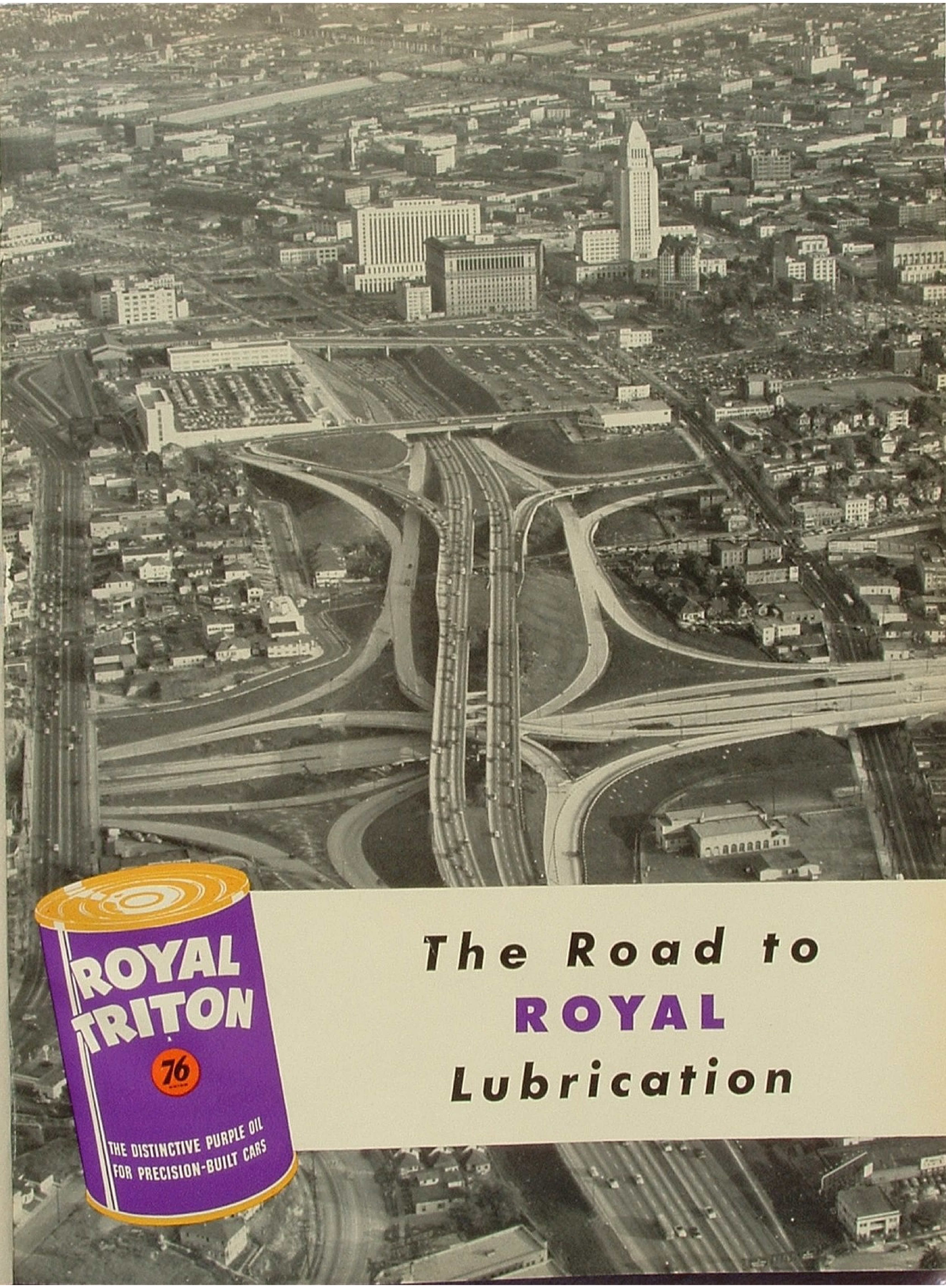
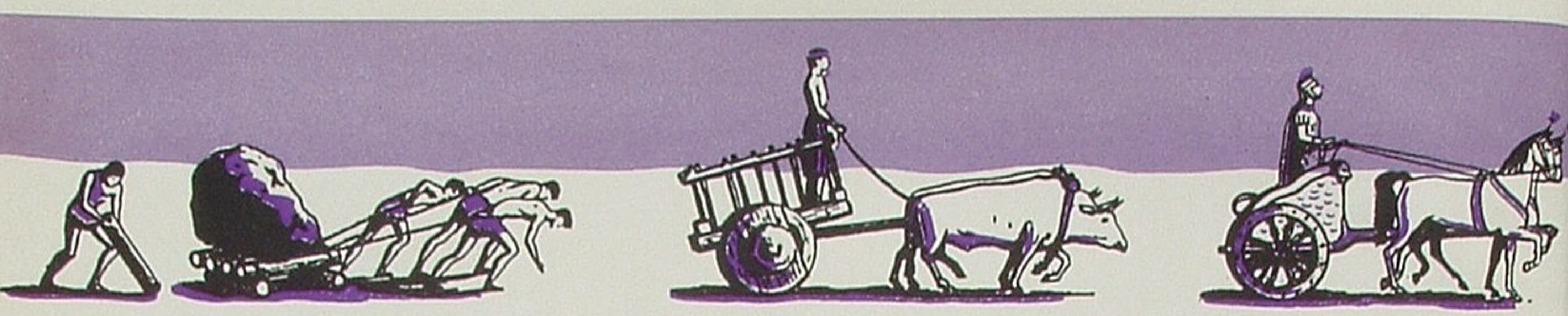
The Road to ROYAL Lubrication



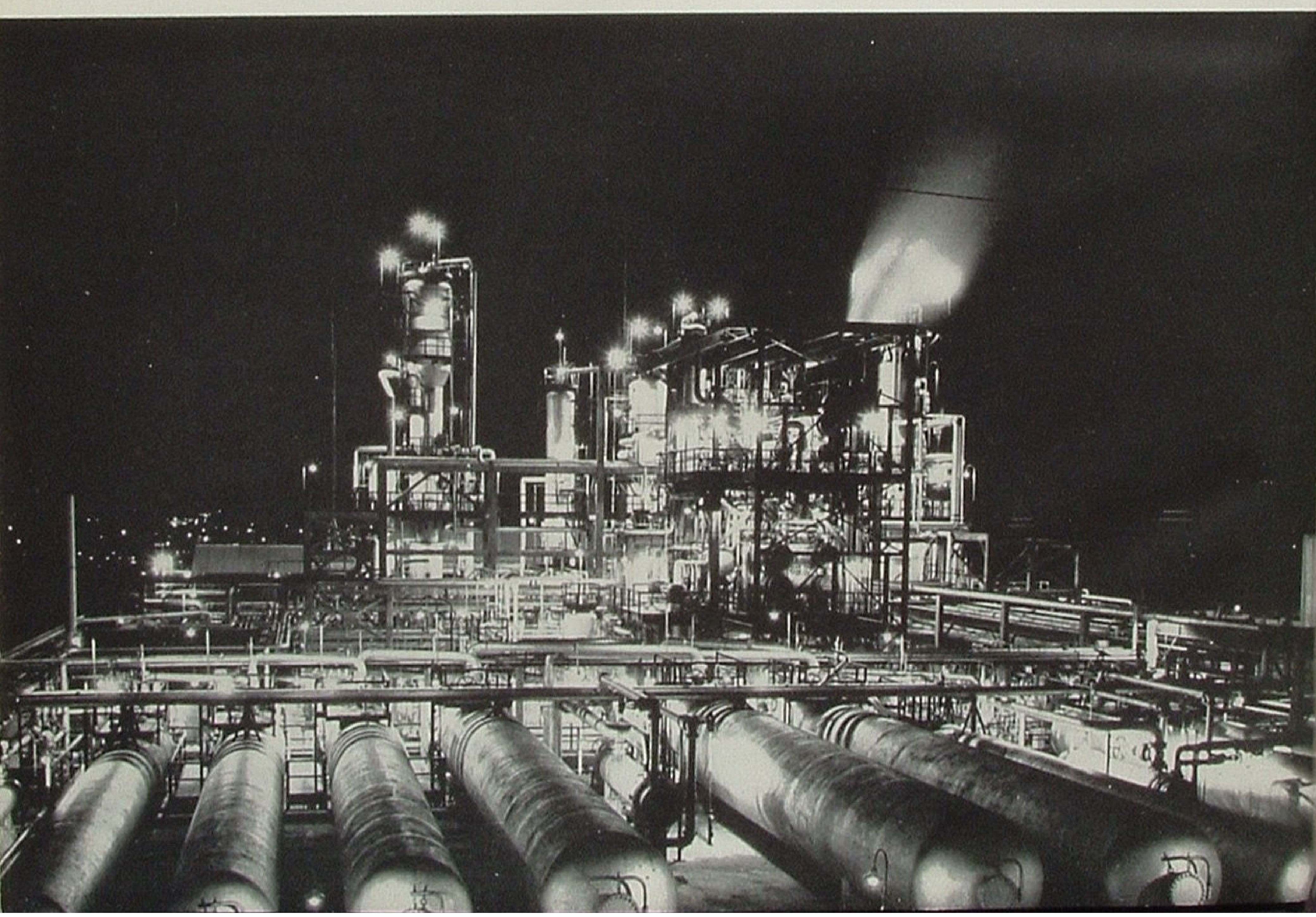


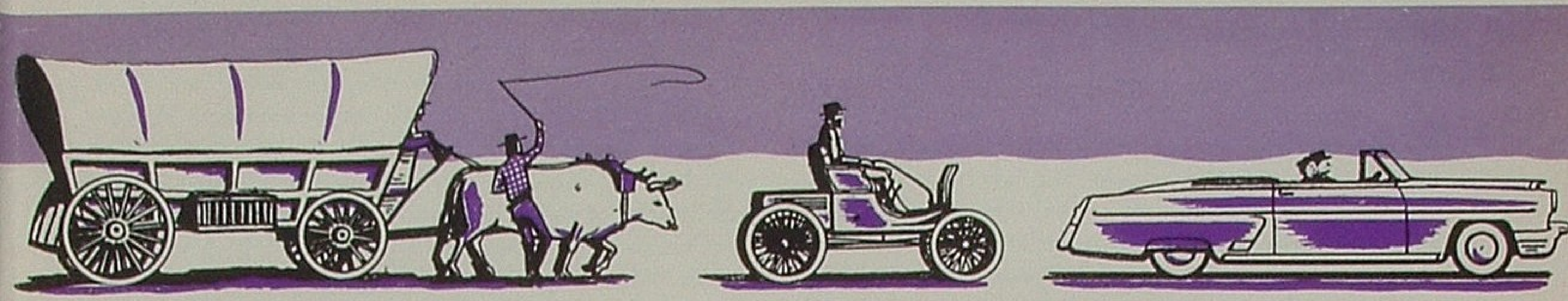
The success of Union Oil people, as well as the Company we comprise, is dependent to a great extent upon the type and amount of knowledge each acquires and upon the intelligence and vigor with which such knowledge is applied. Lubricants, obviously, are products of major importance not only to the petroleum industry but to the economy of the entire world. Oil people in particular are expected to know the basic facts about lubricants—how they are produced, manufactured, marketed. Therefore, in a spirit of helpfulness on the parts of many who aided in the preparation of the text, the following facts are offered. We trust this knowledge will contribute to the continuing success of Union Oil people, both individually and collectively.

from The Industrial Relations Department

The Road t

Millions of wheels in industry and on the highway today depend for their lubrication upon such petroleum industry facilities as our Duo Sol Unit 220 at Oleum Refinery.





ROYAL Lubrication

The Wheel

The wheel is so commonplace in this modern machine age that few of us pay proper respect to its invention. True, it is a fairly simple mechanism—one that might have been suggested to our ancestors by a rolling stone. But its adaption to the service of mankind was, and continues to be, ingenious.

Recorded history fails to tell us where, when or by whom the wheel was first put to use. We know only—from old writings, carvings and paintings—that carts and chariots were used by the ancient Sumerians and Egyptians, and that similar conveyances were known to a few other pre-Christian peoples. Nevertheless, many primitive nations and tribes trudged on century after century, apparently without the benefit of wheels.

Probably the first wheeled vehicle ever built moved on a pair of wooden discs laboriously carved from a section of tree trunk. A stout pole, with its ends secured to the centers of the two discs, may have served as an axle. Perhaps a carrying platform or rack, with a shaft for guiding and pulling, was somehow saddled between the wheels. Whether the axle remained stationary as the wheels revolved around it, or the rigidly attached wheels and axle both revolved under the rack, are questions for speculation. But there is no debating that the inventor quickly ran into trouble. Where moving parts rubbed together, an ominious sound developed. Soon the grating surfaces grew hot and began to smoke from friction. Worst of all, the rubbing parts gave evidence of rapid wear. The vehicle was a failure—unless something could be done to arrest friction.

It must have been about this same time that man began his earliest experiments in lubrication. The inventor and his advisers probably tried water, mud or any other type of slippery substance at hand that might halt the inroads of heat and friction. And sometime during the course of that early research they found a commodity of great merit. It may have been oil of the petroleum variety, for we know that chariots of the Egyptian kings were greased with "mum" or pitch from oil seeps existing in that country. However, it is more likely that animal fats were first used, because, down through the many centuries that followed, most of the world's axles were greased with products made from beef and mutton tallow, lard or whale oil.

Indeed, many things have happened to the wheel since that ancient day of its earliest inception. It has lent itself to millions of changes and refinements. Now it not only carries us and our worldly goods from place to place, but tills and harvests our fields, does the hardest work in our mines and factories, helps to generate our power, provides us with relaxation and entertainment, even measures the time of day. Without wheels or a knowledge of them, civilization would skid promptly and chaotically back to the drudgery of former times.

But in paying tribute to this great invention, let us not forget the silent partner in its success—oil. This equally commonplace and indispensable servant of our age rescued the wheel from failure and has marched side by side down through the centuries with all wheels in their every revolution and evolution.

Animal fats long ago proved unequal to the growing demand for better, cheaper and more abundant lubricants. However, in 1859—when sea-going oil men were beginning to complain about a scarcity of whales—a pioneer oil well was drilled in Pennsylvania, opening a new source of supply. Fortunately, this event preceded the automobile and most other machines now in use. For without the volume and variety of products thus made available, few machines would be in operation today.

