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Closely allied to—in fact, forming a part of—the crude-oil industry is the business of refining crude petroleum. Distributed over the United States there are between six and seven hundred of these refineries, ranging in daily capacity from a few barrels to 80,000 barrels. In some instances the investment in a single plant comes close to $50,000,000. There are 75,000 tank cars in America, of which about 75 per cent. are owned by the industry. These and similar statistics indicate that much capital has been drawn to this particular field of endeavor.

While it is recorded that man has utilized petroleum in its crude state for the last two thousand years, it has remained for the nineteenth and twentieth centuries to produce processes by which the various constituent elements are extracted and to find new uses for the products. According to the United States geological survey the world's production of petroleum during the past fifty-four years was 9,000,000,000 barrels of 42 gallons each. Approximately 62 per cent. of this oil was produced in the United States.

Crude petroleum may be broadly classified as to paraffin-base oil, asphalt-base oil and mixed-base oil. Examples of paraffin-base oil are furnished in the light oils of Pennsylvania and West Virginia. The California, Trinidad, Gulf coast and Mexican oils are principally of asphaltic base. The oils of Oklahoma and Kansas are generally of a mixed-base. Wyoming crude oil varies, some being of asphaltic-base and some of paraffin-base. There is a wide variation in the composition of the petroleum deposits in the different sections of the United States. For example, Pennsylvania and West Virginia produce a small quantity of an oil of such high lubricating qualities that it will serve as a lubricant without treatment; near Lander, Wyoming, there is found an oil so viscous that it is used for road work without refining, and an oil produced from the Garber pool of Oklahoma is so combustible that it has been used in its crude state, in lieu of gasoline, to run an automobile.

Refineries may be divided into three general groups, according to their type, as follows:

Group 1.

Included under this group are:

(1) The "skimming" or "topping" plant, so called for the reason that only the lighter products of gasoline or naphtha, kerosene and sometimes gas oil are extracted, the residuum being sold for fuel oil.

(2) The "lubricating" plant, which carries the process of "topping" a step farther, producing lubricants from the residuum before disposing of it as fuel oil.

Group 2.

Under this group we place the general refinery, which may employ any of the several patented processes, the character of which will depend upon the composition of the crude oil available and the end-products and by-products desired. Where a large gasoline and illuminating oil yield is desirable the cracking process (destructive distillation) is often employed, whereas fractional distillation with steam is usually used where lubricants are the objective.

Group 3.

This group will contain the miscellaneous types of refineries.

Casinghead gasoline plants have come into some prominence during the last fifteen years. This branch of the industry has to do with the extraction of gasoline from casinghead gas. Casinghead gas is the gas given off from an oil well and is usually rich in gasoline content. Two methods of extraction, with variations, are in general use. In the first, the compression method, the gas is compressed at a low temperature. In the second, the absorption method, the gas is caused to bubble through an absorption medium, usually "straw oil," from which it is afterward refined. While the refining of oil shale at one time promised to become one of the world's leading industries, the small number of such refineries today, most of them being confined to Scotland, makes the subject of only passing interest. These remarks are also applicable to coal refining (destructive distillation) for the production of coal oil. However, it is not improbable that the situation will be reversed some fifty or one hundred years hence, should the prophecies concerning the exhaustion of the world's petroleum deposits be fulfilled.

The refining of petroleum involves, first, the purchase and transportation of the oil; second, the storage thereof and, third, the refining, storage and marketing of the products.

## Oil Well to Tank Farm

Consideration will be given first to the purchase of crude oil. The last few years have witnessed the gradual amalgamation of the oil industry, as regards not only the producing end of the business but the transporting and refining divisions as well. This is so much a matter of common knowledge that it needs no argument. As a result large pipe-line companies, the functions of which are the purchase, treatment and transportation of oil, have grown up. These companies usually are subsidiaries of holding companies which also control large production as well as refineries.

Crude oil generally is purchased direct from the producer at his lease. As the oil comes from the well it is run or pumped, as the case may be, into the lease storage tanks. Practice is not uniform in this respect, but a great many producers now pass the oil through a settling tank before pumping it into storage. This is especially advisable where the well is making some sand and salt-water. Until recently millions of barrels of oil from wells in the mid-continent field, which were producing salt-water, went to waste for lack of an economical means of separating the portion of the oil emulsified in the salt-water. The discovery of chemical and electrolytic methods of treatment changed all this, and made possible the reclamation of 50,000,000 barrels during a single year. This oil would have been entirely lost otherwise.

Oil expands with heat and contracts with cold, but it is bought and sold on the basis of 60° F. The general practice is to subtract 1 per cent. of the volume for every 20° above 60° F., and, conversely, to add 1 per cent. of the volume for every 20° below 60° F. The following is a table of approximate allowances for various petroleum derivatives:

Light gasoline—subtract or add 1 per cent. for every 15° above or below 60° F.

Other naphthas, gasolines, and illuminating oils—subtract or add 1 per cent. for every 20° above or below 60° F.

Gas oil and lubricating oils—subtract or add 1 per cent. for every 25° above or below 60° F.

