Not Just Oil*

By A. B. Cox.

THE march of civilisation can be marked, to some degree, by the extent to which man since prehistoric times has been able to provide himself with better light and better heat to protect himself from those two great enemies, darkness and cold, so that he had time and a more or less comfortable place for the pursuit of other matters.

Progress down through the ages from the resinous torch and crude earthen lamps filled with animal fat used by the ancients to metal lamps using fish oil and vegetable oils, and from these to tallow candles, has run parallel with the advance of civilisation until the middle of the nineteenth century, when one of the products of petroleum, kerosine, and the development of the kerosine lamp spelled the end of the days of the whale oil industry.

Kerosine is spelled with an " i " because the ending " ine " rather than " ene " is preferred, as the latter is the generic term used by chemists to define hydrocarbon compounds, e.g. ethylene, benzene, naphthalene, and so forth.

The most sought after and the most widely used of all petroleum products during the latter part of the nineteenth century was kerosine, and this presented to the early refiner the problem of getting the maximum kerosine yield from the crude. It was also necessary to improve more extensively the quality of the product which, in a burning oil, means increased light intensity, and prevention of smoking and absence of odour.

Kerosine, having replaced the oil produced from coal used in the " coal oil lamp ", became the greatest incentive to the production of petroleum. Within one or two years after the drilling of Drake's Well, Europe was eagerly seeking to purchase, not only the crude, but the refined products of petroleum. During the next few years kerosine oil from the American refineries on the eastern seaboard of the United States of America found its way, first in wooden barrels, then in tins and drums, to all the near and remote places of the earth. It became known to the Eskimo, the coolie and the desert tribes of Arabia, bringing to them light and heat, with all that they signify of social development.

Burning oils are obtained next in the refining of crude petroleum after the gasolines and naphthas. The cut from the crude known as " kerosine distillate " has a distillation range of between 300° F. and 550° F., and represents, with modern refinery methods, approximately 2% of the yield from crude oil, as compared with 24% in 1899, representing a decline in the demand for kerosine during these three decades. After refining, it is treated with chemicals and various other treating methods, including steam stilling, to remove the sulphur compounds that would cause objectionable odour and smoking when used in lamps, stoves or brooders.

The lives of millions of chickens are dependent upon the reliability of the burning quality of kerosine.

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A great many of the lighthouse beacons use kerosine in the lamps that warn mariners of shoals and reefs, and it can, therefore, be readily understood why, in spite of the small quantity they produce, the refineries must continue their unremitting efforts to improve the burning qualities and make it a safe and reliable product for the various purposes for which it is used.

Unlike gasoline, kerosine does not, at ordinary temperatures, ignite from a spark, and will not burn in an open dish without some substance in the form of a wick, and it is therefore not classed by the petroleum industry as in inflammable liquid.

The inventive genius of mankind that designed and developed machinery to make his work easier, to provide instruments of war and machinery of peace, has

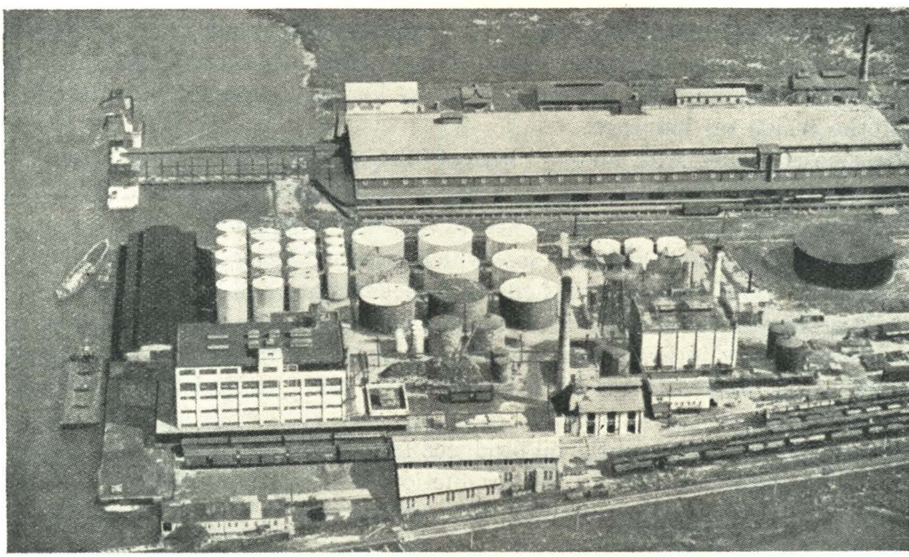

FIG. 1.
Portion of the Texas Company's Norfolk Terminal, located on the Elizabeth River, Norfolk, Virginia, showing lubricating oil tanks and blending and filling plant.