We owe much to the wheel and quite as much to the thin, tough film of lubricant that keeps it revolving year after year. And it is partly to stimulate this appreciation that UNION OIL offers the following facts about lubricating oils and their manufacture.

The Evaluation of Oils

Soon after the petroleum industry began to expand from its point of origin in Pennsylvania, crude oil was found to be a substance of extremely varied and inconsistent composition. Even when careful refining methods were used to extract similar lubricating oil fractions from two different crudes, it was found oftentimes that the refined products were dissimilar.

These observations led to extensive analyses and eventually to a standardization of tests through which the properties of lubricating oils could be measured.

For example, the *gravity* of an oil, or the relationship of its weight to volume, is determined by measuring the depth to which a hydrometer will sink in the oil sample. Early chemists used gravity measurements to identify the source of an oil, and *source* was one of their principal assurances of quality. Today, due to improved refining techniques, gravity tests are not the most reliable indications of an oil's source.

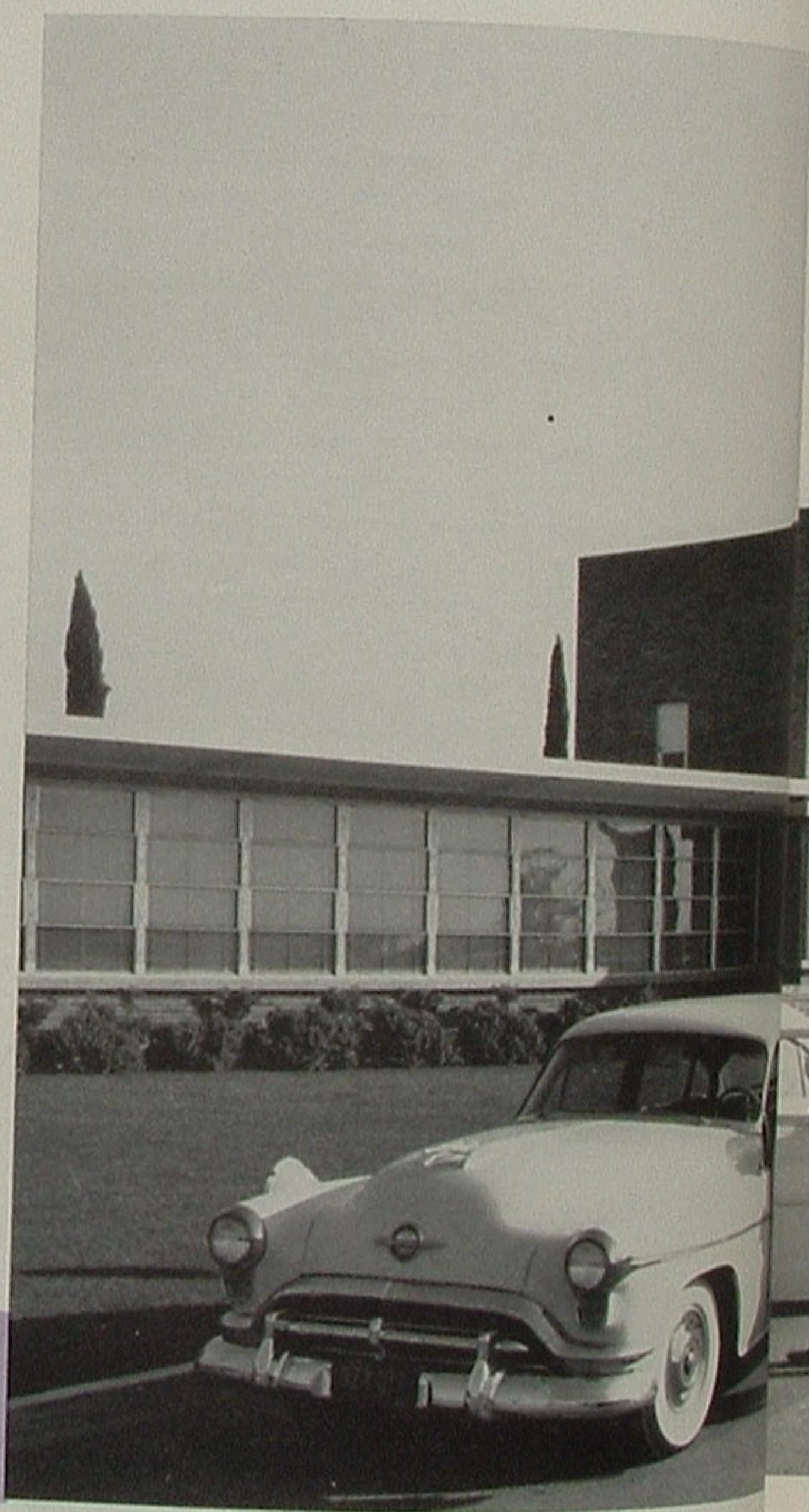
Flash and *fire* tests are conducted by gradually raising the temperature of an oil sample and igniting its vapors. The temperature at which enough of the light oil particles vaporize to produce the first visible flash is recorded as the oil's *flash point*. The higher temperature at which it gives off enough vapors to produce a continuous flame is the sample's *fire point*. Lubricants having a high flash point are preferred because of their lower content of such unstable materials as kerosene and light fractions. Oils having a relatively high fire point are regarded as being better able to withstand service under high temperature conditions.

Carbon residue tests are conducted by removing, through a destructive distillation or controlled boiling-burning process, all liquid fractions of a sample and weighing the remaining deposit of carbon. This provides a good indication of the oil's *cracking* or decomposition tendencies under high-heat operating conditions.

Viscosity, the measure of an oil's resistance to flow, is gauged by means of a viscosimeter. The sample, after being heated to a prescribed temperature, is allowed to flow through a standardized orifice. The length of time in seconds required for a given amount to pass through the orifice determines the oil's viscosity number. The "SAE" numbers now used to classify oils express viscosities according to a grade defining system adopted by the Society of Automotive Engineers.

It was found many years ago that two oils having the same viscosity at, say, 75 degrees F. might vary considerably from each other at the higher operating temperatures of a motor. Accordingly, engineers devised a means of plotting an oil's viscosity-temperature characteristics, and began referring to such pattern of change as the oil's *viscosity index*. Thus, an oil that is not inclined to show pronounced viscosity changes throughout various temperatures is said to have a high viscosity index. Obviously such an oil is preferred for use under widely varying operating temperatures.

Other tests adopted by chemists and engineers in evaluating lubricating oil include *color* tests, to measure the presence of useless and sometimes objectionable color bodies; *sulfated residue* tests, to measure the presence



The supreme test of a motor oil is its day to day performance. Therefore, our Royal Triton 5-20 was given thousands of miles of road tests in this fleet of cars.

of metallic substances and additives; *pour point* determination, to establish the lowest temperatures at which different oils will flow; and so on.

Most of these tests are useful and important to petroleum chemists engaged in manufacturing the highest quality of uncompounded lubricating oil stocks. But when applied to today's best ready-for-the-market lubricants, some of the older measuring sticks are less indicative of merit than ever before. In recent years compounds have been discovered which, when added to an oil, give it far better performance characteristics than those provided by nature.

The supreme test of any oil is its day to day performance in numerous types of machines and under the widest scope of operating conditions. However, such tests are not burdened on the consumer. Instead, research engineers are constantly at work subjecting every new product and product improvement to service tests of all sorts. Laboratory engines, for instance, subject a motor oil to every condition and extreme it may ever be expected to encounter. Then in automobiles—sometimes in fleets of automobiles—the oil embarks on thousands of miles of road tests. It is thoroughly measured, thoroughly compared in the great laboratory of practical use, thereby corroborating or upsetting earlier conclusions. When such a product is advertised as "The World's Finest Motor Oil," there must be firm proof as well as conviction behind the assertion.

The Composition of Oil Stocks

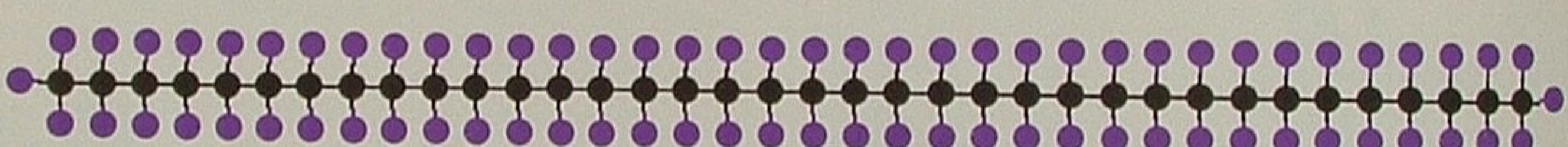
Scientists, delving ever deeper into the mysteries of petroleum, have succeeded in classifying the hydrocarbon families that comprise lubricating oil stocks. In addition, despite the submicroscopic size of individual hydrocarbon molecules, physicists have given us valuable knowledge of their construction.

Petroleum substances are composed basically of carbon and hydrogen atoms, two of nearly 100 varieties of atoms that combine in millions of ways to form all physical substances. The reasons that petroleum alone contains thousands of different compounds is that its carbon and hydrogen atoms have combined in an almost countless variety of hydrogen-carbon or hydrocarbon unions. One carbon atom chemically combined with four hydrogen atoms constitutes a molecule of methane, the lightest of petroleum gases. Increasingly larger numbers of these two atoms combine to form increasingly heavier petroleum gases, liquids and solids until, toward the bottom of this scale, are some molecules each containing thousands of atoms. The pattern or arrangement of such atoms into straight chains, rings or other combinations has led to our classifying the molecules into families.

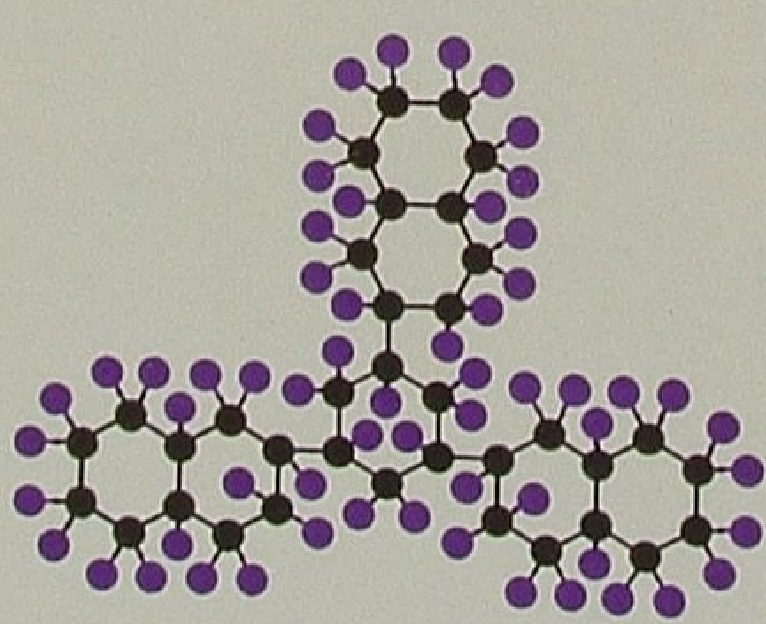
Within the relatively narrow range of petroleum *cuts* known as lubricating oil stocks are five predominating families, namely, the *paraffins, naphthenes, parathenes, resins* and *asphaltenes.* Three of these are represented in accompanying drawings, indicating the different manners in which their atoms may combine. Resins and asphaltenes are not represented because of their large size and completely unknown arrangements.

The *paraffins,* best known of the five families, are long, straight-chain arrangements of the two basic atoms. In molecules of small size, paraffins are the principal components of gases and other light petroleum products. But in sizes large enough to be classed as lubricating oil fractions, they tend to solidify into waxes at ordinary temperatures, hence must be removed almost entirely in refining processes. Nevertheless, paraffinic or waxy crude generally contains a large proportion of other molecules having lubrication values and high resistance to heat and oxidation.