The price of crude oil, though regulated in a measure by the law of supply and demand, is fixed, to all intents and purposes,

by the large purchasing companies. These companies lower or raise the price at their pleasure and often in a very arbitrary manner. However, crude petroleum prices vary with the quality of the oil, an oil of high gasoline or lubricant content commanding a much better figure than one containing only a small percentage of these products. Oil and its products are graded according to gravity in degrees Baumé.

The following are conversion formulæ between Baumé and specific gravity:

$$\text{Degrees Baumé} = \frac{140}{\text{specific gravity} \frac{60^\circ}{60^\circ} \text{ F.}} - 130$$

$$\text{Specific gravity} = \frac{140}{130 + \text{Baumé}^\circ \frac{60^\circ}{60^\circ} \text{ F.}}$$

In buying and selling crude oil an allowance, called a pipe-line allowance, is made for bottom settlings or basic sediment and water. This allowance is in favor of the purchaser. The percentage varies somewhat, but throughout the mid-continent field 3 per cent. is usual. Where an oil is found to contain an excessive amount of this undesirable foreign matter the allowance is based on an actual test made with a centrifuge.

As soon as a lease tank is full of oil a measurement, called a gauge, is made. Representatives of both buyer and seller are present. After the oil is run into the pipe line another gauge is made. The results of these gauges are entered upon run tickets, usually made out in triplicate. The representatives exchange tickets, and each sends the second copy to the office, retaining the third. From this point the oil is pumped through buried pipe lines of from four to eight inches in diameter to either temporary or final storage. This latter depends upon the magnitude of the company's operations and the distance of the company's refinery from the oil fields. In the case of the larger companies, the refineries of many of which are situated several hundred miles from the point of origin of the oil, large tank farms are maintained close to the oil field. These field tank farms usually contain

either 37,500-barrel or 55,000-barrel steel tanks, spaced on an average of about twenty-five tanks to one hundred and sixty acres of land. A 55,000-barrel steel tank costs, at the present time, between $20,000 and $25,000. The lines which bring the oil to either temporary storage or to the main trunk lines are called gathering lines. At intervals along both the gathering and trunk lines are booster stations where pressure is put into the lines to carry the oil along. It is often necessary to heat oil in order to make it flow; this heating is also done at the booster stations. From the field tank farms the oil is pumped to the refinery tank farm, where it is again put into storage tanks. It must be remembered that a pipe-line company doing an interstate business is subject to regulation by the interstate commerce commission, coming as it does under the heading of common carrier.

As relatively little crude oil is now moved by tank wagon or tank car, this means of transportation will not be discussed. Another method of transporting oil—by tank steamer—is of considerable importance, especially to the larger companies. However, this method is employed more for the transportation of fuel oil and kerosene than for crude oil. A tank steamer carrying 400 tons of oil tows a barge carrying 6,000 tons of oil. Since the accounting features in this respect fall more within the province of an article dealing with shipping accounts, accounting for the transportation of crude oil will be confined to that done by pipe line.

When the gauge ticket reaches the accounting department the measurements made by the gaugers in feet and inches are converted by means of "tank tables" to their equivalents in barrels (of 42 gallons each). The tank tables are made up, one for each individual tank, by a man who makes a profession of "strapping" tanks—that is, of measuring tanks and compiling tables of the equivalent in barrels to various measurements, graduated to fractions of an inch. Lately there have been published in California two volumes on "tank strapping," but it is unlikely that they will have the effect of causing companies to compile their own tank tables, since the position of the "strapper" is somewhat analogous to that of the professional accountant—an independent and disinterested party.

The barrels shown by the gauge ticket are passed through the crude-purchase journal, charge being made at the agreed purchase

price to crude oil in storage, with corresponding credit (through the refinery department) to the producer for 97 per cent. of the measurement, the remaining 3 per cent. being credited to reserve for bottom settlings and water. From this journal the crude-purchase ledger is posted, and at intervals, usually of fifteen days, statements are sent the interested parties. These parties, in the case of a single purchase, usually number two, the fee owner for the royalty and the lessor for the balance. Where the lease is divided into a number of interests or the royalty has descended to heirs, or for other reasons, the parties may number sixty or seventy, sometimes more. Great care must be exercised that the cheques in payment for oil, usually mailed monthly, are made out in accordance with the latest division order. To the reserve for bottom settlings and water is charged the sediment and water removed from the oil, any amount over or under the 3 per cent. allowance being a charge or a credit against income, as the case may be. Quantities are accounted for separately, the pipe-line department being charged in barrels with the full 100 per cent. of oil purchased. A reserve account is set up for the 3 per cent. bottom settlings and water allowance, and in order that the quantities ledger may be self-balancing, an account crude-purchasing department is credited with the remaining 97 per cent. Accounts are kept with each of the units of organization. For example, accounts somewhat as follows might be used:

No. 1. Gathering line.

No. 2. Field tank farm.

No. 3. Trunk line.

No. 4. Refinery tank farm.

No. 5. Oil delivered to the refinery.

