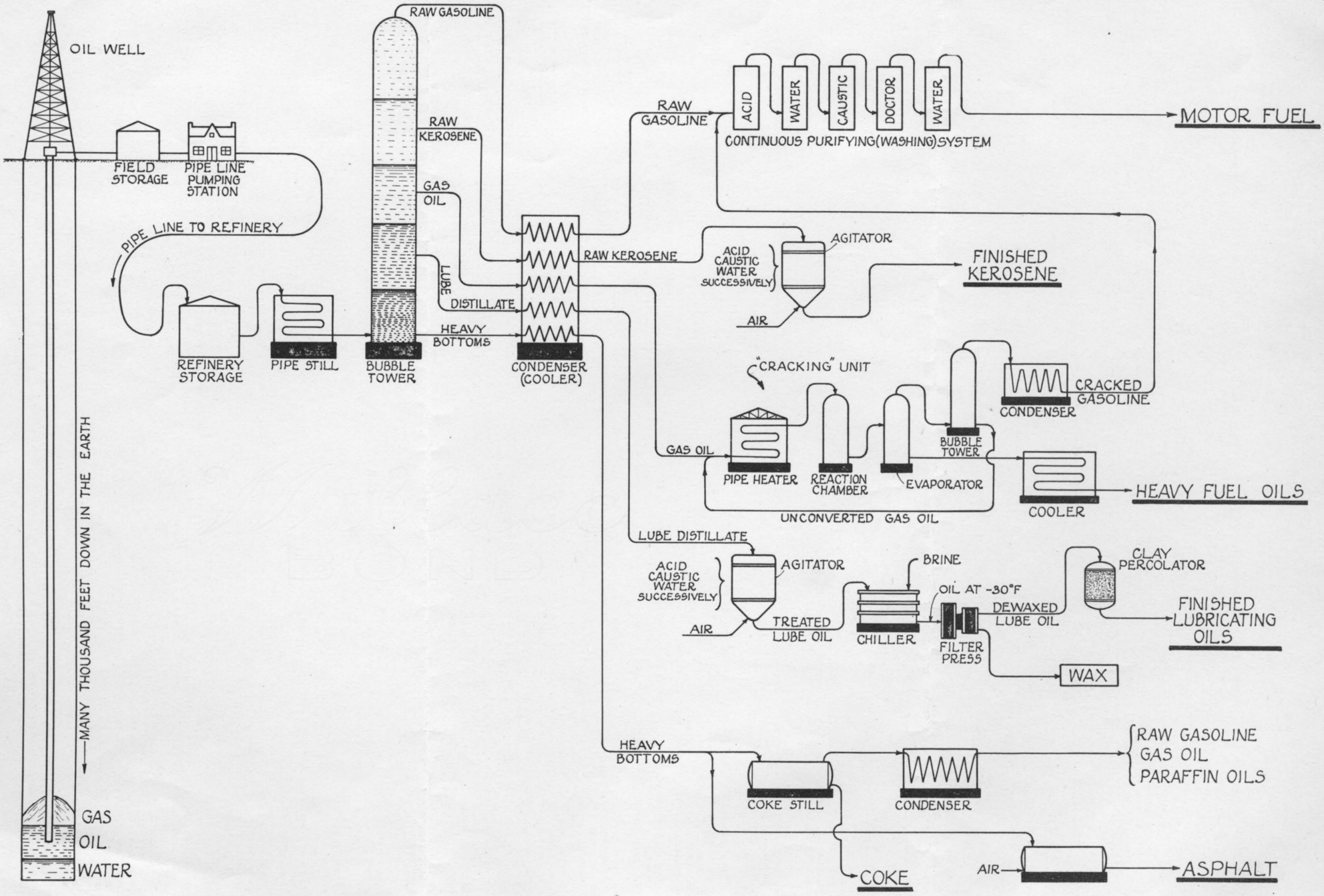
Typical **FLOW CHART** *tracing crude oil from well to finished product*



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GENERAL DESCRIPTION OF THE OIL REFINING PROCESS
as shown by the
AMERICAN PETROLEUM INDUSTRIES EXHIBIT
MODEL PETROLEUM REFINERY

Crude petroleum - a heavy, black, foul-smelling liquid that you would never recognize as the parent of the refined products that enter your every-day life - is found far beneath the earth's surface. From the well it goes by pipe lines to the refinery whence its products go to you via pipe line, tank car, tank trucks and so on. The efficiency of the modern petroleum industry is illustrated by the fact that the total cost of production, transportation and refining of crude oil is only about twenty-five percent of the final cost of the products. The remaining seventy-five percent is divided about equally between taxes and the cost of the complex distribution system which brings the refined products to your door-step.