always been handicapped by friction, that destroyer of power and materials. The noise of the chariots of the Egyptians was stilled by a handful of fat left over from the feast, and so, lubrication was employed to combat and overcome the destructive forces of friction.

The advent of the steam engine and the machinery which it operated made ever-increasing demands upon the then known products for lubrication of moving parts. Before the advent of petroleum, lubricants consisted chiefly of whale oil, fish oil, animal and vegetable oils, and the demand threatened to exceed the supply. When it was found that from refining of crude petroleum a liquid substance could be obtained that would spread a protective film over moving parts and overcome, to an extent, friction, the world entered upon what might be termed the beginning of its machine age.

The operation of practically every mechanical device is today dependent upon suitable petroleum lubricants, and the fact that petroleum is the least expensive and the most easily adaptable source of lubricant available makes it one of the most important products in modern civilisation.

How many people realise what an important part that thin film between the metals of bearings means in our everyday life? Every device that involves motion, from the lowly sewing machine, the high-speed spindles of the woollen mills, to the hot and ponderous rollers of the steel mill, would stop if that film were destroyed.

Each of the many varying uses imposes its own conditions of heat, speed and pressure. To meet these conditions scientific research and the refiner's skill are constantly employed to produce an ever-increasing range of lubricants, all of which must come from the one raw material, crude petroleum.

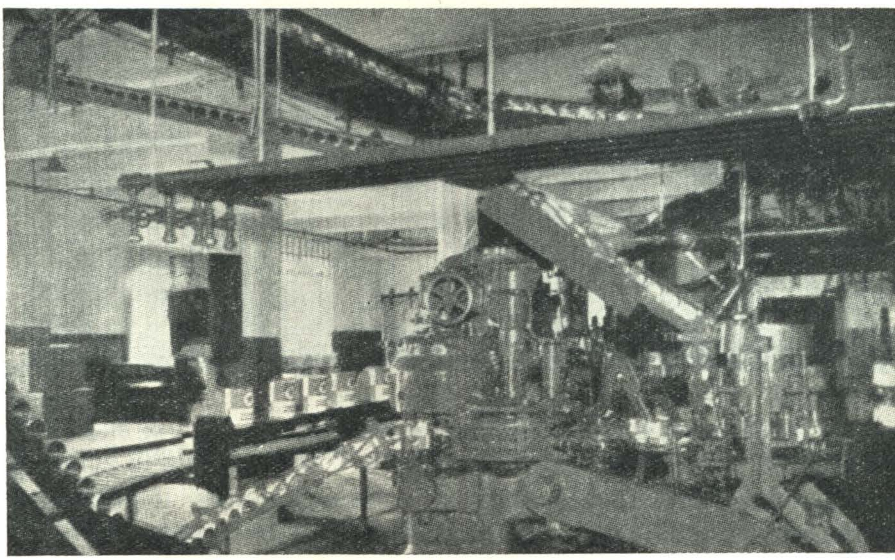

Fig. 2.
Automatic filling machine, with capacity for filling and sealing over 3,000 cans per hour of Texaco Motor Oil.

Lubricants derived from crude petroleum fall normally into two classes, the distillates and the residuums. The distillates, as their name implies, are the fractions or cuts of the crude boiled off in the stills at higher temperatures, following kerosines or burning oils. These distillates are converted to vapour in the still, condensed and segregated into grades having varying viscosities or " body ". The residue left in the still when the process of distillation is completed is called " residuum ", and this product, by filtering or compounding with animal oils, becomes heavy-bodied, dark-coloured oil, suitable for lubrication of steam cylinders and heavy duty bearings or where a heavy viscous liquid is required.

As previously stated, no two grades of crude oil are alike. It is possible, however, to give them certain general classifications, such as " paraffine base " and " asphalt base ", and where a crude contains both paraffine and asphalt, it is known as a " mixed base ".