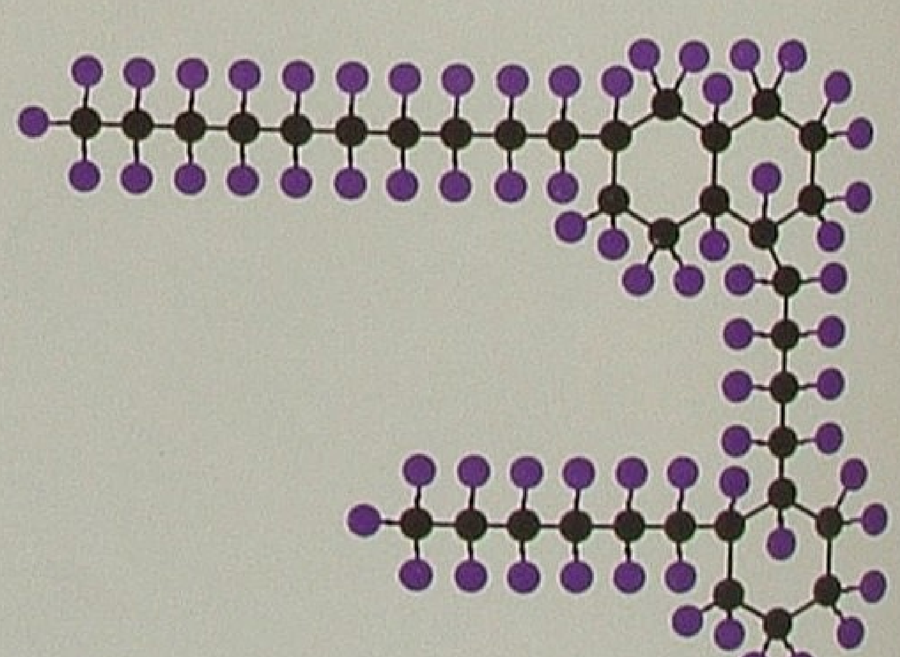
Carbon ●   Hydrogen ●



A paraffin molecule



A naphthene molecule

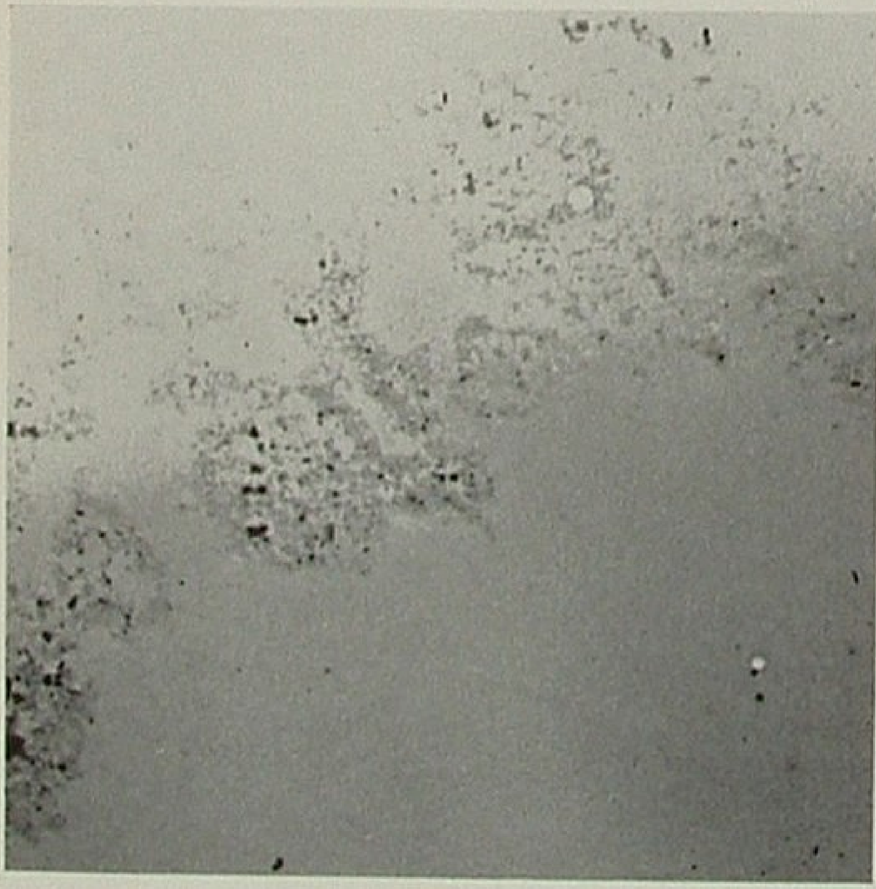


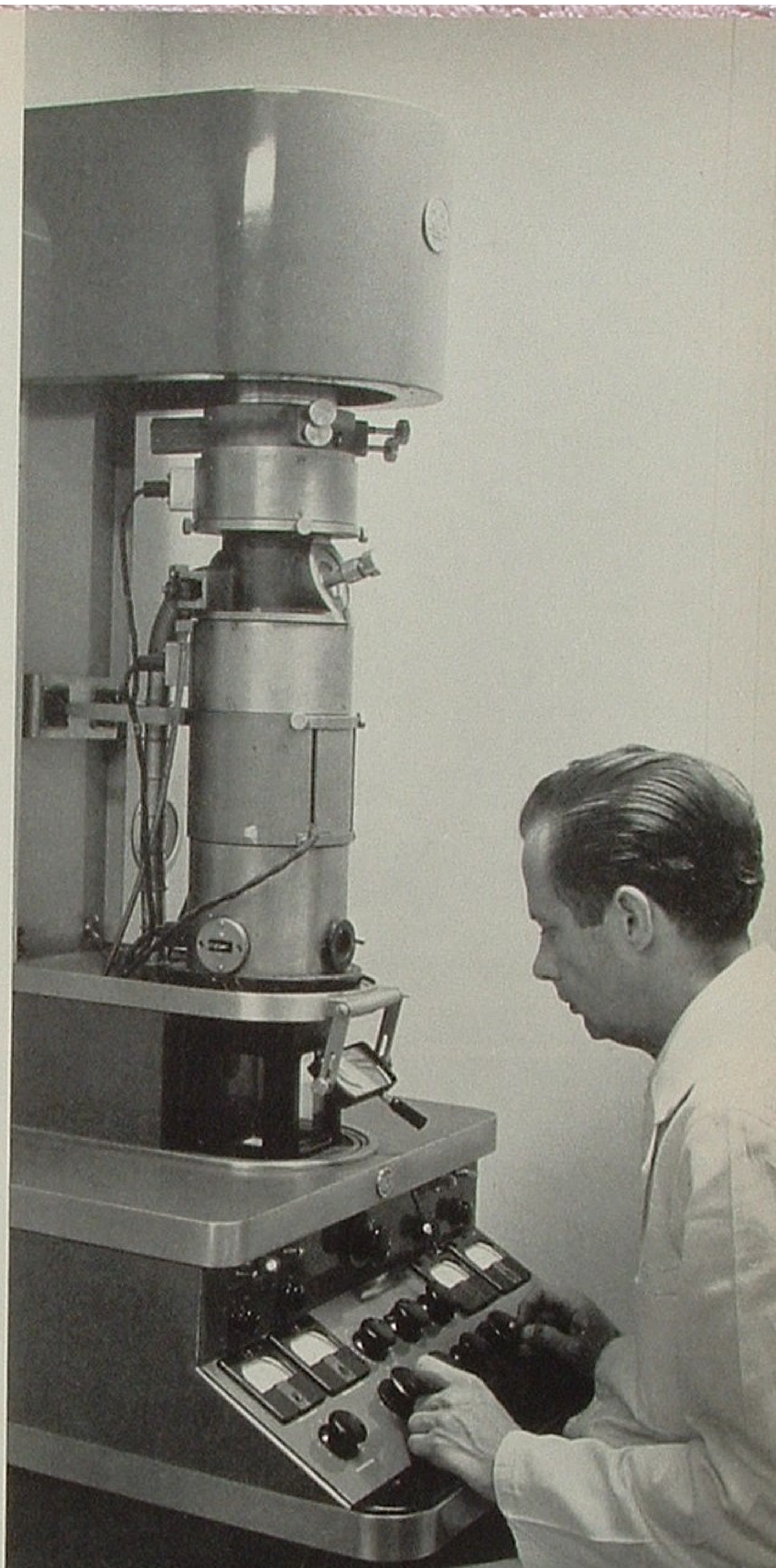
A parathene molecule

The *naphthenes* are ring compounds, meaning that a large proportion of their carbon atoms are joined together in a circular arrangement, as indicated in our drawing. But some of the naphthenes have short paraffinic side chains and are hardly distinguishable from the parathenes we next describe. The naphthenes have outstanding lubrication charactertistics that make them ideal for hundreds of industrial uses. However, they constitute only a select minority in finished motor oils of highest quality.

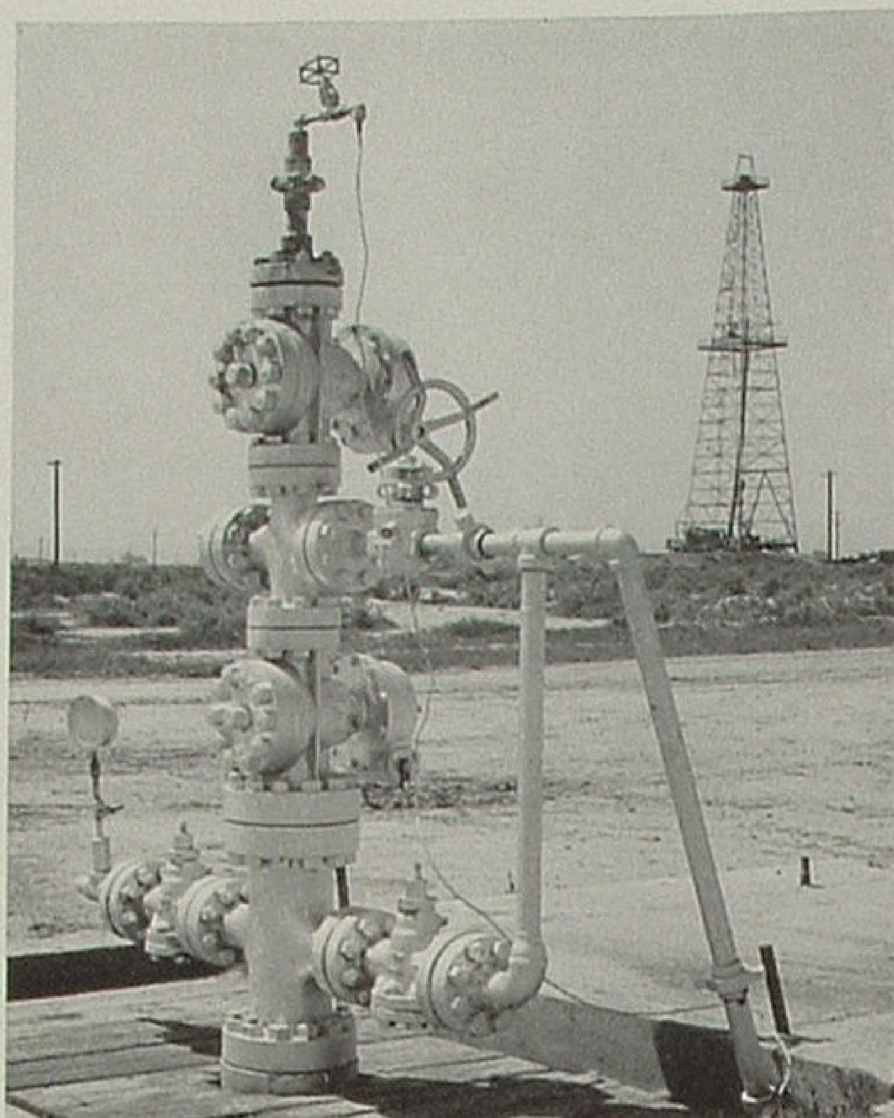
The *parathenes*, as their coined name suggests, are thought to be somewhat of a cross between or combination of paraffinic and naphthenic compounds. They consist of napthene rings to which are attached long paraffinic side chains. These hybrid molecules appear to retain the better qualities of their pre-marital families. They have the higher heat and oxidation resistance of the paraffins, but better flow characteristics. They are the lubricating *cream* of all oil stocks. They are regarded as the most desirable hydrocarbon components of the finest motor lubricants.

The *resins* and *asphaltenes* are among the less welcome molecules found in stock being refined for motor oil use. Their complicated ring structures carry a high proportion of carbon in relation to the hydrogen atoms present. They are heavy, dark in color, and better suited for other industrial purposes. Their complete removal somewhere in the refining process is one of the requisites of motor oil quality.





An invaluable tool to scientists in their endless search for knowledge pertaining to oil is the electron microscope, above. Left is a particle of compounded oil as it appears when enlarged to some 25,000 magnifications.



Rio Bravo wells, above, are a major source of Union Oil's paraffinic San Joaquin Valley light refining crude.

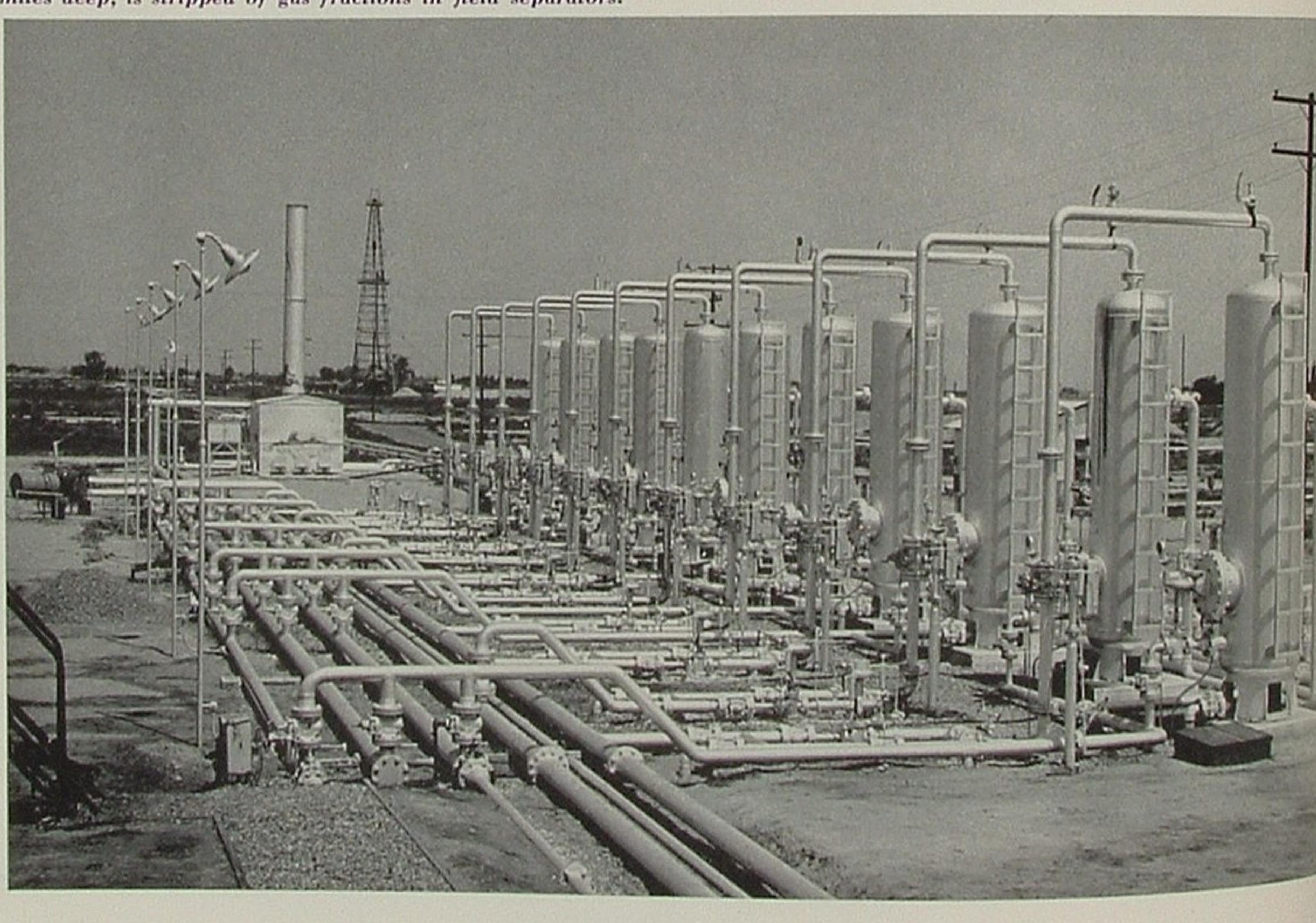
The oil, coming from producing zones more than two miles deep, is stripped of gas fractions in field separators.