Naturally the subdivisions will vary with each company. Each of the various units is charged with oil received and credited with its deliveries and losses. The final account, of course, is oil delivered to the refinery. The information from which these records are made up is obtained from daily operation reports rendered by the units. These reports, when used together, tell a complete story of the day's operations with respect to crude oil, and any material discrepancies are immediately detected. It must be remembered, however, that loss factors, such as evaporation, line losses from seepage, line breaks, etc., and fire losses

must be taken into account carefully, if accurate results are to be obtained. In the case of line breaks the loss can be closely approximated when pressure, viscosity* of the oil and the size of the line are all known. Losses arising from seepage and evaporation are more difficult to estimate, but experience usually shows the percentage to be more or less constant. It should be kept in mind that both the gathering and the trunk lines are usually full of oil. This must be considered in taking physical inventory, and it is also well to remember that all oil in the lines may not be the property of the company, since most pipe-line companies do more or less business as common carriers.

The problem of storing crude petroleum has received increased attention during the past few years, and improvements in methods promise to save the industry many millions of dollars heretofore lost through evaporation and seepage. It formerly was a general practice to run oil into earthen storage, in the shape of large pits. Sometimes these pits were concrete lined and were roofed, but oftener not. Not only is most of the present-day storage done in steel tanks, but the effect of variously colored tanks and the methods of putting the oil in are being studied. It has been found that oil stored in white tanks shows a smaller percentage of loss than in tanks painted black. Steel-roofed storage tanks usually show a loss of contents of from ½ per cent. to 3 per cent. a year in volume. In one case it is claimed that Cushing, Oklahoma, crude oil, which had been in storage for nearly two and one-half years, showed a change of from 40° to 38° Baumé, a lowering in gravity of only 2°. This loss is unusually small, but losses will vary with the original gravity of the oil and the type of storage. Both line and storage losses are ordinarily higher where casing-head gasoline has been run in with the oil, as it frequently is. It is to be noted that the lighter and most valuable elements evaporate first. In a test recently made, oil with a Baumé gravity of 42° lost 4.5 per cent. in volume when the gravity fell to 40°; an additional decline of 2° brought the volume loss to 11 per cent., and when the gravity was finally allowed to weather to 37° the loss in volume was 14.5 per cent. This practically amounts to a loss of 14½ per cent. of the volume in naphtha, gasoline and kerosene. The enormity of the loss is easily seen.

*Viscosity of oil refers to its resistance to flow; the Saybolt viscosimeter is in general use in the United States.

### Refining

The refining of petroleum is quite simple in theory; in practice it is one of the most complex processes, or series of processes, conceivable. From the viewpoint of an accountant this is especially true. The single raw product, crude petroleum, is split up into a number of finished products, each of which has a value and commands a market of its own. The following is a fair sample of recoveries in the mid-continent field:

| | Degrees Baumé gravity | Recovery percentage |
|---|---|---|
| Gasoline | 65.7 | 28.00 |
| Naphtha | 48.2 | 18.00 |
| Kerosene | 40.1 | 15.00 |
| Gas oil | 34.6 | 15.00 |
| Viscous neutral oil | 28.0 | 10.00 |
| Steam refined cylinder stock | 24.0 | 6.00 |
| Refined paraffin wax | ..... | 0.50 |
| Asphalt | .... | 3.50 |
| Loss in refining | .... | 4.00 |
| | | 100.00 |

In order that some idea of refinery procedure may be given, it has been thought advisable to prepare a chart of a small refinery; see figure I (page 267). Such a chart is practically indispensable when an accounting system is under consideration; and a few days spent at the refinery will nearly always prove to be time well spent.

As shown in figure I the crude petroleum is pumped into the fire still where it is subjected to a temperature ranging from about 200° F. to 325° F. Crude naphtha is the first condensate over, and at this point a separation often is made between crude naphtha and crude heavy naphtha, the condensate distilling over at temperatures between 326° F. and 475° F. sometimes being set aside separately. However, in the plant shown in figure I this distinction is not made.

The crude naphtha is next transferreed into an agitator, where it is agitated by air with sulphuric acid. After allowing the acid-tar to settle, the sludge acid is run off. The product is then washed by spraying water from the top of the agitator. After draining off the water, the crude naphtha is again agitated, this time with caustic soda, and the washing process is repeated. The treatment

of products with sulphuric acid and caustic soda removes the offensive odor and dark color which are inherent in some petroleum derivatives.

From the agitator the crude naphtha is pumped into a steam-still for fractionation. Here the product is cut to gasolines and deodorized naphtha, the various grades of each differing according to the practice of the refiner. In our illustration but one grade of each is produced, the residuum from the steam-still being treated as a wax distillate.

Returning to the first receiving-house it will be found that kerosene distillate is the condensate following crude naphtha. After treatment in an agitator the product is transferred to bleacher tanks where it is allowed to settle for from twelve to twenty-four hours. The resultant product is commercial kerosene.

The next two products over are solar oil and gas oil. There is very little difference between the two, and they are quite often treated as one cut. A good deal of solar oil is exported to Great Britain. The principal use for both solar and gas oil is the production of artificial gas therefrom.