The treatment of lubricating oils after they leave the stills and have been condensed from vapour and cooled is designed to free them from any impurities, improve their colour, increase their resistance to oxidation and temperature changes, and render them suitable for the varying commercial uses.

The processes for making lubricating oils vary widely, and depend largely upon the character of the crude. Some crude oils are not suitable for manufacturing lubricating oils, others contain a high percentage of wax that has to be separated from the lubricating oil, and this calls for laborious processes of distillation, chilling, pressing and filtering.

Fig. 3.
Automatic machine for filling and capping four-gallon tins of gasoline at the rate of 2,500 per hour. This machine was invented by an employee of the Texas Company.

With a paraffine or mixed base crude it is necessary to remove the wax, otherwise it would congeal at ordinary temperatures and lose the greater part of its lubricating value. This is accomplished by chilling of the oil, after which it is pumped through a filter press consisting of many circular pieces of very heavy canvas set vertically between perforated steel plates. The alternate layers of canvas and steel plates are held together by a heavy screw or hydraulic press and the oil is pumped through the press horizontally. As the oil passes through the canvas the wax is caught and held. The press is then opened, the plates separated, allowing the wax to fall into a trough, from which it is carried away by a screw conveyor for further treatment. The pressed or dewaxed oil is again distilled and it is possible, by this second distillation, to obtain by further fractionation oils of different viscosities. These, when treated in various ways, become light bodied lubricating oils used in delicate and high-speed machinery, automobile oils, compressor oils and engine oils of various types.

The dewaxing of heavy cylinder stocks is sometimes carried out by running it through certrifuge machines, which throw out the wax by centrifugal force, thus lowering its cold test to a point where it can be used at ordinary temperatures.

Scientific research work during the first years of the twentieth century, when naphthenic or asphalt base crudes were first discovered, developed the fact that lubricating distillates of varying characteristics could be distilled off these crudes and, after treatment, would produce a high grade lubricating oil, and coming from an asphalt base crude, it was free from wax and could be more easily treated. It was also free of carbon residue, and could be filtered to a pale golden colour, making it highly suitable for lubrication of the automobile engine.

Prior to this time the oils used for automobile lubrication were made from the light viscosity distillates and heavy viscosity residuums of paraffine base crudes blended to the required viscosity or body.

The use of naphthenic distillate oils tended to decrease formation of carbon through their resistance to emulsion, their low cold test and their low wax and carbon content. Their advent was one of the important milestones in the development of automotive lubrication.

Due to the nature of the naphthenic base lubricating distillates, they do not require dewaxing, and they are pumped direct to agitators, where they are treated with sulphuric acid, neutralised with caustic soda washed with water, filtered, and pumped to storage.

Through its characteristic of absorbing into its microscopic pores the practically invisible particles that darken the colour of lubricating oils, fuller's earth, or what is more commonly called " clay ", is used to remove that colour by filtering. Fuller's earth is a soft earthy material much like clay, but not plastic, occurring in nature as an impure hydrous aluminium silicate. Large deposits of this material are found in Florida, Texas, and other areas. This process of removing the colour by filtering is accomplished by percolating the oil through a bed of fuller's earth placed in the bottom of a suspended vertical tank, repeating the process until the desired colour is obtained. Some refiners use the anti-gravity method, forcing the oil up through the bed of earth. In another method the oil is cut back or mixed with naphtha, pumped through a contact drum, where it comes in contact with clay finely ground to keep it in suspension, after which the clay is screened or settled out and the oil re-distilled to remove the naphtha. The used or spent clay, which is nearly black, is recovered and roasted in large revolving kilns. This restores it to its natural colour, after which it can be re-used with but slightly lowered efficiency.

Another phase of the refining of petroleum products is the manufacture of paraffine wax, one of the most interesting, as well as the most complex processes of petroleum refining. Its operations range from high temperature distillation to low temperature refrigeration, and while usually considered a part of the manufacture of lubricating oils, if it were a separate industry it would be highly rated and its commercial value better understood.