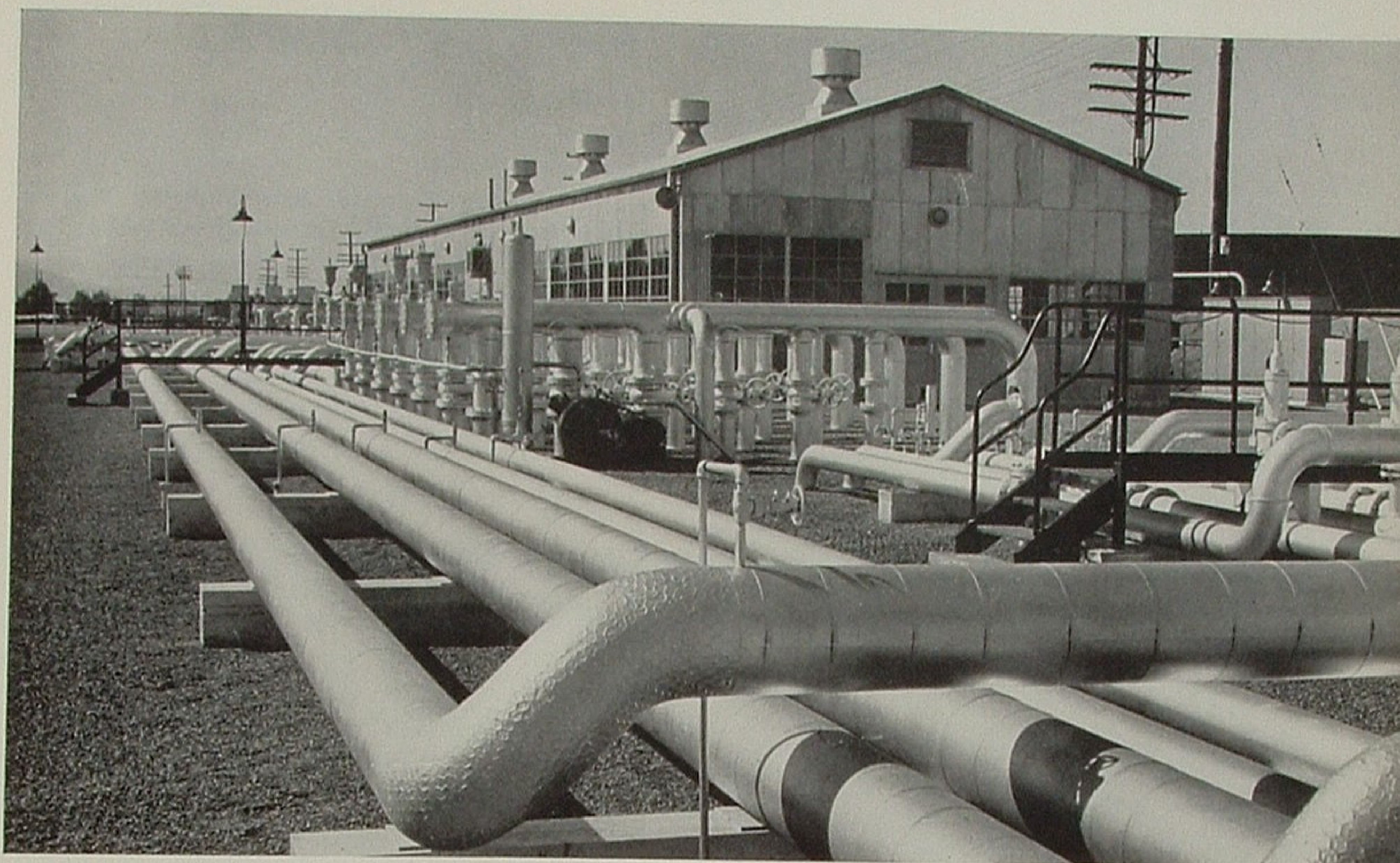
Sources of Paraffinic Crude

Strictly speaking, none of the world's crude oils contains a clean *cut* of *royalty* to the exclusion of less noble followers. Rather, in nearly every instance, the preferred parathenes and valuable naphthenes are accompanied by varying quantities of non-lubricating paraffins, resins and asphaltenes. Generally, crudes in which the identifying paraffins are prominent—popularly known as paraffin base crudes—will yield a higher percentage of top-quality lubricants in relation to other hydrocarbons present.

But a great deal depends upon the refining. If the non-lubricating paraffins, resins and asphaltenes can be removed, there will remain an excellent lube oil stock containing a predominance of parathenes, a minority following of valuable naphthenes, and only a trace of the paraffinic hydrocarbons.

For many years Pennsylvania oil fields were acknowledged to be the principal source of paraffinic crudes. During the same era fields of the Midcontinent, West and South were given a rather secondary oil reputation because of their predominantly naphthenic and asphaltic crudes. These early conclusions later proved to be as inaccurate as they were unfortunate. Not only were excellent paraffinic crudes found in newer fields and deeper zones of western areas, but the West had mean-





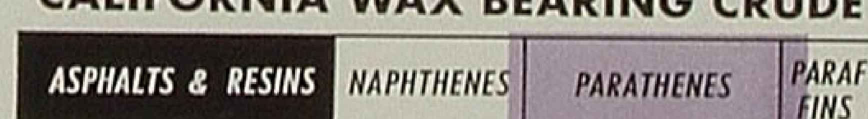
Transporting of the crude oil via pipe line or tankship from Rio Bravo to Oleum Refinery is initiated by our Junction Pump Station, above, whose engines, pumps and heaters are among the industry's newest and most efficient.

while developed a greatly advanced method of refining lubricants.

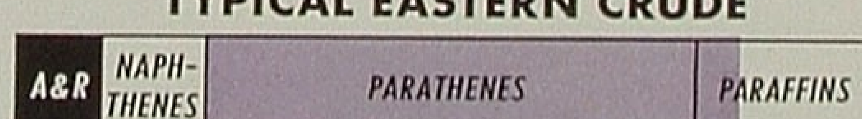
A typical source of Union Oil's paraffin base crude today is the Rio Bravo Field, discovered by our company in 1936 nearly 12,000 feet beneath the topsoil of San Joaquin Valley in California. Known as San Joaquin Valley light refining crude, this oil contains a cut of lubricants that are equal in every respect—and superior in some ways—to the East's best paraffinic oil stocks. True, the quantity of parathenes found in each barrel of Rio Bravo crude is proportionately not as great as the per-barrel yield of Pennsylvania crudes. But the quality is there—in every measurable characteristic.

The superior qualities we have just spoken of are triumphs of refining. Union Oil's propane-solvent process of refining proved to be the most effective commercial method ever tried of removing resins and asphaltenes from oil stocks. Our Triton Motor Oil, minus resins and asphaltenes as well as paraffin waxes, came nearer to being the ideal motor lubricant than any competitive oil on the market. It was so good, in fact, that several large oil manufacturers of the East are now resorting to solvent refining in order to stay in the quality race.

CALIFORNIA WAX BEARING CRUDE



TYPICAL EASTERN CRUDE



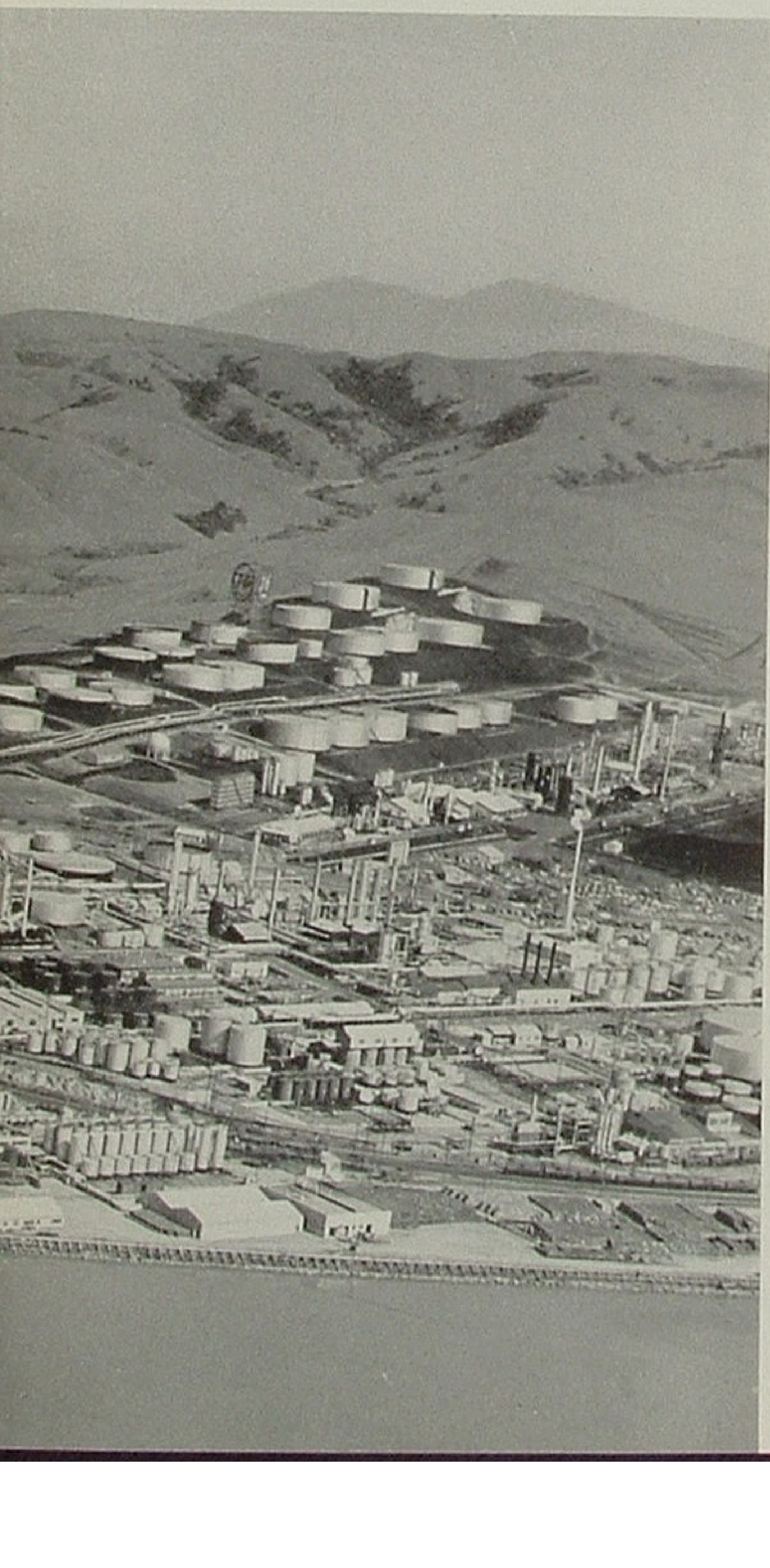
San Joaquin Valley light refining crude is stripped of its gaseous fractions before leaving the producing field. It then proceeds by pipe line, or less frequently by tankship, to our refining facilities in the San Francisco Bay area. In either case the crude is carefully handled by modern pumping units, of which Union Oil's Junction Pump Station, shown herewith, is an efficient example.

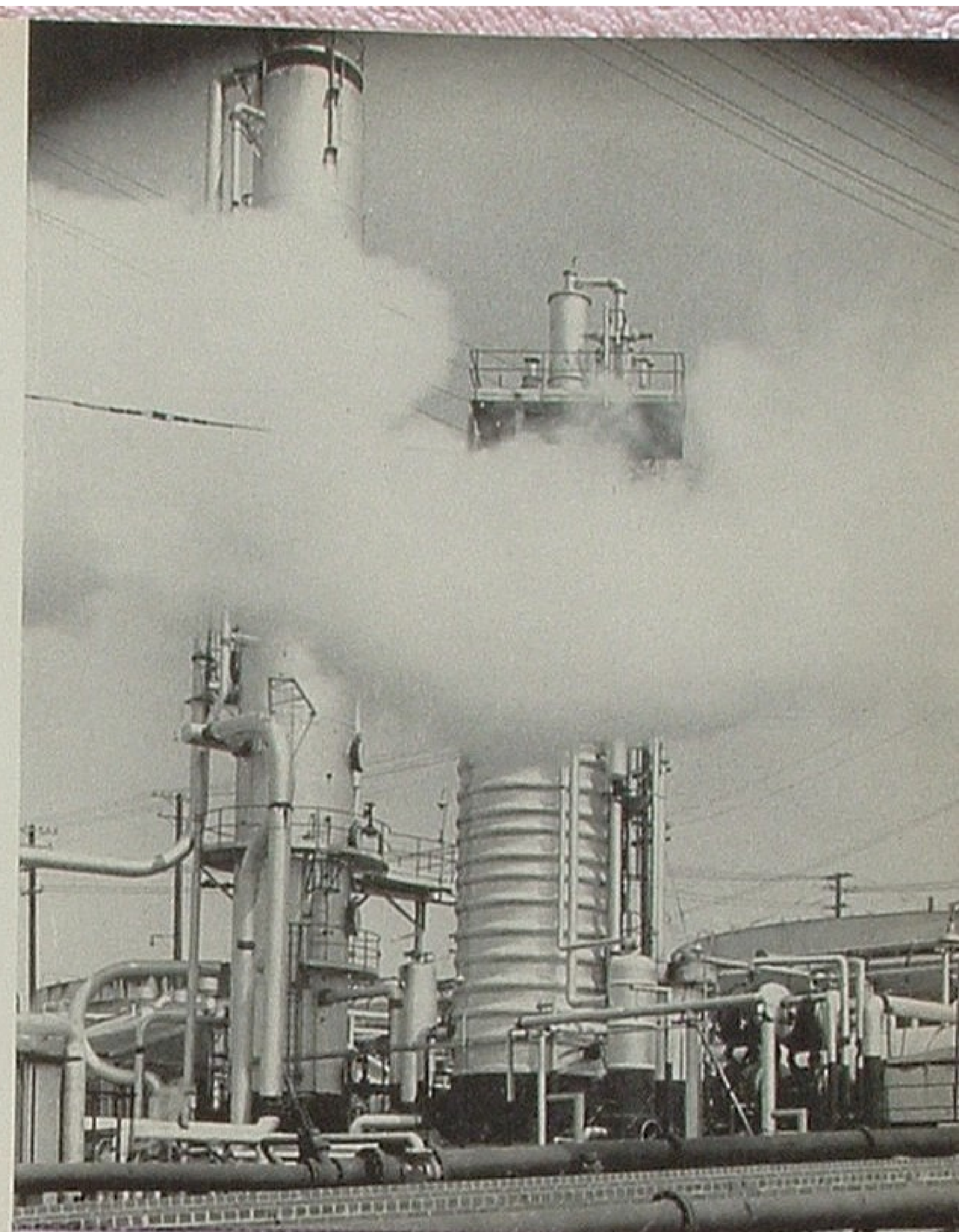
The Refining of "ROYAL" Stocks

OLEUM After its journey of over 300 miles from the Rio Bravo Field, our selected San Joaquin light refining crude arrives at Oleum Refinery. Here, on a 440-acre site overlooking the Carquinez Straits of San Francisco Bay, Union Oil Company has been using and improving its oil manufacturing talents since 1895. The concentration of special facilities and skills acquired and improved over the years has brought to this refinery full responsibility for the manufacture of all Company lubricating oils and greases. Such long experience is an important requisite in the refining of quality oils.