A modern refinery is an enormous affair. You can get an idea of its size from the tall bubble towers which actually are over 100 feet high. An inch in this model equals about a foot in the actual refining plant. Crude oil is carried by means of pipe lines, tank cars or tank steamers to the refinery. Here it passes through a series of operations, both physical and chemical, through which it is changed into the amazing variety of useful substances which man has learned to make from it. The most important and the most common refinery operation is fractional distillation, - that is, boiling the oil and separating and collecting its different vapors.

The crude oil is pumped from a storage tank 1 through coils in a heater 2 similar in principle to an ordinary hot water heater except that the coils are thousands of feet long. These coils are heated to more than 700° Fahrenheit, a temperature high enough to boil away all but the heaviest parts of the oil, that is, all but the fuel oil or asphalt.

The mixture of vapors from the coils is discharged into the bottom of a high bubble tower 3 and the vapors rise through it while the fuel oil or asphalt settles out and is drawn off. Here the vapors are separated, cooled and collected in trays which are placed at various heights in the tower. The process is illustrated by the animated diagram at the edge of the table before you. The circles represent the oil molecules of the different products. See how the smaller molecules - the lighter oil - tend to rise to the top of the tower while the larger molecules - the heavier oil - remain at the bottom of the tower. The heavy vapors do not rise far before they are cooled and condensed in the lower trays of the tower. The heavy lubricating oils are contained in this fraction. In the trays higher up the gas oil is condensed and collected. Near the top the kerosene is drawn off. The lightest vapor, the gasoline, passes out of the very top of the tower and is condensed in coils immersed in cool water.

After the crude oil has been fractionally distilled through the bubble tower the five separated fractions are stored. For the time being we will put the fuel oil or asphalt in tank No. 31, the lubricating oil in tank No. 23, the gas oil in tank No. 16, the kerosene in tank No. 13 and gasoline in tank No. 4.

This fractional distillation was a purely physical separation that involved no chemical change. The oil was literally taken apart and each part put away for further handling. Each of these parts, however, contains materials which must be removed before they can become the finished products of commerce. This is done largely by chemical processes.

Let us now see what further treatment the five products we have must go through. First, the raw gasoline must be purified to make it the fine, high-grade fuel that your filling station puts into the tank of your car.

From tank 4 the gasoline is run into a continuous gasoline treating plant, through towers 5 to 11 to the right. The process is called continuous treating because it is an almost automatic operation by which the gasoline is run through all the towers in succession without stopping. The object of this process is to remove those gum-forming substances and corrosive sulphur compounds from the raw gasoline which would damage your car if they were left in. The raw fuel is pumped into the bottom of the first tower to the left 5 and forced from the bottom to the top of each tower in succession. As it flows upwards through each tower it encounters a chemical treating agent. The first of these is weak sulphuric acid, in tower 5, the next strong sulphuric acid in tower 6. Then it is washed with water in tower 7, treated with caustic soda in tower 8, and next, in tower 9, treated with what we call a "doctor solution" made from litharge and caustic soda. Then it is allowed to settle in tower 10, Finally the gasoline is washed with water in tower 11 to remove any of the chemical treating agents which may have been left in it. When the raw gasoline has passed through all these towers it is run into tank No. 12 for storage. It is now free of all harmful material, its odor is improved and its color is water-white. Now it has become fit to use in your car.

To the right of the gasoline treating plant is a kerosene treating plant in which kerosene is refined and made ready to use in lamps, stoves, tractors or any of the numberless uses of this oil. The raw kerosene is taken from storage tank 13, but instead of being pumped into a series of towers it is pumped into the cone-bottomed tank or agitator 14. It too goes through a series of strange baths. Here acid and other chemical treating agents are added and mixed with the kerosene by blowing air into it. After a while the air is cut off, the mixture is allowed to settle, and the treating agent is drawn off at the bottom. In this manner the kerosene is successively treated with acid, washed, treated with caustic soda and washed again, after which it is ready for use and stored in tank 15.

And now we come to the well-known "cracking" process. This is one of the most important developments in the oil industry. It doubled the amount of gasoline that could be produced from crude oil, improved its quality and made possible many important improvements and economies in automobile design and operation. Were it not for cracking, all the crude oil produced would not yield enough gasoline to satisfy the present demand.

Remember the gas oil that was stored in tank 16? Gas oil is mainly used for making more gasoline, and for this purpose it is put through the cracking process. In the process, as its expressive name indicates, the fundamental chemical structure of the oil is completely changed. The oil is taken apart - so to speak - and when it is put together again, it is no longer gas oil, but two other products, mainly gasoline and some heavy oil. The cracking plant, where this process takes place, as you see, looks very much like the distillation plant. But there is this difference. The distillation plant separated the crude oil into five products without chemical change. The cracking process, however, involves a chemical change, and is brought about by heating the oil at high temperatures under pressure. Let us follow this operation.

The entire cracking process is illustrated by the animated diagram which you see at the edge of the table before you. The various size circles represent molecules of gasoline, gas oil and heavy fuel oil. See how the molecules in the heater and reaction chamber are breaking up, dividing and recombining to form new products.