Wax is not always present in a state which will permit of its removal by the ordinary method of chilling and cold pressing. This is particularly true in the lower wax distillate cuts where the so-called " amorphous wax " occurs. Any attempt to press this material simply results in its going through the filter pad with the oil. It is usually rendered crystalline or pressable, however, by the process of dry distillation. The wax from this process, a partly refined wax called " slack wax ", is conveyed to dump tanks, where it is melted through contact with steam coils, and then pumped to storage. This wax generally contains from 30% to 60% of commercial wax, the remainder being oil and poor quality wax which could not be removed by the cold pressing operation. The removal of these products is accomplished by subjecting the slack wax to a process known as " sweating ", in which the separation of the oil and low melting point wax from crystalline paraffine wax is accomplished, and is based largely on the latent heat of fusion or the progressively higher melting points of the various substances making up the slack wax.

A wax sweating unit consists of a series of pans arranged vertically in a sweat-house or oven. The pans are from eight to ten feet in width, and from twenty to sixty feet in length. Each pan has a substantially supported screen placed near the bottom and a series of coils in fixed position slightly above the screen, the coils being used for continuous water circulation. Steam coils are ranged along the sides or

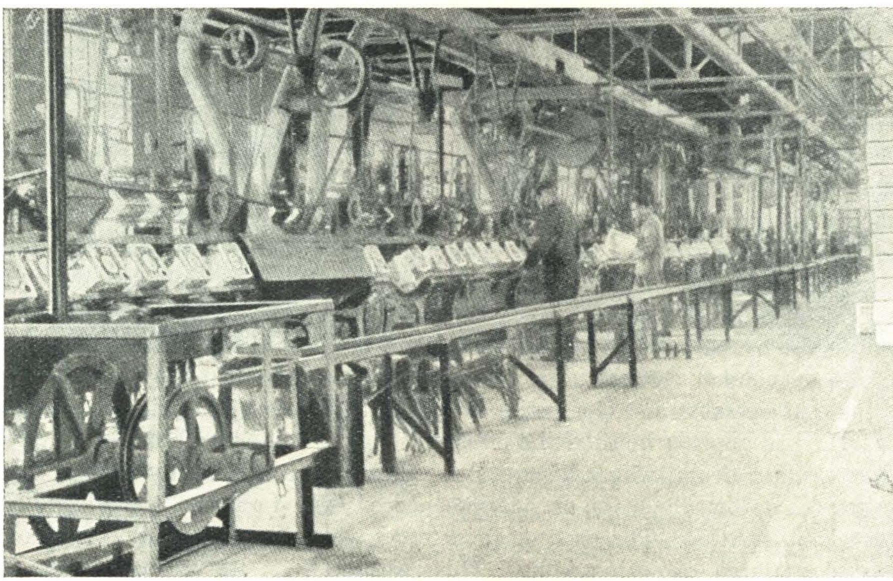

FIG. 4.
View of the automatic four-gallon can soldering machine at the Texas Company's can manufacturing plant, Port Arthur, Texas. Nine operations are involved in soldering the seams of the cans, including the application of the molten solder and wiping of the seam to remove any excess, the entire process being automatic.

floor of the room to provide the necessary room heat. After pumping the slack wax into the sweating pans, a sufficient amount of water to float the mass above the screen is introduced. This mixture is then cooled to a solid cake by circulation of cold water through the coils. The water supporting the cake is withdrawn, leaving the wax resting on the screen. The room is then closed and the temperature of the room and the water in the coils gradually raised. The gradual increase of heat tends to separate out the oil and low melting point wax, with the result that as the heat is increased the wax cake in the pans becomes more and more free of oil until the desired separation is effected. The wax left in the pans, called crude scale wax, has a melting point of about 122° F. to 126° F. and oil content of about $\frac{1}{2}\%$ to 1%.

This crude scale wax is then melted out of the pans and prepared for commercial use by chemical treatment and filtering through fuller's earth at temperatures well above its melting point, after which it is cooled, moulded into cakes and prepared for distribution, entering our daily lives in polishes, protection to foods, pharmaceutical and hundreds of other uses.

Some years ago research chemists and engineers discovered that greatly improved lubricating oils in distillate form could be obtained by carrying out the process of distillation under vacuum. By creation of partial vacuum in the still, the boiling point of the crude or charging stock is reduced, thus allowing the process to be carried out at lower temperatures, effecting a saving in fuel, in the cooling capacity of the condensers, and better yields. To accomplish this on plant scale, however, presented many problems to be overcome by engineers in design of the equipment.