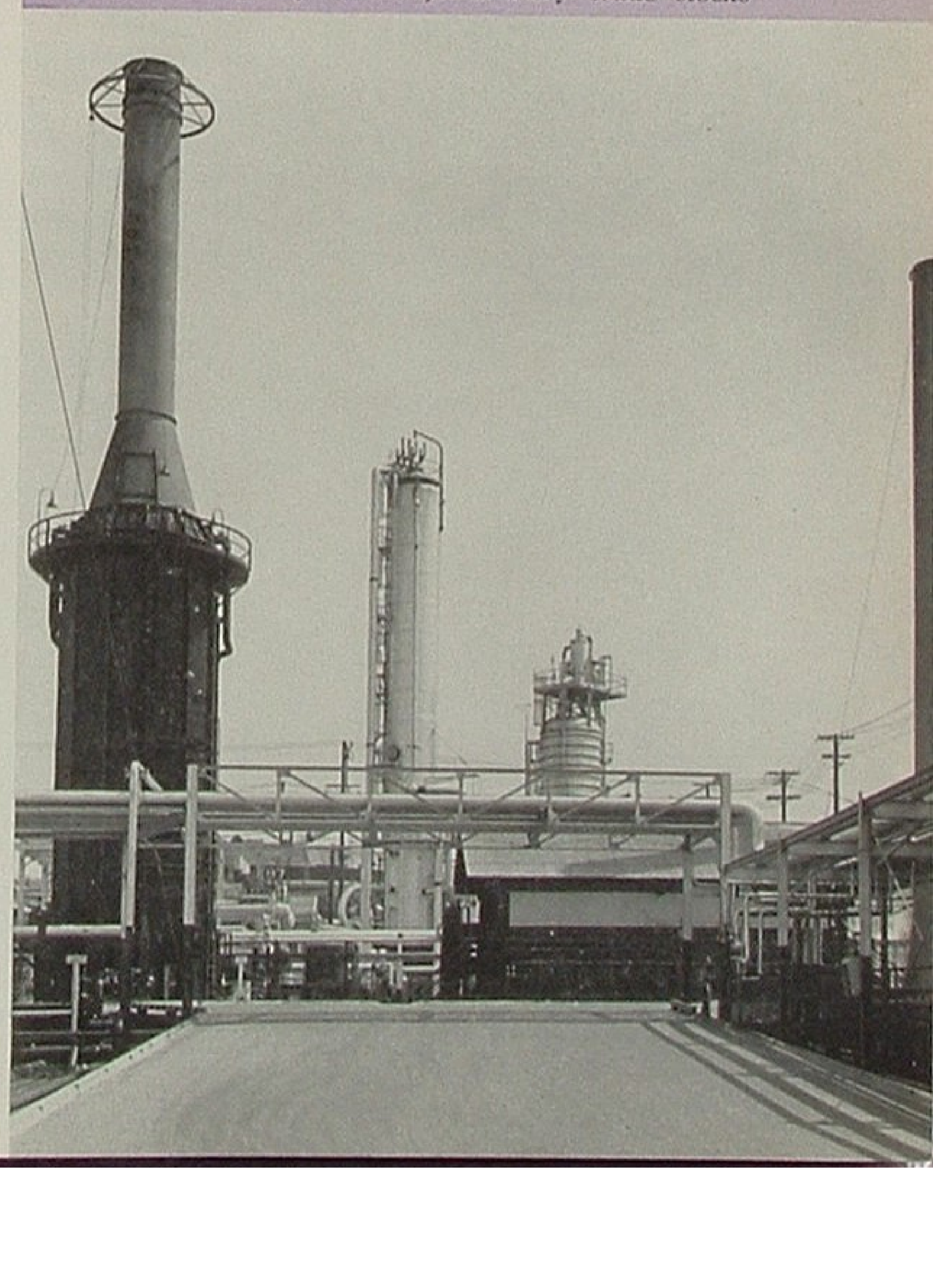
Distillation Unit 67 First step in the manufacture of "Royal" lubricants is the segregation of our waxy crude into lubricating oil

and lighter fractions. This is done at Oleum in the heaters and distillation columns of Unit 67. After being heated to around 600 degrees F., the crude is admitted to distillation columns, where the hot oil separates into liquid and vapor streams. The vapors bubble upward through liquid-covered trays in the columns; their gasoline fractions are condensed on the trays and removed; and the lighter petroleum gases continue upward and out the tops of the columns. Both types of products are of course conserved for sale or use. The remaining liquid portion of the crude is drawn from the bottom of Unit 67's columns and is given the rather inappropriate refinery label of *residuum*. It is the residuum—containing long, waxy, heat-resisting molecules—that we are interested in following.





Oleum Refinery on San Francisco Bay, left, manufactures our entire output of lubricants. Heaters and columns of Distillation Unit 67, above and below, first remove light fractions from waxy crude stocks



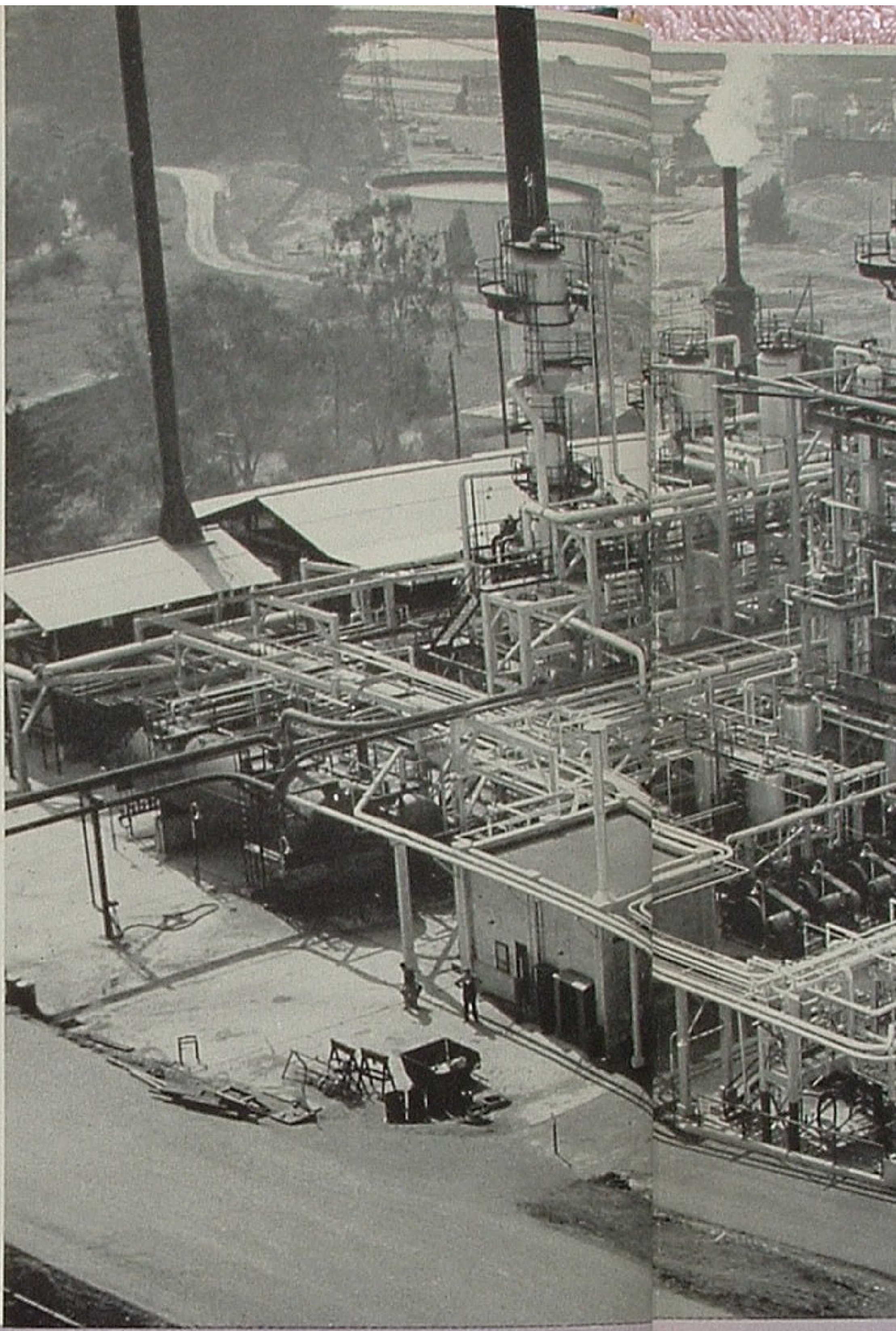
Duo Sol Extraction Unit 220

Union Oil pioneered the propane-solvent method of refining some 20 years ago, and, when improvements were engineered into the process recently, were prompt to construct the most efficient plant available, Oleum's present Duo Sol Unit 220.

The name "Duo Sol" implies that two solvents are used in further refining the oil-rich residuum from Unit 67. One of these solvents is *propane*—a paraffinic hydrocarbon, incidentally, which has the aloof characteristic of refusing to associate with asphalts, resins and some of the less desirable naphthenes, but readily attracts the paraffinic waxes, parathenes and more desirable naphthenes. *Selecto* is the patented name of the second solvent, which is a mixture of phenol and cresylic acid. This solvent has the useful characteristic of refusing to associate with the propane clique of followers but freely attracts the asphalts, resins and low-grade naphthenes.

Both solvent actions take place simultaneously in the Duo Sol Unit's battery of large horizontal tanks. Nearly all other intallations in the unit are employed in recovering and reconditioning the solvents for use again in the same process.

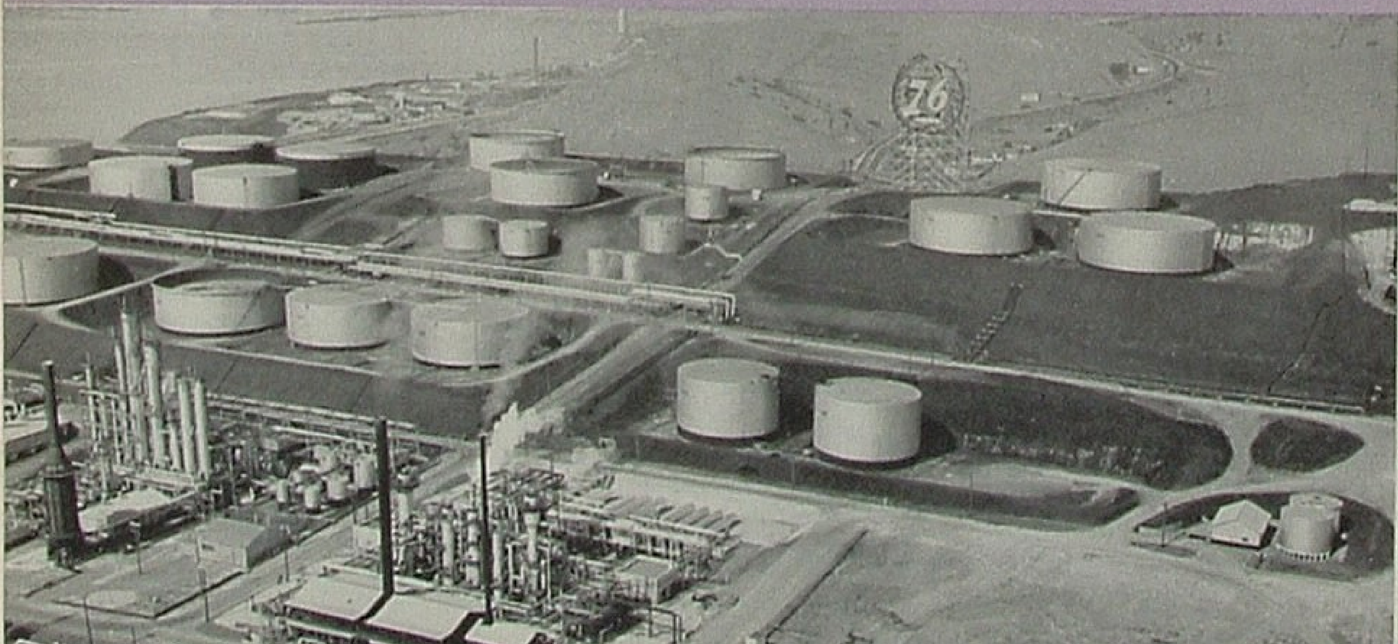
A thorough mixing of solvents and feed is accomplished by injecting propane at one side of the tank battery, Selecto at the other side, and our lubricating oil residuum in the middle. The resulting counterflow of solvents and feed assures complete exposure of the oils to their treating agents and effects a clean separation into two outcoming streams. One, called *extract*, is a mixture of Selecto solvent with its newly acquired following of asphalts, resins and inferior naphthenes. The other, called *raffinate*, is a mixture of propane with the paraffinic waxes, parathenes and superior naphthenes. The extract, after being stripped of its Selecto, is sent to Oleum's coking unit for cracking into petroleum fuels. So, let's see what happens to the raffinate.

