight of the dried residue (gum) was determined.

According to the specifications 100 ml of the refined motor benzol should not contain more than 10 mg gum. Such a test indicated the stability of the refined motor benzol during storing. Exhaustive tests which were performed over a period of several years had shown that such a motor benzol could be easily stored and did not form any deposits in the jet of the carburetor. With the rigid specifications lifted, the refining methods could be modified and many variations were proposed.

The most commonly method used consisted in replacing the 66° Be' sulfuric acid by a 50° Be' one. Such an acid removed the diolefines, however, preserved the monoolefines, thus increasing the yield of the refined product. The total refining losses could now be cut down to 5-6%, without deteriorating the quality of the refined motor benzol.

The procedure is now as follows:

The crude light oil is redistilled so that it does not contain more than 4% products which are boiling over 180° C (356° F), if the stripping system is not equipped with an auxiliary still which allows to produce directly a high grade crude light oil.

The crude light oil is almost always fed to the batch acid wash agitator which consists of a cylindrical tank with a conical bottom. The agitator is equipped with inlet piping and sludge drain piping, covered by a tight fitting lid and provided with a gadget for agitation. The agitators are lined with acid proof bricks, however unprotected steel vessels are found too. The agitation is carried out by means of a vertical shaft to which impellers are fixed. The Otto Company used a centrifugal pump located outside the agitator, the suction line of which was led just underneath the surface of the light oil. The reason is to withdraw a light oil from the agitator which is completely separated from the acid. The light oil is returned to the agitator by means of a pipe which is led through the conical bottom.

Securing a complete mixture of the light oil with the employed chemical, the contrivance has the advantage that the agitator is free from any moving parts. Repairs can be easily made and the agitator proper is easily accessible. Sometimes heating or cooling coils are provided in order to be able to maintain a desired temperature of the light oil during the refining procedure. The capacity of the agitators was mostly 5,000 to 6,000 gallons. When refining light oils originating from low temperature carbonization which contain large amounts of unsaturated hydrocarbons it is advisable to employ low temperatures and to remove the heat which is due to the reaction of the unsaturated hydrocarbons with the acid. For such cases the agitator can be equipped with a jacket through which an artificially refrigerated brine solution is run.

The washing procedure is well known and need not be described. When refining motor benzol, approximately 3-4% sulfuric acid ( $60^{\circ}\text{Be}$ ) has to be employed. Before treating the light oil with sulfuric acid, the phenols and pyridines can be extracted by means of diluted sulfuric acid and aqueous caustic soda solution, however such an extraction is only economical, when large quantities of light oil have to be refined. The sludge which results from the acid treatment is allowed to separate and is withdrawn from the bottom of the cone of the agitator. The product is then washed by adding subsequently water, caustic soda solution and water. Each agent is thoroughly mixed with the light oil, allowed to separate and is separately withdrawn. While in most cases the acid sludge separates easily from the light oil, more or less troublesome emulsions are sometimes observed, when the light oil is neutralized with caustic soda. Experience has shown that the formation of emulsions, should they occur during the neutralization by means of caustic soda solution, can be prevented by replacing the caustic soda by sodium carbonate or vice versa. Very little is known about the reasons which lead to the formation of emulsions and at present there seem to be no methods available, based on scientific investigations, which allow to take the proper steps

in advance in order to prevent the formation of emulsions. I intended to measure the interfacial surface tension between light oil and the various agents employed during the refining process with respect to the formation of emulsions. However, the investigations had to be postponed and could not be carried out. The treated product has now to be distilled in order to remove the polymerized products. In most cases the batch distillation is employed, whereby the stills have a capacity of up to 15,000 gallons. In order to remove sulfur compounds the benzol vapors are led through a bath of concentrated caustic soda solution. The employed caustic soda solution has a specific gravity of 1.43 and contains 40% sodium hydroxide. 1 m<sup>3</sup> (265 gallons) of the solution is capable of desulphurizing approximately 200 metric tons benzol. The reason for the extraction of hydrogen sulfide from the benzol vapors lies in the fact that during storage hydrogen sulfide is oxidized to elementary sulfur which corrodes the fuel lines and the carburetor. Such sulfur is therefore called "aggressive sulfur" and the maximum permissible amount is 2 mg element. sulfur per 100 ml motor benzol. Central refining plants employed continuously operating distillation equipment too, however, by far most of the benzol was distilled in batch stills.