FIG. 5.
Typical stand of Tupelo timber at one of the Texas Company's timber holdings, Louisiana, U.S.A.

High-speed vacuum pumps of large capacity were required to maintain a vacuum equivalent to about twenty-eight inches of mercury throughout the entire system which had previously been operated at a few ounces off atmospheric pressure. Coupled with this is the necessity of preventing the slightest air leaks in any of the equipment that would put a greater burden on the vacuum pumps or tend to destroy the vacuum. The design of the equipment must be such that it cannot only withstand internal weights and pressure, but also provide against collapse.

Engineering ingenuity succeeded in overcoming these many problems, with the result that vacuum distillation was carried out quite extensively, making it possible to obtain high viscosity lubricating oil distillate of very low carbon residue and cold test that could only be obtained previously in the form of residuum. The purer nature and light colour of these distillates also made it unnecessary to treat them as extensively, effecting a slight reduction in costs.

Further research has developed many processes based upon the use of the solvent method of treating lubricating oils. These methods are based upon the ability of certain chemicals to dissolve undesirable constituents and thus make it possible to remove them.

One of the latest processes developed upon a practical scale is the "Furfural" process.

The oils treated in this way are capable of forming a highly protective film on the engine parts through their ability to resist oxidation and temperature changes.

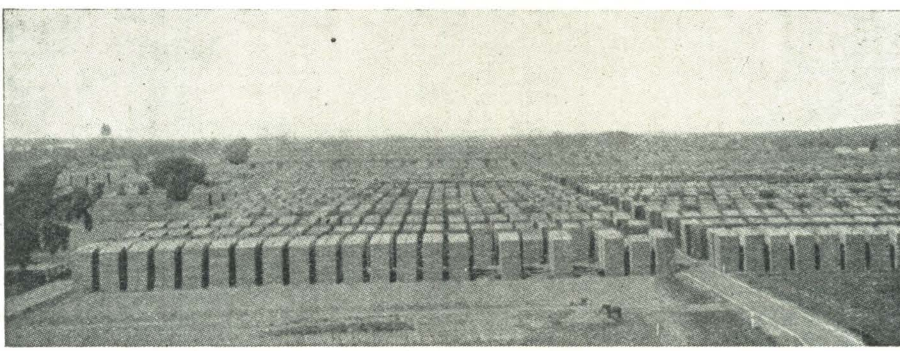

FIG. 6.
10,000,000 feet of Tupelo lumber drying in the yard of the Texas Company's Morgan City, Louisiana, shook mill waiting to be manufactured into cases.

Without actually making a trip through a large refinery, it is difficult to conceive of the many delicate instruments required to maintain accurate control of the many phases of these varying processes—plain and recording thermometers, flow meters and pressure gauges of varied types costing fortunes and requiring a department of skilled men whose sole duty is to check and maintain them in operating condition.

The multiplicity of processes and the widely varying demands for lubrication, together with the research necessary to continually improve the quality and make lubricants to suit the increasing demand for high-speed engines and machinery, have developed the lubrication section of the modern refinery to a point where investment in plant and equipment runs into millions.

Automatic machinery, the ever-increasing speed of automotive equipment, development of the Diesel engine and metallurgical development that is related to bearing metals present new problems daily to the lubricating engineer, and these problems automatically pass from him to research chemists and engineers of the petroleum industry. To meet new and changing conditions, new products of different characteristics and specifications are required. This is directly reflected by changes in refinery methods, alterations and increases in plant and equipment to produce a lubricating product that is not just oil, but a substance specially designed and manufactured for the particular purpose for which it is used, whether it be in the air or on the ground, on land or sea, in the snow and ice of the arctic, or under the boiling sun of the tropics.

In an earlier article mention was made of the widely varying nature of the long list of materials, and the many professions and trades employed in the oil industry. When we think of oil we are apt to visualise a white thin liquid in the form of gasoline or kerosine, or the darker coloured motor and lubricating oils, all in liquid form. This liquid, however, must have something rather substantial wrapped around it, and this thought leads to another great industry built up by and within the oil industry, the manufacture of containers in all their varieties of size, shape, colour and materials.