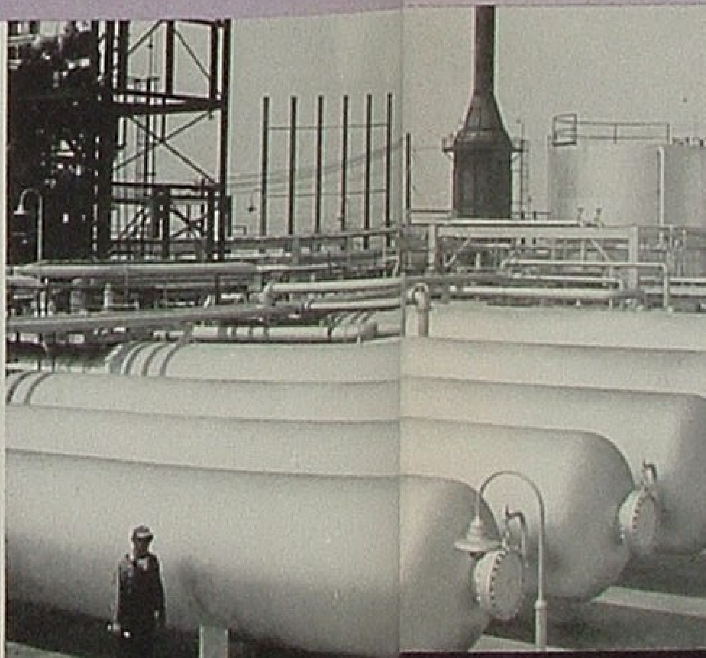


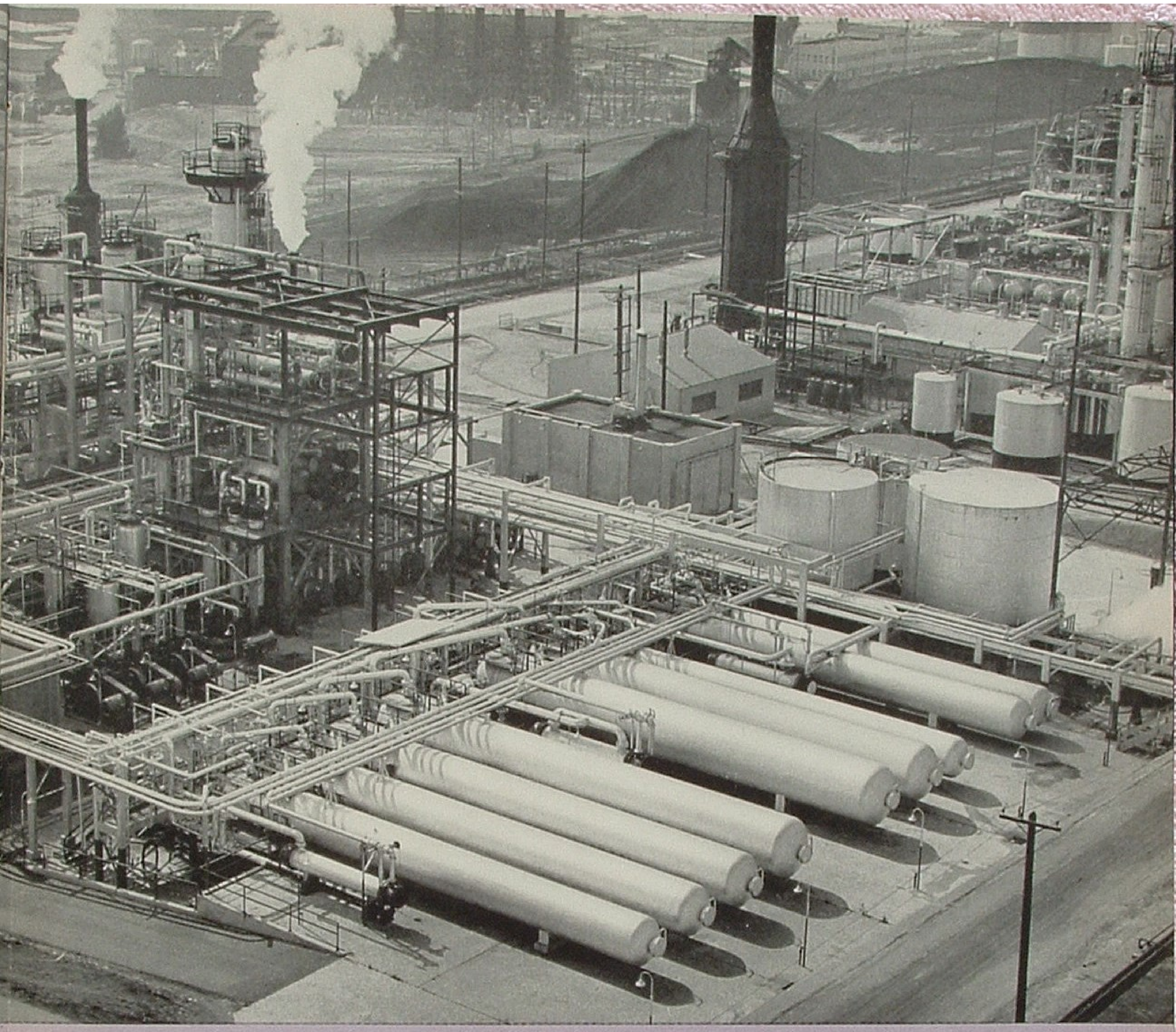
In aerial views above and below is shown Oleum's Duo Sol Extraction Unit 220, where quality oils are segregated.

Separation of inferior from superior lubricating hydrocarbons takes place in the large horizontal tanks through

aid of two solvent
separated raffina

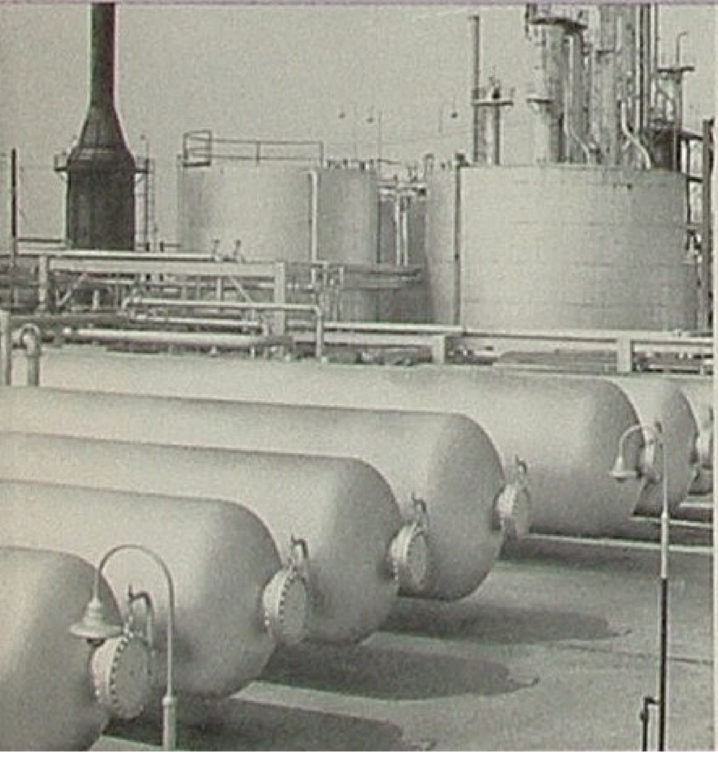


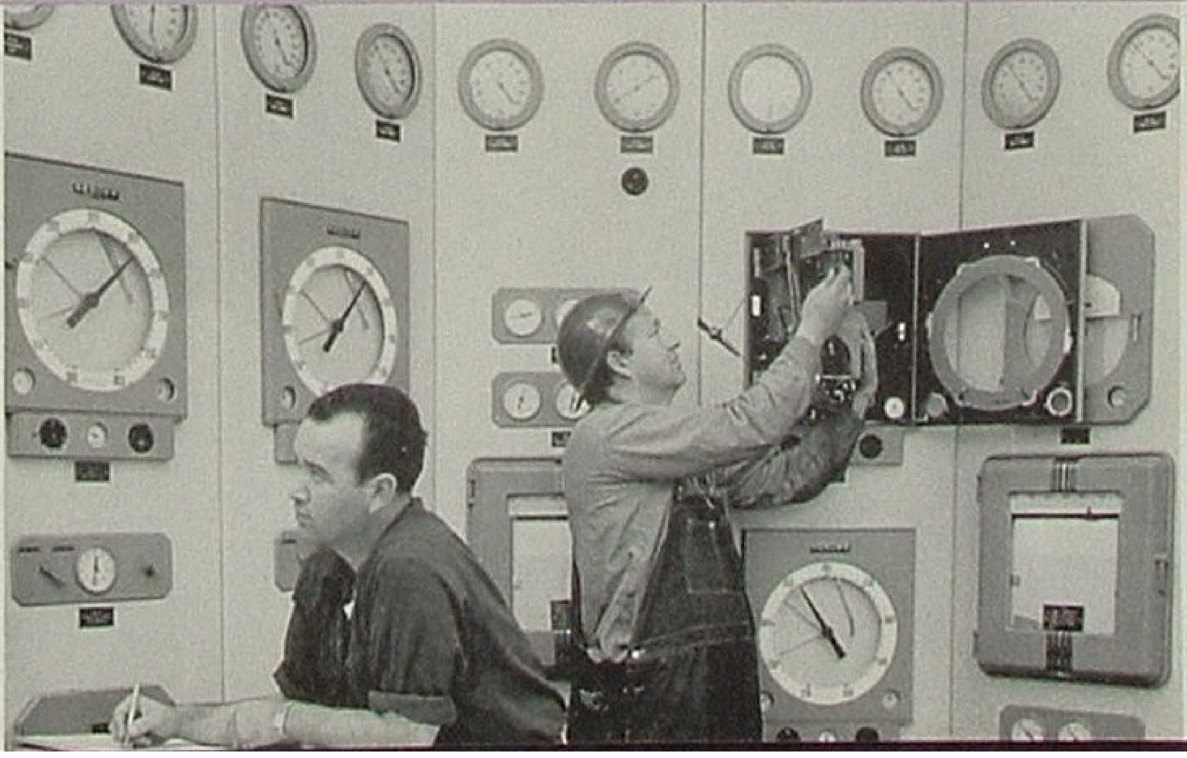


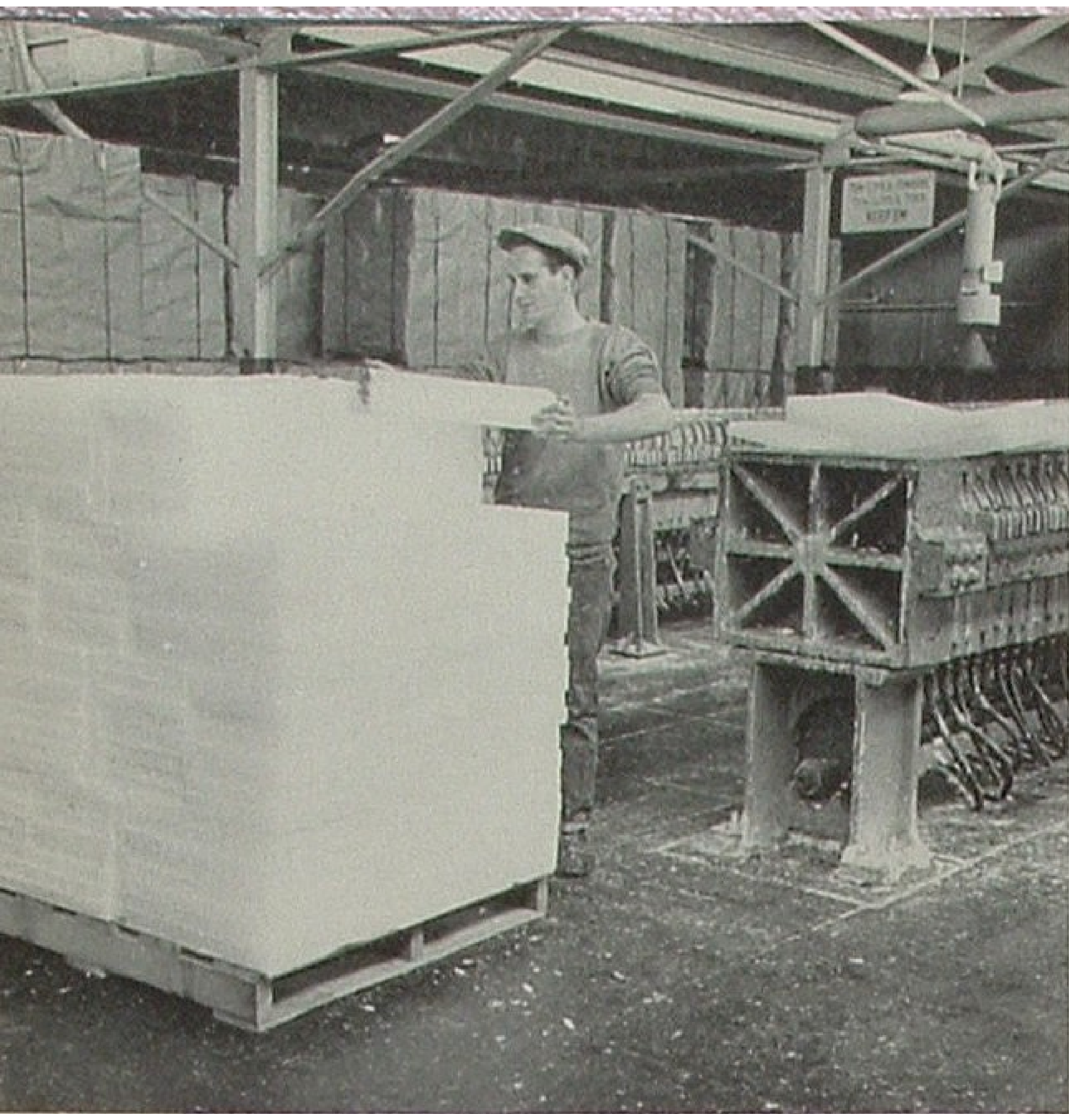


aid of two solvents, Selecto and propane. Only the propane separated raffinate is used in manufacture of lubricants.

This unit, one of the largest and most modern of its kind, is operated to a maximum degree through instrumentation.