The question has often been discussed whether it is advisable to treat the total light oil or to separate the light oil in various fractions prior to the refining procedure. Treating the light oil as it comes from the stripper has the advantage of less steam consumption. However, the chemical composition of the various light oil fractions is so different that a separate acid treatment may be justified. The first fraction up to 100-110<sup>o</sup> C. (212-230<sup>o</sup> F) is almost colorless and requires only very little refining, whereas the following fractions need more acid treatment. If the entire light oil is refined, the components which need more refining are diluted and do not react so easy with the acid <sup>if</sup> as they are present in a higher concentration, resulting in a higher acid

consumption. When large volumes of light oil have to be refined it seems advisable to distill the product prior to the refining procedure and treat the various fractions separately, applying such quantities of sulfuric acid which are necessary to give the desired effects. The treated fractions can be either mixed before the final distillation or they are distilled separately and blended afterwards.

Unlike in U.S.A., where the acid sludge is mostly discarded, European practice prefers to separate the unused acid from the polymerized products, the "resins". Due to the densely populated industrial areas it is impossible to dispose of the acid sludge without polluting the streams which ordinarily furnish the drinking water. There exist numerous processes which recover acid and resins. Direct steam is passed into the heated sludge and the distillates are recovered. Other processes dilute the sludge with water and separate the diluted sulfuric acid from the resins. The acidic vapors which are liberated during heating of the sludge must be neutralized before they are escaping into the atmosphere. Since the maintenance of such equipment is very high the value of the reclaimed products does not justify the operation of such plants. The diluted sulfuric acid is used for the production of ammonium sulfate, however the quantity of the acid which can be admitted in the saturator is limited, if a pure white salt shall be manufactured. The recovered resins are almost without value. They are sometimes admixed to the coal tar, however the operators of tar distillation plants object against such a practice, because sulfur compounds which are decomposed during the distillation will corrode the walls of the stills. It has been proposed to distill the resins separately and to use the distillate as benzol wash oil. It is claimed that such oils are very resistant with respect to the formation of asphalts. In some cases the resins are dumped or burned.

The sulfuric acid process although it shows some disadvantages, is very simple and therefore widely used. One of the disadvantages is the formation of the previously described acid sludge. The rigid specifications of the Benzol Association prevented for a long time the application of improved washing processes. However, with the introduction of the weak acid treatment some proposals could be realized. The "Ufer process" was used at several installations because it provides a rather simple solution of the regeneration of the acid sludge. The light oil is first treated with sulfuric acid (about 60° Baume'). The acid sludge is not removed; as soon as the reaction is complete a measured volume of water is added to the treated light oil. By diluting the acid sludge the acid separates from the resins which in turn, are dissolved by the light oil. The diluted acid (about 40° Baume') is utilized at the ammonium sulfate recovery plant, whereas the resins together with the light oil are transferred to the still. The resins remain in the heavy residue after the distillation and can be admixed to the tar. Good results are obtained when the content of the agitator is thoroughly agitated and the temperatures are properly controlled. In order to be able to maintain always the desired temperature the agitator was equipped with heating or cooling coils. The water was admitted in the agitator in form of a widely dispersed spray in order to secure a very intimate contact with the light oil. The applicability of the Ufer process depends on the characteristic of the light oil. The suitable refining temperatures and acid concentrations must be found out by trial.

Very few plants employed the "Instill process". The reagent consists of a mixture of ferric sulfate, very little free sulfuric acid and an adsorbent earth. The pyridines must be first removed by a weak acid wash. The preheated light oil is treated with the Instill reagent, separated, cooled, neutralized by caustic soda and redistilled. The quality of the obtained product is almost the same as that which originates from a weak acid treatment.

Near the end of the war the Otto Company made some semi-commercial experiments which differed from the usually applied method in so far as the distillation procedure of the treated product was somewhat modified. Normally, when the refined product is redistilled the final temperatures become so high, that direct steam must be applied in order to vaporize the heavy fractions. It was found out that some of the polymerized products were slightly decomposed under the influence of the elevated temperature, thus increasing the gum content of the distillate or in order to keep the gum content low the distillation must be interrupted at somewhat lower temperatures than are necessary in order to obtain the highest yields of distillate. A decomposition of the distillate can be prevented if the distillation is carried out at a temperature of  $80-90^{\circ}\text{C}$  ( $176-194^{\circ}\text{F}$ ). This is possible by applying an increasing vacuum pressure during the distillation so that the distilling temperature is kept within the above mentioned limits. By doing this the yields can be slightly raised, a little weaker acid than usual can be employed or the amount of acid can be lessened. The process is of value when light-oils which contain high amounts of unsaturated hydrocarbons have to be refined.