From figure I it will be noted that the residuum from the fire still is pumped into the tar still. Here the wax distillate is produced by "cracking." This product, together with that received from the steam-still, is reduced to a temperature of from 15° to 20° F. by means of refrigeration, and it is then pumped through a high-pressure hydraulic filter-press. The wax, about 20 per cent of the original product, is thus separated from the pressed distillate. From this point the slack wax is transferred to sweat pans, where any remaining oil is sweated out. This oil is pumped in with the pressed distillate, while the wax is filtered through fuller's earth in order to decolorize it. The wax is then ready for barreling for market.

The pressed distillate is pumped into a reducing still where the gas oil is removed and the desired lubricant stocks are produced. As cracking is to be avoided in the production of lubricants, steam is introduced into the still, thus making possible the separation of the products at much lower temperatures than otherwise would be necessary. The various grades of lubricants are then filtered through fuller's earth in order to remove impurities. The practice with lubricating oils varies, some refiners treating the products with sulphuric acid before marketing them.

## Refinery Cost Finding

In finding refining costs it must be kept in mind that uniform methods are to be desired more than minute exactness. Although any new factors of a permanent character which may come up from time to time must be given careful consideration, unusual factors resulting from extraordinary conditions should not be permitted to affect costs.

There are numbers of cost-accounting systems in use in the industry, but it is believed that those systems which employ the principles outlined in the method which follows will recommend themselves, not only by reason of their theoretical accuracy, but by their simplicity as well.

In every instance an operating ledger should be maintained, which details the expenses of each process of refining. Account of quantities is carefully kept, just as in the case of the transfer of the crude oil from the field to the refinery tank farm. At the outset it may be stated that the extraction from crude oil of its most valuable element, gasoline, indicates that there should be used, as a factor in pro-rating to gasoline its proportion of the cost of the crude oil, the market value of the gasoline. In like manner the values of the other products recovered from the oil may be considered as directly affecting the cost of the portion of the oil entering into their manufacture. In the case of applying to the various products the cost of processing, however, it would seem, at first thought, that the values of the products treated would have nothing whatever to do with the allocation of such cost. But unless these values are taken into consideration, together with the quantities of each product treated, the resultant costs, in some cases, will exceed the market value of the product.

The result will be that a few of the products, for example, the lubricants, will show a loss at all times. (If the expense in any process really exceeded the proceeds of the product, it would be cheaper to throw the stuff away. The truth is that each process assists in furthering a number of products each of which must bear the proper share.) It also would be found necessary to reduce the inventories of these products to market for balance-sheet purposes. For these reasons values are considered to be factors in the allocation of both the cost of the crude oil and the cost of processing the products. There has been some contention lately that changes in the market price of both crude oil in storage

and finished products should be taken into account, in the first instance in finding costs and, in the case of finished products, in determining final net income. It is proposed—and in a number of instances it is being done—to carry the inventory of crude oil at market at all times, crediting increases in value to reserve for increased value of crude oil in storage and taking credit for the profit as disposition is made of the final products. The inventories of finished products are to be treated in a similar manner.

So long as profits are not anticipated there is no objection to the practice, but the case of the refiner is not analogous to that of the oil producer. The latter may, and usually does, credit income at the posted market price for oil produced, irrespective of whether or not the oil has been sold. The practice is well established. The producer has taken something from nature which may have cost him a relatively negligible amount, and the market for his product has always been so ready that the product is well considered as almost an equivalent to cash. The refiner, on the other hand, in purchasing crude oil has acquired a raw product which is not held for resale in its original form. An advance in the crude-oil market does not necessarily signify a corresponding increase in the value of the finished products expected to be produced therefrom. Since to take up such a change is clearly to anticipate a profit which may never materialize, one must apply the rule of cost or market, whichever is the lower.

As indicated above, the cost of the crude oil is allocated to products on the basis of their respective market values times the quantities of each produced. This is better illustrated as follows:

PRODUCED PER BARREL (42 GALLONS) OF CRUDE OIL COSTING $2.00

| | Per cent. of yield | Gallons | Market | Amount | Per cent. to total |
|---|---|---|---|---|---|
| Gasoline | 33.3 | 14 | .20 | $2.80 | 45.57 |
| Naphtha | 21.5 | 9 | .15 | 1.35 | 21.97 |
| Kerosene | 16.6 | 7 | .10 | .70 | 11.39 |
| Gas oil | 16.6 | 7 | .05 | .35 | 5.70 |
| Wax | 4.8 | 2 | .40 | .80 | 13.01 |
| Asphalt | 2.4 | 1 | .05 | .05 | .81 |
| Loss | 4.8 | 2 | .0476 (Crude) | .0952 | 1.55 |
| | 100.0 | 42 | | $6.1452 | 100.00 |

The last column indicates the percentages to be applied to the cost of the crude oil—in this instance, $2.00—in apportioning this cost to the commodities recovered. Cost means cost delivered to the refinery tank farm, the cost of gathering, field storing (when temporary), transporting and treating the oil being cleared to crude oil in storage at the end of each accounting period.

The crude oil should be charged out of storage at a price which will exhaust the opening inventory first.