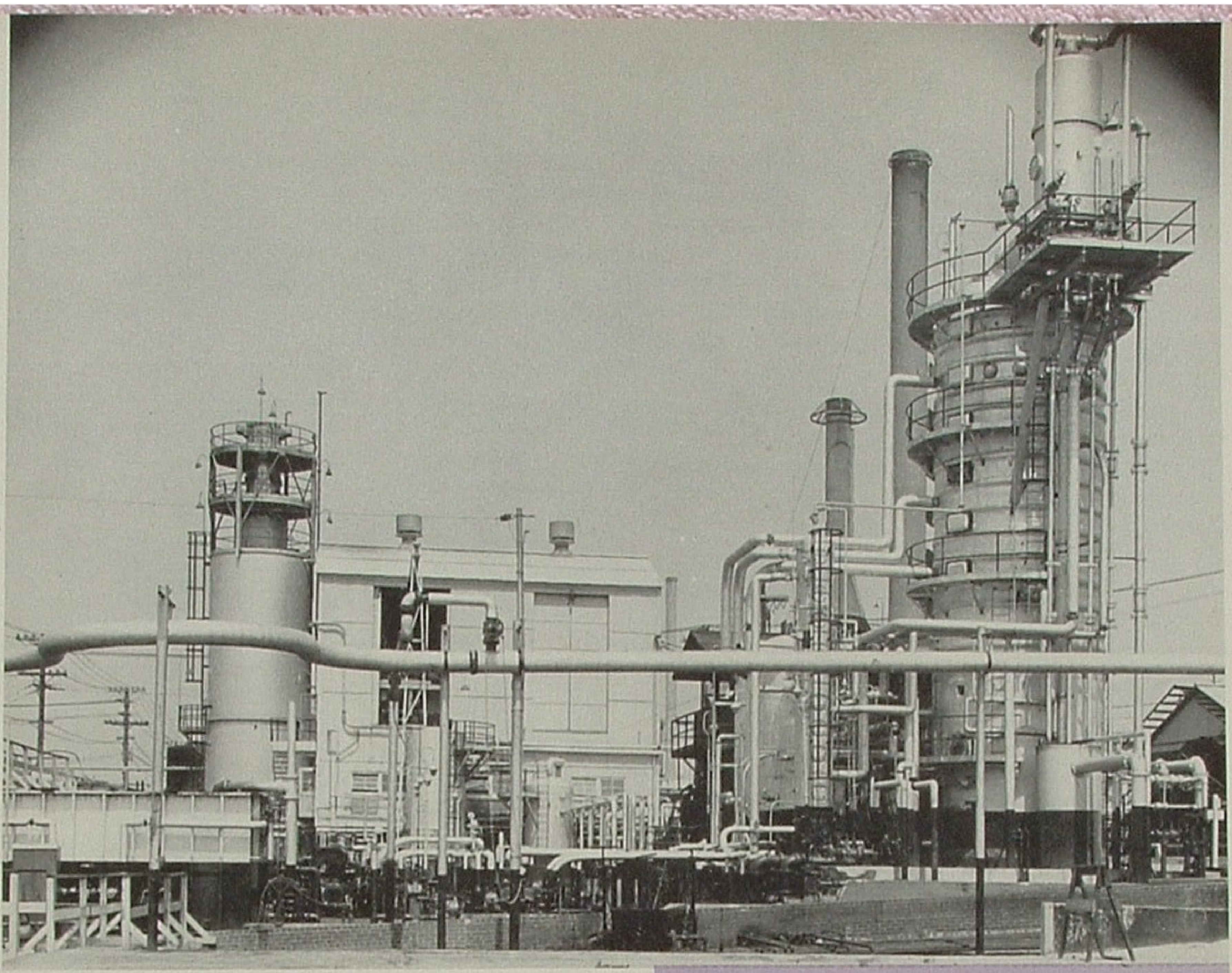


Dewaxing Unit 210

Propane, the solvent with *quality* tastes in the Duo Sol process, is now called upon to achieve a second separation in Oleum's Dewaxing Unit 210. Normally gaseous at atmospheric temperatures and pressures, propane is first compressed and cooled to a liquid, then added under pressure to the raffinate feed stream. When this pressure is released slightly, the propane begins to boil off or evaporate, and in so doing draws heat from or chills the raffinate. When the oil gives up enough heat or cools to a temperature of minus 40 degrees F., nearly all of its paraffinic wax hardens or crystallizes into solid form. The wax crystals are then simply removed by straining the cold propane solution through layers of fabric. This filtering takes place on rotary drums where, through glass apertures, observers can watch the solid waxes and liquid oils take leave of each other.

Propane from the dewaxing process is conditioned for reuse. The paraffinic waxes are cleansed of oil impurities and packaged for hundreds of industrial uses under the brand name of Aristowax. The oil, now called *dewaxed long raffinate,* moves through a pipe line toward the concluding steps of its refinement.

Dewaxing of the oil-rich raffinate is accomplished in facilities below through a propane-chilling process. At minus 40 degrees F., nearly all of the oil's paraffinic wax crystallizes and is removed by filtering. The wax, above, is marketed under the brand name of Aristowax. The dewaxed raffinate follows a pipe line route to Unit 105.



Clay Fractionation Unit 105

Clay takes part in Oleum's refining processes as a means of removing from oil stocks small quantities of color bodies and unstable substances that might lower the oil's resistance to oxidation. The clay used is a type of fuller's earth mined in the West. It is mixed in closely controlled amounts with the feed stream of dewaxed raffinate, producing a *clay-oil slurry*.

When heated to about 675 degrees F. and pumped into the vacuum distillation column of Clay Fractionation Unit 105, this slurry separates into three viscosities. Two are vapor fractions, which, after condensing on overhead trays, emerge as finished *neutral oils* of light and medium viscosities. The liquid bottom stream, containing clay, is sent through a rotary type filter to remove all traces of clay and accompanying impurities. It then becomes known as *bright stock* and constitutes the third or heavy grade of completely refined oil. From these three stocks are blended all intermediate viscosities of lubricating oils.

Thus, from San Joaquin light refining crude and through solvent refining we have obtained oil stocks of highest commercial quality. They are the mineral oils best suited to the rigorous requirements of internal combustion engines.

Fuller's earth is measured, below, into the oil to remove its few remaining color bodies and unstable compounds. Then, in other facilities of Unit 105, above, the oil is filtered and distilled, emerging in light, medium and heavy grades of finest lubricating stocks from which all viscosities are blended.

Grease Manufacture

Certain types of bearing surfaces—notably wheel bearings and axles, the chassis of an automobile, etc.—are more efficiently lubricated with tenacious, heavy-bodied oils that do not tend to drip off or wash away. Even the heavy *bright stock* we have described is too light in viscosity to satisfy such demands. So oil refiners have had to improvise.

For many years the journals or bearings of railway cars have been lubricated by packing journal boxes with oil-soaked cotton waste. Acting as a wick, the waste keeps constantly at work coating the bearing with a thin film of lubricant.

In much the same manner petroleum greases keep other types of bearings lubricated, except that most of the greases employ *soaps* as thickening agents or stabilizing structures. The soaps we speak of are generally prepared by chemically combining fats, such as our beef tallow, with carefully selected metallic hydroxides. Unlike cotton waste, the soaps themselves may have considerable lubrication value.

A vast amount of research has centered around the development of good greases, particularly in regard to the metallic hydroxides or *bases*. For it is the base that often governs where and how a grease may be used.

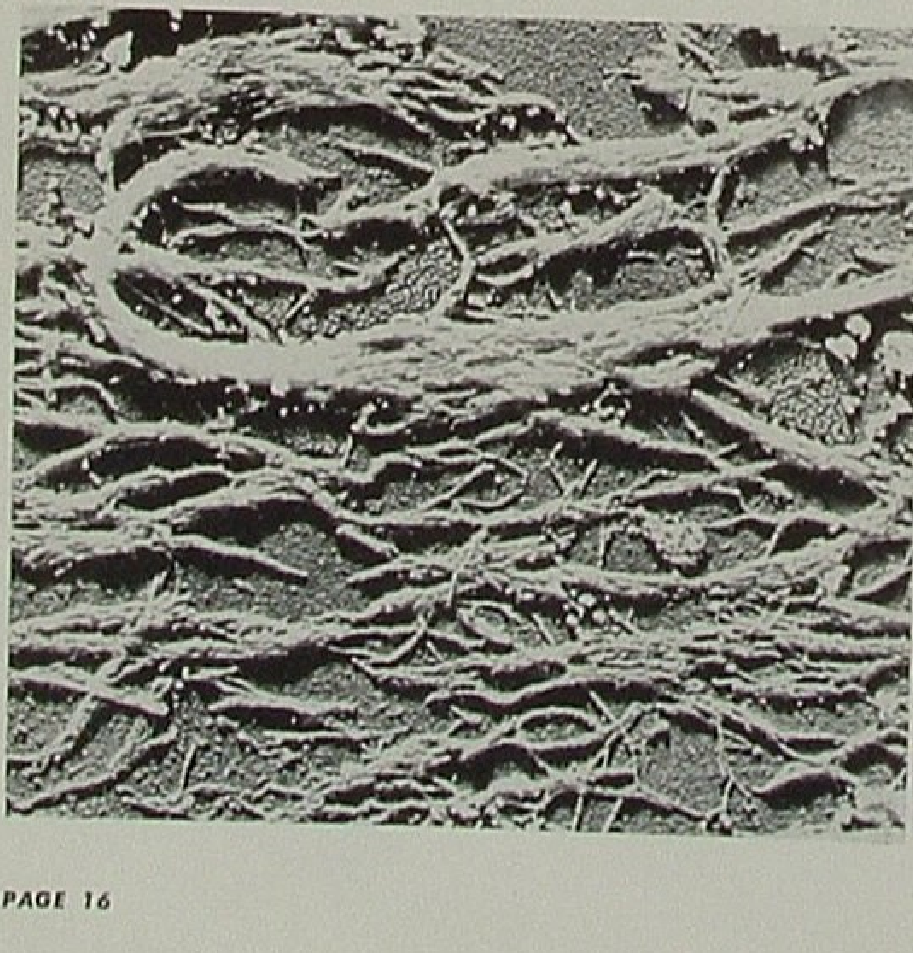
It was found, for instance, that greases made with a *sodium* base had very good resistance to high temperatures but would not stand up in the presence of water. *Calcium* base greases, on the other hand, had good water resistance but were failures if subjected to anything above mild temperatures. *Aluminum* base greases offered a pleasing translucent appearance but were inferior to sodium greases from the heat standpoint and to calcium greases from the cost standpoint.

Shortly before World War II, Union Oil climaxed a lengthy search through nature's stockpile of metallic hydroxides with the selection of an ideal *barium* compound. Here, for the first time in the history of grease making, was a base with excellent stability under high-heat conditions, or in the presence of water, or under operating conditions where both heat and water had to be contended with. In other words, it was the world's first multi-purpose grease. Furthermore, it could be manufactured and sold within the so-called "popular" price range of other lubricants.

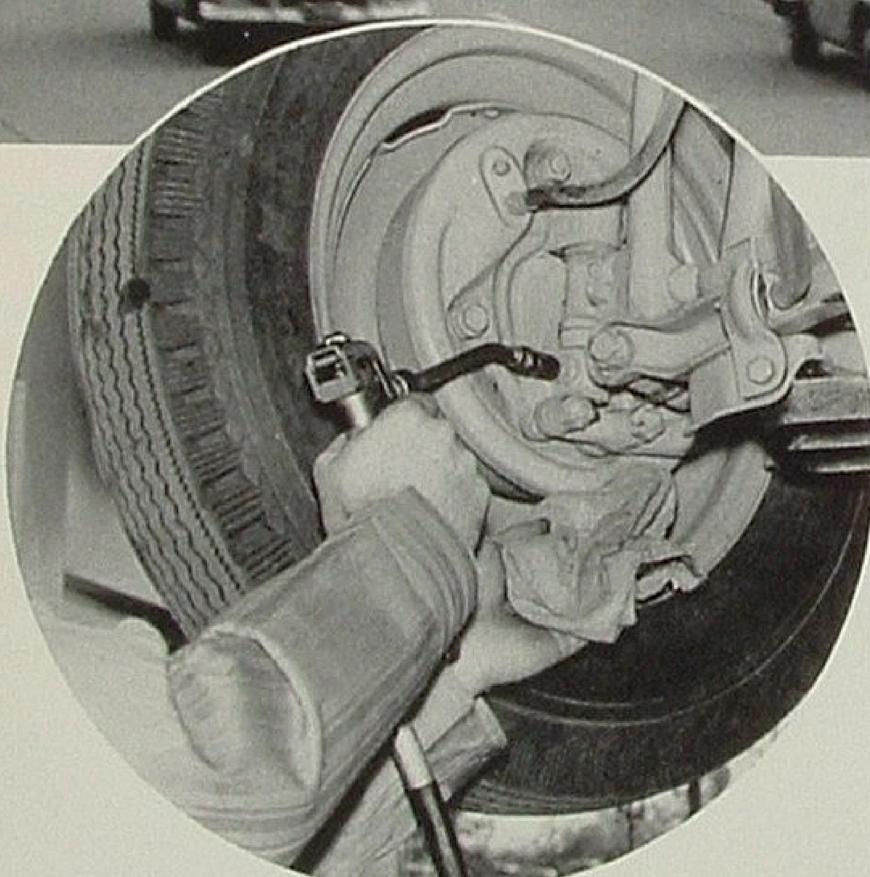
Certainly no Union Oil products have ever met with more spontaneous success than has this barium base lubricant, which we call Unoba Grease. It was the answer to many heat-and-moisture mechanical operations that had previously defied efficient lubrication. Unoba also greatly simplified grease application in general by decreasing the varieties needed and somewhat reducing the dangers of product misapplication. Its present use throughout the United States and on all five continents is proof of Unoba's quality.

Greases are made by chemically compounding the metallic hydroxide and fat with selected lubricating oil stocks such as those we have been discussing. The compounding is done in large grease kettles, the largest of which will accommodate a batch of 20,000 pounds. Immense electrically-driven paddles stir the ingredients together. Heat is added in precisely controlled amounts to properly assist the reaction and expel excess moisture. When perfectly compounded, the grease is sealed in metal containers holding from one pound up to 500.