One plant eliminated almost entirely the utilization of sulfuric acid by heating the crude light oil under pressure to  $150 - 200^{\circ}\text{C}$  ( $302-392^{\circ}\text{F}$ ) whereby a pressure of 6-15 atm (85-210 pounds p. sq. inch) is created. The diolefins which are responsible for the formation of gum are polymerized while the aromatics and mono-olefins remain untouched. The heat treatment is carried out in autoclaves which have a capacity of about 15,000 gallons. The heating systems of the autoclaves are connected in series in order to obtain a good heat economy. Pyridines which are present in the crude light oil are extracted by an acid wash prior to the heating procedure. The pressure treated product is redistilled in order to remove the polymerized diolefins.

Besides sulfuric acid, a great variety of other chemicals has been proposed as polymerizing agents. Such chemicals are aluminum chloride, ferric chloride,

zinc chloride etc., however none of such processes were applied on a large scale, despite they are capable of furnishing a properly refined product.

All the processes which have been mentioned before are intermittent ones, which require a batchwise refining procedure. Despite many efforts which have been made in the past continuously operating acid refining processes were never widely used. There existed one or the other design which in one way or the other tried to solve the problem, however, none of the proposed processes was frequently employed. The difficulty lies in the fact that various processes must be carried out successively whereby each process requires a different time of reaction and separation of the light oil from the spent reagent. Since the formation of emulsions depends sometimes on a slight change of the temperature the concentration and the quantity of the applied chemicals a continuously operated refining system must be designed rather spacious and becomes then expensive.

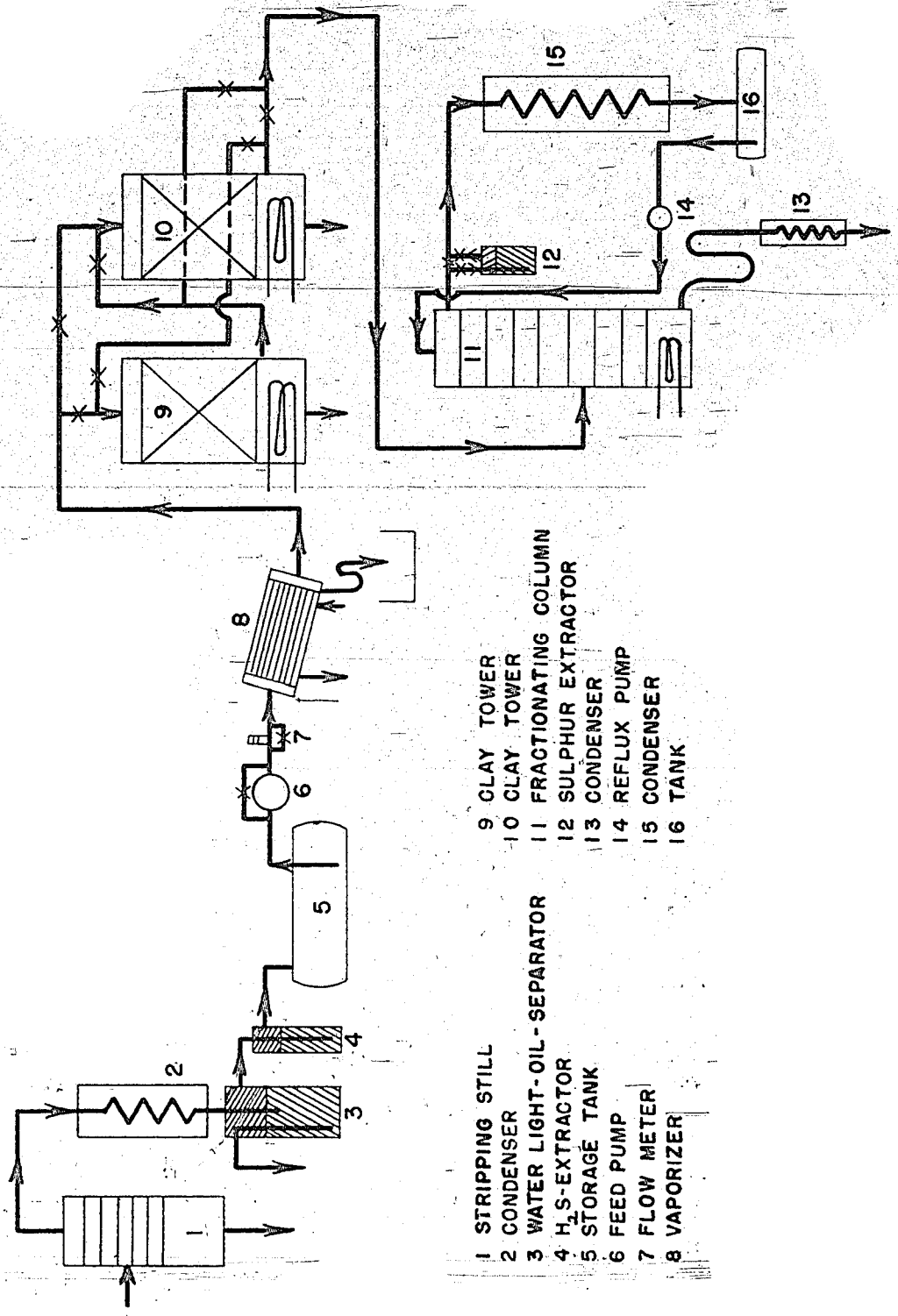
Since vapor phase treatment with activated clays is frequently used in the petroleum industry, we tried to apply the same method to crude light oil. The following sketch represents a flow sheet of the installation. The wash oil is stripped from the light oil by passing through the stripping still (1). The stripped oil is withdrawn from the bottom of the still, cooled and returned to the light oil scrubbers. The light oil vapors leaving at the top are condensed (2) and separated from water (3). The water free product is forced through a bath of caustic soda (4) in order to extract the hydrogen sulfide from the crude light oil which is stored in (5). A feed pump (6) sucks the product from tank (5) and pumps it over a flow meter (7) into the vaporizer (8) which is heated by steam. The heavy residue, which has not been vaporized is withdrawn cooled and disposed of. The superheated light oil vapors are admitted in the top of the clay tower (9) and are flowing downwards to the bottom. The gummy polymers which due to the elevated temperature are not too viscous and which have not