The clearing accounts, such as boiler-plant expense, power-plant expense, water-supply expense, etc., are pro-rated to departments (field-tank-farm department, pipe-line department, refinery department, etc.) and then to processes, upon a pre-determined basis of service rendered. In the case of the boiler and power plants a combination of demand factors and actual consumption furnishes the best means for making this distribution.

General refinery expenses are first apportioned to the various departments on some equitable basis, such as payroll* chargeable to each. Refinery-tank-farm expense, warehouse expense, barn, garage and auto expense, shop-department expense, laboratory expense, general refinery expense, and refinery-office expense are included under the heading of general refinery expenses, when not directly chargeable to a particular department. The amounts allocated to refinery department are then apportioned to the various processes, again using as a basis for this distribution the payroll charges.

For the purpose of illustrating the use of this system of cost finding, the following set of figures is assumed. One hundred barrels of crude oil (4,200 gallons) costing $2.00 a barrel have been refined, part of the products being in a finished state while others are in process. The expenses, after all accounts have been cleared, are as follows:

| | |
|---|---|
| Fire still | $ 50.00 |
| Agitator I | 15.00 |
| Agitator II | 3.00 |
| Bleacher tank | 3.00 |
| Steam still | 25.00 |
| Tar still | 10.00 |
| Refrigeration | 1.00 |
| Wax press | 1.00 |
| Sweating | 1.00 |

*Another basis for this allocation is in the ratio of the direct expense of each department or process to the total direct expense of all departments or processes.

| | |
|---|---|
| Reducing still | 10.00 |
| Filter I | 1.00 |
| Filter II | 1.00 |
| Filter III | .75 |
| Wax moulding | .25 |
| | $122.00 |

The production figures, together with the allocated cost of the crude petroleum, are as follow:

ALLOCATION OF COST OF CRUDE PETROLEUM

| Production | Per cent. of yield | Gallons | Market price | Value | Per cent. of each to total value | Allocation of cost of crude |
|---|---|---|---|---|---|---|
| FINISHED: | | | | | | |
| Gasoline | 30 | 898 | $0.20 | $179.60 | 35.6 | $ 71.20 |
| Naphtha | 20 | 598 | 0.15 | 89.70 | 17.8 | 35.60 |
| Kerosene | 15 | 449 | 0.10 | 44.90 | 9.0 | 18.00 |
| Solar oil | 10 | 299 | 0.05 | 14.95 | 3.0 | 6.00 |
| Gas oil | 10 | 299 | 0.05 | 14.95 | 3.0 | 6.00 |
| Lubricating oil | 6 | 180 | 0.15 | 27.00 | 5.4 | 10.80 |
| Heavy lubricating oil | 6 | 180 | 0.15 | 27.00 | 5.4 | 10.80 |
| Wax | 3 | 87 | 0.40 | 34.80 | 7.0 | 14.00 |
| | 100 | 2,990 | | $432.90 | | |
| IN PROCESS: | | | | | | |
| Crude naphtha | 50 | 500 | 0.10 | $ 50.00 | 10.0 | 20.00 |
| Solar and gas oil | 20 | 200 | 0.02 | 4.00 | .8 | 1.60 |
| Kerosene distillate | 15 | 150 | 0.03 | 4.50 | .8 | 1.60 |
| Wax and pressed distillate | 12 | 120 | 0.05 | 6.00 | 1.1 | 2.20 |
| Slack and filtered wax | 3 | 30 | 0.20 | 6.00 | 1.1 | 2.20 |
| | 100 | 1,000 | | $ 70.50 | | |
| | ... | 3,990 | | $503.40 | | $200.00 |

Next we have to apportion to the various products the cost of processing each one. This we do by deriving the percentages shown in exhibit "A" (pages 264-5) in the following manner: Eight hundred and ninety-eight gallons of gasoline valued at twenty cents per gallon have been produced. This gallonage has passed successively through the fire still, agitator and the steam still

(see figure I). We therefore multiply this gallonage by the market value of gasoline and get $179.60. This figure we may carry to a supplementary sheet, temporarily, under the captions fire still, agitator I and steam still. In like manner the other finished products are carried out under their respective process headings at their market values. Products in process are treated in a similar manner, the values used being the prices the refiner would be obliged to pay were he to purchase a similar semi-finished product upon the market. Another method of determining these values is to find the value of the finished products which could be made from the particular product in process and then to deduct therefrom the estimated cost of conversion into finished products.

In our hypothetical case it has been assumed that of the 500 gallons of crude naphtha on hand 250 gallons remain in the crude-naphtha tank, while 250 gallons have passeed through agitator I and are now in the steam still. In the latter process the naphtha is taken as averaging one-half of the process, and for this reason it will be inserted on the supplementary sheet as follows:

*Crude naphtha*

| Fire still | Agitator I | Steam still |
|---|---|---|
| 500×.10=$50.00 | 250×.10=$25.00 | 125×.10=$12.50 |

It may be mentioned that a product which is still in a particular process is taken as averaging one-half the process.

After all products, both finished and in process, have been carried into the supplementary sheet the columns are footed and the percentage which each amount in a column is of the total of the column is carried to exhibit "A." These percentages, when applied to the total expense of a process, give the expense to be allocated to each product.