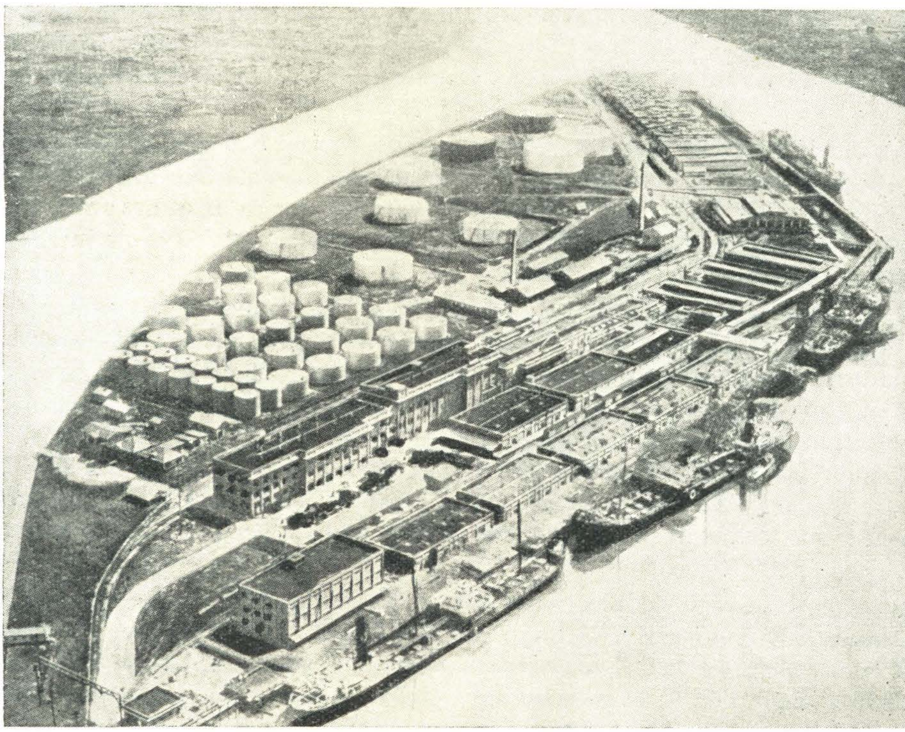

FIG. 7.
Airplane view of the Texas Company s Port Arthur terminal, showing refined and lubricating oil tankage, loading docks, can plant, shook mill, box factory and storage warehouse.

While some of the members of the oil industry depend upon established package manufacturers, the larger units have found it safer and more economical to control entirely this phase of their business, resulting in a complete case and can manufacturing plant becoming an adjunct of the large refineries. It is now a far cry from the early case and can plants making five gallon cans and cases to the modern plant capable of producing every type, size and shape of can, beautifully lithographed in from one to five colours, from the small four ounce oiler upward through the various sizes to suit the needs of the consumer.

Keen competition and the consequent need for economy demand the most up-to-date and efficient machinery, both semi and full automatic, not only to print the tin plate, stamp, form and solder the container, but also to manufacture the many accessories, such as spouts, caps, handles and the many other small parts that are either an essential part of the container or are used with it. Believing that " the package sells the goods ", no effort has been spared to bring the art of lithographing to a high degree of perfection. The man of many languages also has his chance, for the packages destined for the near and far corners of the world must be printed in the language and with the weights and measures of the consuming country.

The Odyssey of the kerosine tin would read like a romance if we followed its wanderings, carried by land and sea, on the shoulders of native porters, on the backs of camels or other beasts of burden, until it makes its last contributions to the welfare of man in the form of a roof over the humble coolie, a water container for the desert traveller, or a cooking utensil for the native of some of the most remote places of the earth.

Although the paper carton has, in later years, replaced to some extent the wood case, overseas and long distance travel maintain the manufacture of the wood case in the list of allied industries. One of the materials for cases comes from the tall straight Tupelo gum trees (sometimes called Bay Poplar), which grow in the large swamps of Louisiana and East Texas.

The lumber jacks employed in the cutting of this timber in the swamp forests work constantly in water nearly waist deep, in semi-tropical heat, plagued by mosquitos and menaced by the deadly water moccasin. Many of them are negroes, living on the edges of these swamps, and making their way about in small, narrow, round bottom boats called " pirogues ", shaped from tree trunks. Their home is in the swamp, and it is a difficult matter to get them to live or work outside. Many of the workmen are Louisiana French, called " Cajans ", descendants of the Acadians, expelled from Canada at the close of the French and Indian War, and immortalised in Longfellow's " Evangeline ".