been adsorbed by the clay are recovered in the lower part of the tower which is equipped with a steam coil in order to vaporize light products should they have been condensed. The liquid polymers are continuously or periodically withdrawn. The light oil vapors are then admitted in the top of the clay tower 10 which takes care of the final refining. Gummy polymers are withdrawn and disposed of. The two clay towers in series are connected with a system of valve and gas piping connections to permit changing the order of the towers so that the vapors before leaving the plant come in contact with almost fresh clay. The refined vapors are admitted in the fractionating column (11) and separated into motor benzol and heavy residue. The fractionating is aided by a stream of reflux, withdrawn from tank (16) by reflux pump (14). The heavy residue is discharged at the bottom of the still, cooled and can be used as heavy solvent. The motor benzol vapors leaving at the top of the column <sup>before</sup> being condensed (15) are led through a bath of hot caustic soda solution (12) (spec. grav. 1.43) which removes sulfur and hydrogen sulfide. The refined product is stored in tank (16).

We succeeded in manufacturing a motor benzol the gum content of which was within the limits specified by the Benzol Association. The clay consumption was about 3% by weight of the processed product. Such a consumption seems to be rather high and should be lowered. Since some of the resins are adsorbed by the activated clay, a high boiling solvent should be percolated through the bed which, by extracting the clay, opens its pores and extends its useful life. Provisions should be made in order to refresh the clay by burning out the carbon residue, however the operation of such a furnace is economical only if a large plant is operated. Due to the specifications of the Benzol Association the application of an inhibitor was not possible and the refining had to be done exclusively by the clay, combining the clay treatment with a following application of an inhibitor would certainly cut down the clay consumption. There is almost nothing known about the influence of the contact time on the clay consumption. Such experiments could not be carried out because we had to process the daily

# VAPOR-PHASE REFINING OF LIGHT OIL WITH ACTIVATED CLAY



- 1 STRIPPING STILL
- 2 CONDENSER
- 3 WATER LIGHT-OIL-SEPARATOR
- 4 H<sub>2</sub>S-EXTRACTOR
- 5 STORAGE TANK
- 6 FEED PUMP
- 7 FLOW METER
- 8 VAPORIZER
- 9 CLAY TOWER
- 10 CLAY TOWER
- 11 FRACTIONATING COLUMN
- 12 SULPHUR EXTRACTOR
- 13 CONDENSER
- 14 REFLUX PUMP
- 15 CONDENSER
- 16 TANK

produced light oil and could not vary the throughput within wide limits. However, the activated clay process is a rather simple solution of the old problem to operate a continuous refining system.

As mentioned before, due to the specifications of the Benzol Association the inhibitor process, which would have saved the scarce sulfuric acid, could not be applied despite the fact that good results were obtained.

Despite many proposals, the acid refining process still prevails and batch agitators are still widely used because the refining procedure can be easily modified and adjusted to the special characteristic of the light oil to be treated. By lowering the strength of the acid the yields were improved and losses cut down. Continuously operating acid refining equipment was almost not employed, however, continuously operating fractionating columns were sometimes used. The first vapor phase refining system for light oil with activated clay which was operated in Germany has been described.

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