From the results obtained in exhibit "A," the costs shown in exhibit "B" (see page 266) may be derived. This exhibit, of course, can be carried further so as to show the cost of treating a gallon of each product under each process.

### Account Classification

The capital-asset accounts may be subdivided, preferably in a subsidiary plant-investment ledger. Other assets differ in no material respect from those in any other business, and for this reason they need not be listed. The same thing may be said in regard to liability accounts.

Income accounts:
- Sales (subdivide) wholesale
- Sales ( do ) retail
- Tank-car mileage
- Miscellaneous income

Expense accounts:
- Outside purchases (subdivide)
- Outage and leakage, etc., allowances
- Cost of refined products sold—wholesale
- Cost of refined products sold—retail
- Inventories adjustment: crude oil
- Inventories adjustment: products
- Inventories adjustment: other

Production expenses:

*Pipe-line Department*

Gathering lines—
- Tank-gauging labor
- Other labor and superintendence
- Miscellaneous supplies and expense (taxes, insurance, etc.)
- Changing lines: labor, supplies and expense
- Oil shortage
- Injuries and damages
- Depreciation
- Repairs: labor, material and expense

Field tank farm (temporary storage)—
- Tank-gauging labor
- Other labor and superintendence
- Oil shortage
- Depreciation
- Cleaning tanks expense
- Miscellaneous supplies and expense (taxes, insurance, rent, etc.)
- Repairs
- Cleaning and dehydrating expense

Trunk lines—
- Labor and superintendence
- Miscellaneous supplies and expense (taxes, insurance, etc.)
- Changing lines: labor, supplies and expense
- Oil shortage
- Depreciation
- Repairs

Pumping stations—
- Labor and superintendence
- Fuel and water
- Miscellaneous supplies and expense
- Oil shortage
- Depreciation
- Repairs

*Refinery Department*

Clearing accounts—

| | | |
|---|---|---|
| Boiler-plant expense<br>Power-plant expense<br>Water-supply expense<br>Refinery tank farm expense | subdivided as to | Labor and superintendence<br>Fuel, steam and water<br>Depreciation<br>Miscellaneous supplies<br>Repairs<br>Changing lines expense<br>Power<br>Et cetera |

Distillation (fire still, steam still, etc., separately)—
- Labor and superintendence
- Fuel, water and steam
- Depreciation
- Miscellaneous supplies and expense
- Repairs

If thought desirable, distillation expense may be further subdivided as to stills, condensers and receiving houses.

Agitators expense (No. 1, No. 2, etc.)—
- Labor and superintendence
- Chemicals
- Water, steam, etc.
- Depreciation
- Miscellaneous supplies and expense
- Repairs

Bleacher-tanks expense—
- Labor and superintendence
- Miscellaneous supplies and expense
- Depreciation
- Repairs

Wax-plant expense—

| | | |
|---|---|---|
| Refrigeration<br>Pressing wax<br>Sweating wax | subdivided as to | Labor and superintendence<br>Fuel, water and steam<br>Depreciation<br>Miscellaneous supplies and expense<br>Repairs |

Filtering expense (No. 1, No. 2, etc.)—
- Labor and superintendence
- Fuller's earth
- Burning: labor, fuel and expense
- Miscellaneous supplies and expense
- Depreciation
- Repairs

Wax-barrelling or moulding expense—
- Labor and superintendence
- Miscellaneous supplies and expense
- Depreciation
- Repairs

*General Refinery Expenses*

Product-storage expense—
- Labor and superintendence
- Shortage (classify)
- Cleaning tanks
- Depreciation
- Repairs

Marketing and traffic expense—
- Loading racks expense (classify)
- Tank-car rentals
- Tank-car repairs
- General expense (classify)
- Service-stations expense (classify)

General clearing accounts—
- Refinery-office expense (classify)
- Laboratory expense (classify)
- Barn, garage and auto expense (classify)
- Shop-department expense (classify)
- Warehouse expense (classify)
- General refinery expense (classify)