In the cracking plant the gas oil cannot be converted completely to gasoline by one passage through the system. It must be circulated several times before it is completely converted. For this reason the fresh gas oil is not pumped directly to the heater but is pumped into the bottom of the tall bubble tower 21 at the right. Here it mixes with gas oil which has already gone through the cracking process before. The mixture is then pumped out of the bottom of the tower into the heater 17, at the left.

This heater looks like the heater in the distillation unit, but is much hotter, and in it the oil is heated to as much as 1000 degrees Fahrenheit, while under pressures of as much as 1000 lbs. per square inch. To give more time for the changes to take place the oil vapors are passed without cooling from the heater into an empty drum or reaction chamber 18 in which the process continues. From this reaction drum the oil and vapors go into an evaporator or separating tower 19 where the heavy tar separates out and is removed. The tar is stored in a tank 20 while the gasoline vapors pass through the bubble tower 21 where the gasoline which has been formed is separated from the gas oil that has not been completely converted. The unconverted gas oil is separated from gasoline by cooling coils inside the tower near the top. The gas oil, after mixing with the fresh gas oil, is pumped out of the bottom of the tower. The gasoline vapors pass out the top of the tower and down to the cooler 7.

From the gas oil we have thus produced a quantity of raw gasoline in addition to the raw gasoline which we secured from the distillation of the crude oil. This raw cracked gasoline goes to the storage tank 4 where it is mixed with the raw gasoline produced by distillation and, as we have previously seen, is now ready for refining.

Next we come to the refining of lubricating oils. The raw lubricating oil in storage tank 23 is now run into an agitator 24 (not quite like the agitator in a washing machine, but it mixes things up about the same way) where, like kerosene, it is treated with acid and other chemical reagents. Here also the oil and chemicals are mixed by blowing air into the cone bottom of the agitator after which the treating agents are allowed to settle and are drawn off. After another final washing the oil is cleaned from sludge and asphalt and is drawn off for storage in tank No. 25.

This treated oil, however, still contains something that wouldn't do your car and your temper any good on a cold morning if we didn't remove it. That something is wax which is held in solution so long as the oil is warm, but which hardens at low temperatures. The principle of extracting this wax is the simple fact that wax becomes solid at a low temperature while the oil remains liquid. The oil is pumped through a cooler 26, entering at the top left and flowing back and forth, leaving the cooler at the bottom. The inner oil pipes are surrounded by outer pipes through which brine at a temperature of 40 degrees below zero Fahrenheit is circulated. Thus the oil is cooled far below freezing temperature and practically all the wax is removed. To prevent the wax from settling in the pipes and stopping the flow of oil the inner pipes are provided with screw type scrapers which push the wax along as it is deposited and keep it moving.

This cold mixture of wax and oil is then pumped into filter presses to the right 27 to separate the oil from the wax. The oil passes through the filter cloths while the wax is held behind on the cloths in the press. When the press is full of wax the filtration is stopped and the wax is removed. The partly open press shows the internal construction and how wax accumulates inside. The oil passes out to tank 28 and the wax is stored separately in tank 29. This wax is the source of the paraffin the housewife has in her kitchen.

The oil is now free from wax and is finished except that its color is not satisfactory and it is not clear. To clarify the oil and improve its color it is pumped into the top of a percolator 30 where it trickles slowly down through a large bed of fine clay. The oil comes out clear, of bright color and ready to use.

And now to turn to our fifth basic product. What happens to the fuel oil or asphalt in tank 31? This may be used as it is for industrial fuel oil, although it is too thick and heavy to be suitable for household heating. To make it suitable for the construction of roads and roofs and many other uses, it may be run through an asphalt still 32. This still is fired from beneath, and during the heating process air is blown into the oil, oxidizing it and changing its properties so that it becomes asphalt. Besides, asphalt some lighter oils are formed during this process.

Some of this heavy oil that is not required for fuel oil or asphalt is converted into the petroleum coke you use in your furnace. It is run into a coking still 33 which is similar to the asphalt still except that it has no air pipes and is heated to a much higher temperature so that the heavy ends are finally boiled off or converted into petroleum coke. Lighter oils are also formed and these, together with the like oils from the asphalt still are pumped into the condenser box 34 after which they are usually cracked and converted into gasoline.

After the process in the coke still 33 is complete and the still is partly cooled, it is opened and workmen go in with bars and shovels and remove the coke in lumps. You see this operation in the model before you. After the coke is crushed and sized it is ready for use as household or industrial fuel.

We have now shown you how the major products of petroleum are separated and refined. Here it is possible to show you only the basic processes. Actually the refinery produces many grades of these products and also tens and hundreds of entirely different products. Each one of these presents its special refining problems. To solve them is thework of petroleum chemistry, which was once regarded as simple but today has become one of the most complex branches of applied chemistry.