After cutting, the logs are towed out of the swamps by powerful motor boats to the sawmill, where they are either sawn into shooks, as the parts of the cases are called before they are nailed together, or sawn into planks which are again transported to a shook mill to be re-sawn into shooks. Fuel for the generation of steam required to operate these out-of-the-way sawmills comes not only from the sawdust produced by the saws, but every scrap of waste wood, which is run through a powerful machine called a " hog ", where the scraps of wood are torn between two great saws into fine pieces that can be fed with the sawdust through a blower system into the boiler furnace.

The shooks, after being planed and cut into the required lengths, widths and thicknesses for all the many sized packages, go through printing machines, using from one to three colours, then to the automatic nailers which form them into cases ready for the filled cans of oil.

When we consider that one package plant may consume 70 tons of tin plate daily, manufacture 700,000 cases per year, and use 1,600,000 nails each day, the magnitude of this child of the oil industry staggers the imagination.

NOTES.

In order that the reader may have a more comprehensive understanding of some of the terms used and methods by which refining processes are controlled and the standard of quality maintained, we are setting out hereunder explanations of the various terms used.

Viscosity.

Viscosity or body of petroleum products may be said to express the lack of fluidity of the material, or that property, its internal friction, which resists any force tending to produce flow.

To determine the viscosity of petroleum products, many different instruments are used, particularly in different countries. These instruments are called viscosometers, and operate upon somewhat varying principles, but in general they express viscosity of lubricating oil as the number of seconds required for a given quantity of oil at a given temperature to flow through a standard orifice.

The Saybolt Standard Universal Viscosometer is the most widely used method in the petroleum industry. This instrument is made entirely of metal, and in operation the oil tube with overflow cup at the top and surrounded by a bath of oil and water, is filled. When the oil has been gradually heated by the surrounding bath to the desired temperature, and held at this temperature for a period sufficiently long to bring the entire body of the oil to uniform temperature, the cork is pulled from its position, allowing the oil to flow through the small outlet tube at the bottom of the oil tube into the receiving flask. When the cork is pulled from its position, a stop-watch is started, and the watch stopped when the bottom of the meniscus of the oil reaches the 60 c.c. mark on the receiving flask. This time, in seconds, is the Saybolt Universal Viscosity of oil at the temperature at which the test is made. Thus, viscosity of 80 at 210° F. indicates that 80 seconds were required for 60 c.c. of oil to pass through the orifice.

This test is one of the most important, for it is used extensively in research, refinery control and the selection of oils most suitable for commercial use.

Pour Point (Cold Test).

Pour point of oil is the lowest temperature at which the oil will flow or pour when it is chilled without disturbance under certain definite specified conditions. In this test the oil is placed in a cooling bath, maintained at a temperature of not less than 15° F. nor more than 30° F. below pour point of the oil. Beginning before the expected pour point, at intervals of, and in multiples of 5° F., the test jar is removed from the jacket carefully and tilted just sufficiently to ascertain whether there is a movement of the oil in the test jar. As soon as the oil in the test jar does not flow when the jar is tilted, the jar is held for exactly five seconds in a horizontal position. When it reaches a point where there is no movement, temperature is recorded, and 5° F. above this solid point taken as the pour point or cold test of the oil.

This test is essential not only in the handling of the product, but in determining its suitability for certain uses, e.g. it is necessary to know whether the oil will flow through pipelines at certain temperatures, and in the case of lubricating oils, which are exposed to low temperatures, it is necessary to know that they will not thicken, refuse to flow and thus lose their lubricating value when in use.

Carbon Residue.

In this test a small quantity of oil is placed in a crucible, to which heat is applied until all the oil has been evaporated and burned away. The carbon remaining in the crucible is weighed and calculated to percentage of sample.

This test furnishes pertinent information relative to lubricants for internal combustion engines, domestic fuels and other practices, and it is important that the oil be as nearly free of carbon as possible because of the objectionable nature of carbon deposits that might be formed when the oil is vapourised or burned.