Exhibit A

| FINISHED: | Fire still | Agitator I | Agitator II | Bleacher tank | Steam still | Tar still | Refrigeration | Wax press | Sweating | Reducing still | Filter I | Filter II | Filter III | Wax moulding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gasoline— | | | | | | | | | | | | | | |
| Per cent. treating expense | 35.82% | 61.02% | | | 63.40% | | | | | | | | | |
| Amount treating expense | $17.91 | $ 9.15 | | | $15.85 | | | | | | | | | |
| Naphtha— | | | | | | | | | | | | | | |
| Per cent. treating expense | 17.89% | 30.48% | | | 31.66% | | | | | | | | | |
| Amount treating expense | $ 8.95 | $ 4.57 | | | $ 7.92 | | | | | | | | | |
| Kerosene— | | | | | | | | | | | | | | |
| Per cent. treating expense | 8.95% | | 93.73% | 93.73% | | | | | | | | | | |
| Amount treating expense | $ 4.47 | | $ 2.81 | $ 2.81 | | | | | | | | | | |
| Solar oil— | | | | | | | | | | | | | | |
| Per cent. treating expense | 2.98% | | | | | | | | | | | | | |
| Amount treating expense | $ 1.49 | | | | | | | | | | | | | |
| Gas oil— | | | | | | | | | | | | | | |
| Per cent. treating expense | 2.98% | | | | | | | | | | | | | |
| Amount treating expense | $ 1.49 | | | | | | | | | | | | | |
| Lubricating oil— | | | | | | | | | | | | | | |
| Per cent. treating expense | 5.38% | | | | | 26.79% | 27.05% | 27.05% | | 46.55% | 96.42% | | | |
| Amount treating expense | $ 2.69 | | | | | $ 2.68 | $ .27 | $ .27 | | $ 4.65 | $ .96 | | | |
| Heavy lubricating oil— | | | | | | | | | | | | | | |
| Per cent. treating expense | 5.38% | | | | | 26.79% | 27.05% | 27.05% | | 46.55% | | 96.42% | | |
| Amount treating expense | $ 2.69 | | | | | $ 2.68 | $ .27 | $ .27 | | $ 4.65 | | $ .96 | | |
| Wax— | | | | | | | | | | | | | | |
| Per cent. treating expense | 6.95% | | | | | 34.52% | 34.88% | 34.88% | 85.30% | | | | 85.30% | 100.00% |
| Amount treating expense | $ 3.48 | | | | | $ 3.45 | $ .35 | $ .35 | $ .85 | | | | $ .63 | $ .25 |

Exhibit A—(*Continued*)

| IN PROCESS: | Fire still | Agitator I | Agitator II | Bleacher tank | Steam still | Tar still | Refrigeration | Wax press | Sweating | Reducing still | Filter I | Filter II | Filter III | Wax moulding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crude naphtha— | | | | | | | | | | | | | | |
| Per cent. treating expense | 9.97% | 8.50% | | | *4.41% | | | | | | | | | |
| Amount treating expense | $ 4.98 | $ 1.28 | | | $ 1.10 | | | | | | | | | |
| Solar and gas oil— | | | | | | | | | | | | | | |
| Per cent. treating expense | *.40% | | | | | | | | | | | | | |
| Amount treating expense | $ .20 | | | | | | | | | | | | | |
| Kerosene distillate— | | | | | | | | | | | | | | |
| Per cent. treating expense | .90% | | 6.27% | 6.27% | *.53% | | | | | | | | | |
| Amount treating expense | $ .45 | | $ .19 | $ .19 | $ .13 | | | | | | | | | |
| Pressed and wax distillate— | | | | | | | | | | | | | | |
| Per cent. treating expense | 1.20% | | | | | 5.95% | 5.01% | 5.01% | | 6.90% | *3.58% | *3.58% | | |
| Amount treating expense | $ .60 | | | | | $ .60 | $ .05 | $ .05 | | $ .70 | $ .04 | $ .04 | | |
| Slack and filtered wax— | | | | | | | | | | | | | | |
| Per cent. treating expense | 1.20% | | | | | 5.95% | 6.01% | 6.01% | 14.70% | | | | 14.70% | |
| Amount treating expense | $ .60 | | | | | $ .59 | $ .06 | $ .06 | $ .15 | | | | $ .12 | |
| TOTAL EXPENSE $122.00 | $50.00 | $15.00 | $ 3.00 | $ 3.00 | $25.00 | $10.00 | $ 1.00 | $ 1.00 | $ 1.00 | $10.00 | $ 1.00 | $ 1.00 | $ .75 | $ .25 |

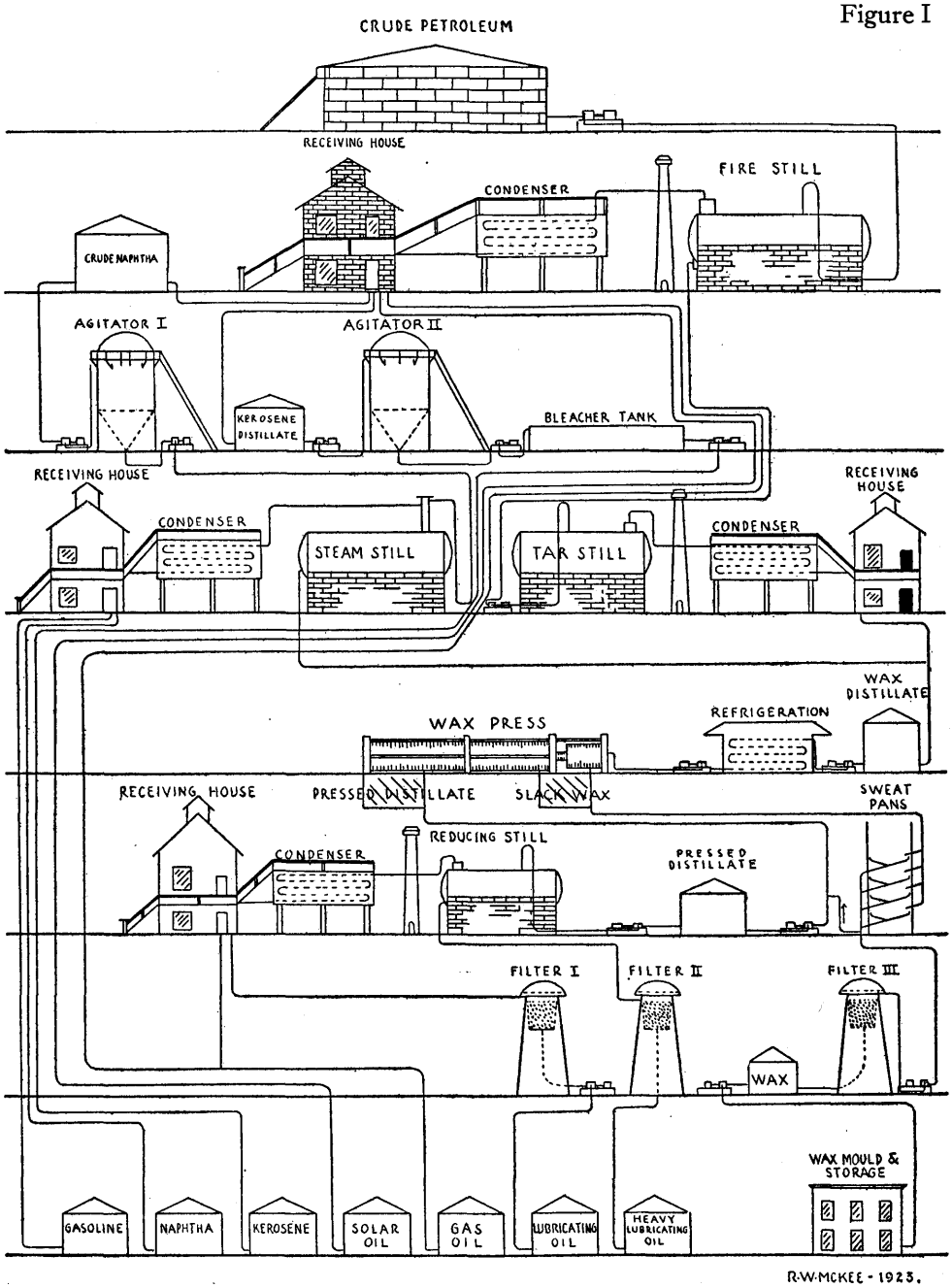
Note: * Product is taken as averaging half of the process.

Exhibit B

COST SHEET

| | Gallons produced | Cost | | Total | Cost per gallon | | |
|---|---|---|---|---|---|---|---|
| | | Crude | Treating | | Crude | Treating | Total |
| FINISHED: | | | | | | | |
| Gasoline | 898 | $ 71.20 | $ 42.91 | $114.11 | .0792 | .0478 | .127 |
| Naphtha | 598 | 35.60 | 21.44 | 57.04 | .0595 | .0358 | .0953 |
| Kerosene | 449 | 18.00 | 10.09 | 28.09 | .0401 | .0224 | .0625 |
| Solar oil | 299 | 6.00 | 1.49 | 7.49 | .0201 | .0049 | .0250 |
| Gas oil | 299 | 6.00 | 1.49 | 7.49 | .0201 | .0049 | .0250 |
| Lubricating oil | 180 | 10.80 | 11.52 | 22.32 | .0600 | .0640 | .1240 |
| Heavy lubricating oil | 180 | 10.80 | 11.52 | 22.32 | .0600 | .0640 | .1240 |
| Wax | 87 | 14.00 | 9.36 | 23.36 | .1610 | .1075 | .2685 |
| IN PROCESS: | | | | | | | |
| Crude naphtha | 500 | 20.00 | 7.36 | 27.36 | .0400 | .0147 | .0547 |
| Solar and gas oil | 200 | 1.60 | .20 | 1.80 | .0080 | .0010 | .0090 |
| Kerosene distillate | 150 | 1.60 | .96 | 2.56 | .0106 | .0064 | .0170 |
| Pressed and wax distillate | 120 | 2.20 | 2.08 | 4.28 | .0183 | .0173 | .0356 |
| Slack and filtered wax | 30 | 2.20 | 1.58 | 3.78 | .0734 | .0526 | .1260 |
| | 3,990 | $200.00 | $122.00 | $322.00 | | | |

Figure I


CRUDE PETROLEUM
RECEIVING HOUSE
CONDENSER
FIRE STILL
CRUDE NAPHTHA
AGITATOR I
AGITATOR II
KEROSENE DISTILLATE
BLEACHER TANK
RECEIVING HOUSE
CONDENSER
STEAM STILL
TAR STILL
CONDENSER
RECEIVING HOUSE
WAX DISTILLATE
WAX PRESS
REFRIGERATION
RECEIVING HOUSE
PRESSED DISTILLATE
SLACK WAX
SWEAT PANS
CONDENSER
REDUCING STILL
PRESSED DISTILLATE
FILTER I
FILTER II
FILTER III
WAX
WAX MOULD & STORAGE
GASOLINE
NAPHTHA
KEROSENE
SOLAR OIL
GAS OIL
LUBRICATING OIL
HEAVY LUBRICATING OIL
R.W.MCKEE - 1923.