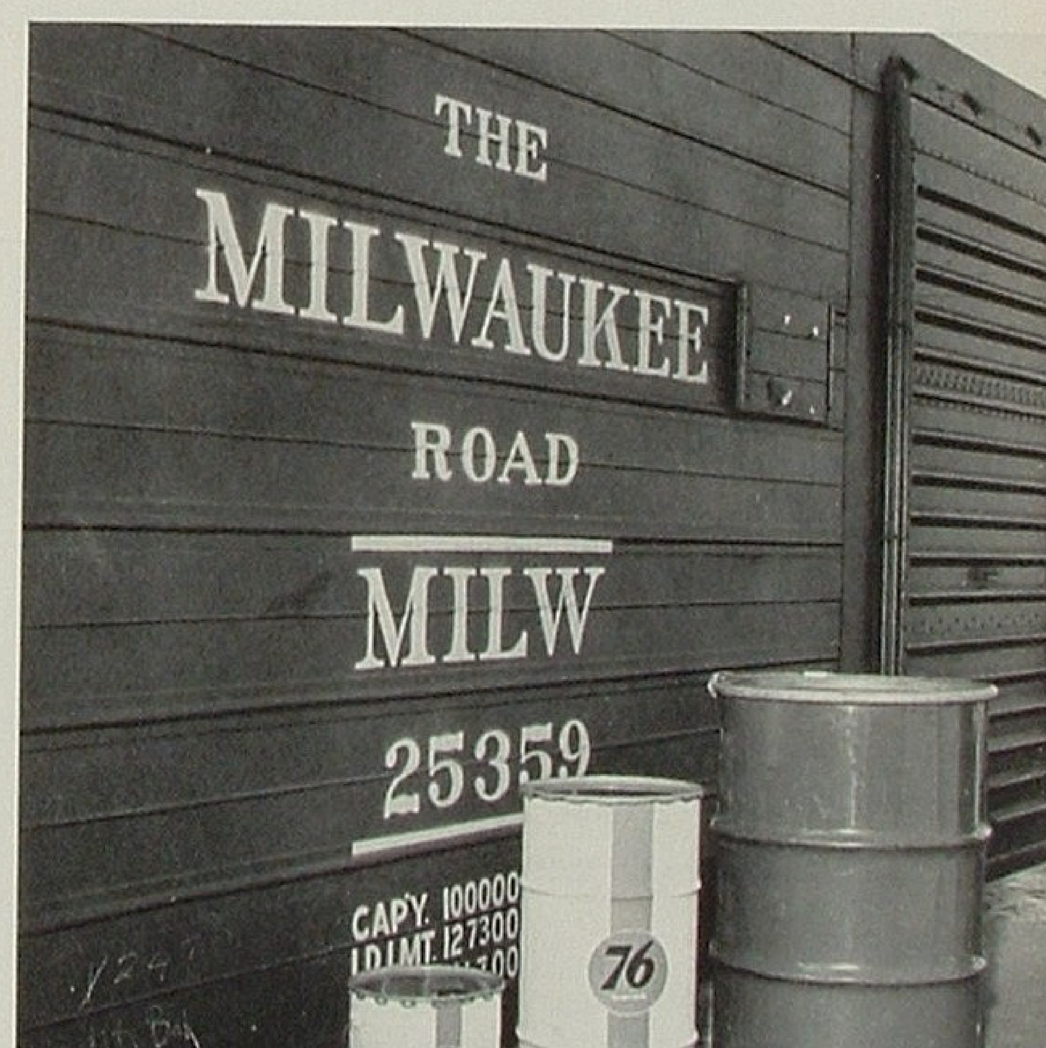
By enlarging a particle of grease to 45,000 magnifications, the electron microscope shows us how lubricating oil is held in a rope-like soap base or structure.



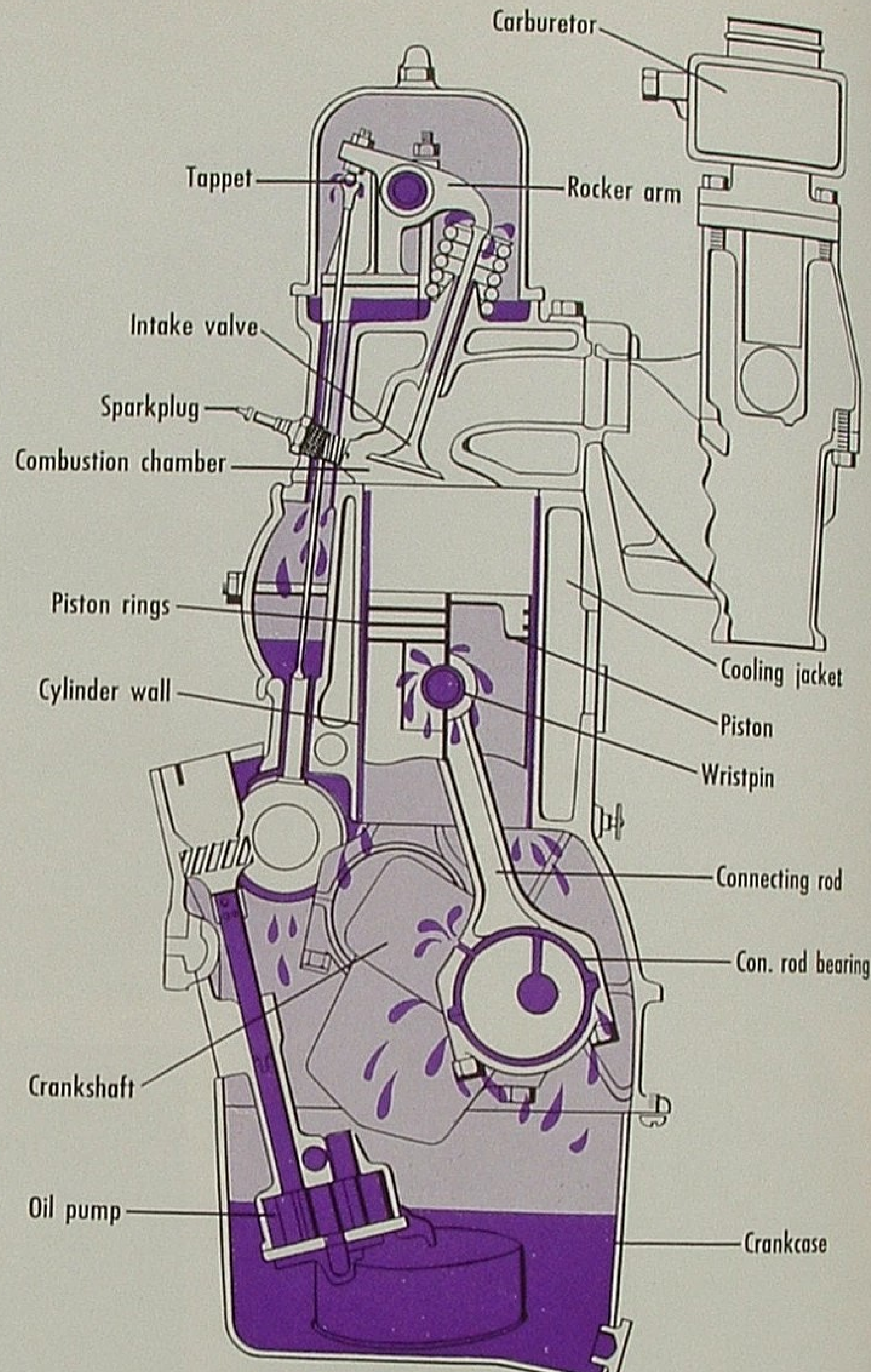
The compounding of oil and soaps into grease is done in immense kettles wherein the ingredients are carefully stirred and heated to assure proper chemical blending.



Union Oil's Unoba Grease was the world's first multi-purpose grease. As one example of its merits, it replaces three greases formerly required to lubricate the chassis, wheel bearings and water pump of an automobile. The demand for it by industry has grown to be world-wide.



Functions of A Motor Oil



Before considering the final steps in the manufacture of finest motor oils, let's look at the inside of an automobile motor. For it is in this mechanical torture chamber that oil undergoes some of its severest tests and performs some of its greatest service.

The internal combustion engine in its simplest version begins with a heavy metal cell known as the *combustion chamber.* A mechanically opened and spring closed *intake valve* admits mixtures of vaporized gasoline and air into the combustion chamber and seals off their escape. Through another aperture in the cell, a *spark plug* gives off perfectly timed electrical sparks to ignite each charge of fuel. The resulting explosion expends itself in all directions, but succeeds in moving only a *piston* occupying part of the combustion chamber floor. The piston is joined by a *connecting rod* to a *crank shaft* in such manner that the piston's forced descent cranks or turns the shaft. Repeated explosions keep the shaft turning in the same direction, and, through a system of gears, this power is transmitted to the vehicles's drive wheels.

Throughout the mechanical sequence, oil plays an important role. The piston, equipped with several flexible *piston rings,* races up and down the *cylinder wall* with each compression stroke and explosion. Therefore, oil must supply a protective film between cylinder wall, piston and piston rings. Oil must also lubricate the valve parts; the *wrist pin,* where connecting rod and piston join together; the *con rod* bearing, where connecting rod and crank shaft meet; all main bearings supporting the crank shaft; and numerous other working parts of the engine.

Combustion engines, moreover, demand more than just a lubricant. Oil that keeps the piston rings and cylinder walls from grinding each other into metallic bits must also serve as a *seal.* Its sealing effect prevents compression waste or loss during the explosion, seals exhaust gases from pushing through into the *crankcase,* and seals itself from entering the combustion chamber.

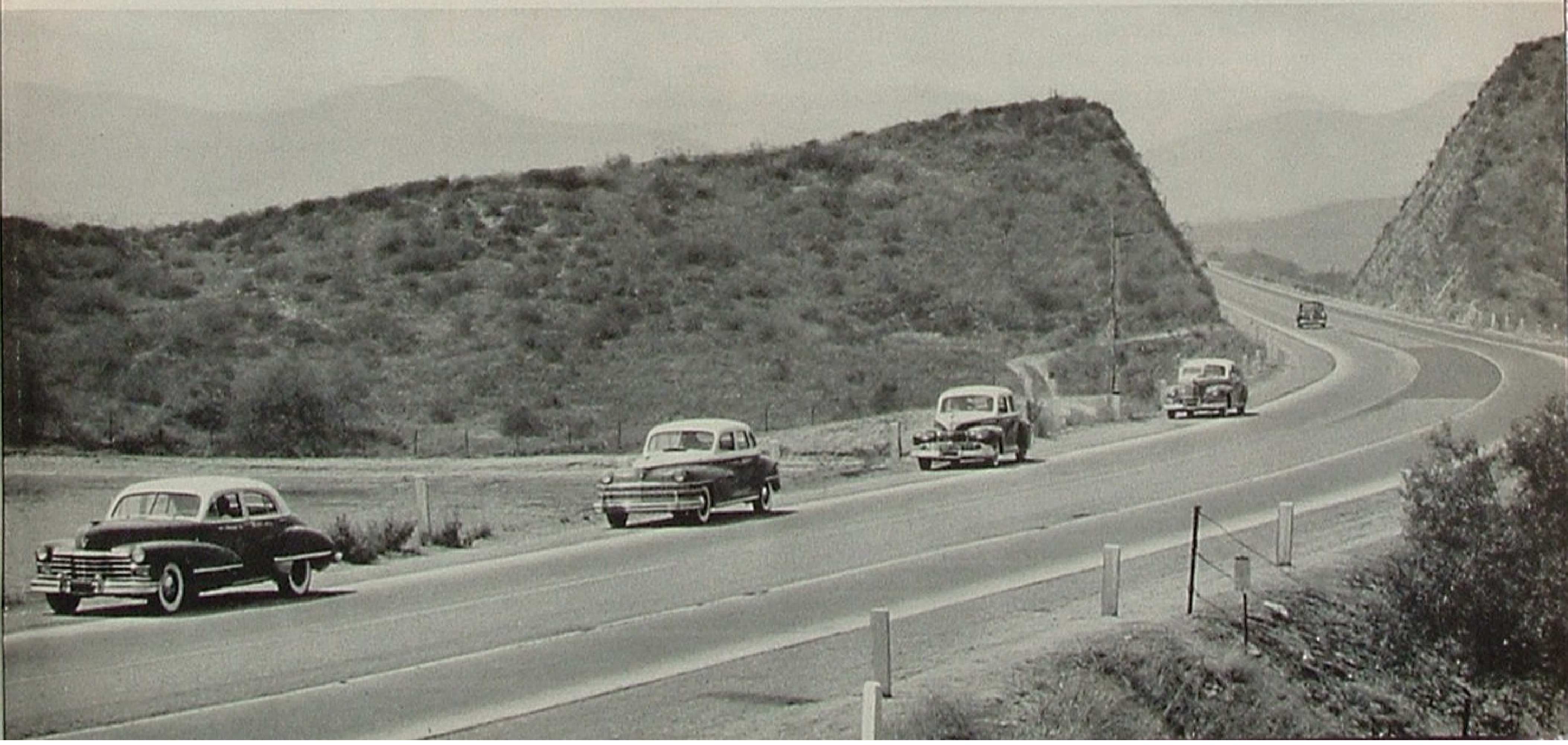
Oil too acts as a *coolant* in helping to carry heat away from the combustion chamber. An oil film between the piston and cylinder wall transmits the heat of combustion through the cylinder wall to the circulating water of a motor's *cooling system*. In some engines large volumes of oil are sprayed up to the under side of the piston, further attracting and carrying away the heat of each gas-air explosion.

No matter how clean are the fuel and air supplied to a motor, their burning or explosion results in a certain amount of deposit commonly spoken of as "carbon." Actually, such deposits are quite unlike pure carbon found in the elements of nature and should not be so confused. Most of this unwanted product of combustion is ejected through the motor's exhaust. But some of it remains on metal surfaces, like soot in a chimney. In time, valves, cylinder walls and piston rings could become coated or lacquered with the stubborn substances. The result would be faulty fuel control on the part of valves, the sticking of piston rings, and engine overheating due to a combination of increased engine deposits and increased friction. Here again oil performs a valuable service—that of cleaning agent. The ability of a good oil to hold these waste materials in suspension and thus keep an engine clean is usually referred to as *detergency*.

To summarize, a motor oil is a lubricant, a coolant, a seal, a detergent. And how well it performs each and all of these services is the surest indication of its quality.

Research technicians do more than judge the performance of an oil. They disassemble the test engine and measure every part for wear and mechanical failure.

Below, this fleet of five cars originally tested our compounded motor oil by traveling 30,000 miles over all types of highways without once stopping to change oil.



Union Oil chemists tested thousands of potentially useful compounds in their search for the outstanding combinations of additives now enriching our finest motor oils.

Lubricating Oil Additives

There is a limit of course to the quality that can be attained in a motor oil through careful selection of crude stocks and scrupulous refining. And having practically reached that limit when solvent refining was adopted, Union Oil chemists began turning their studies in a different direction. Said they, if we cannot further improve lubricating oil stocks via refining, perhaps we can strengthen the natural properties of oils by adding something.

Well, additives had been used before in the manufacture of special oils. We had added animal fats to steam cylinder oil and found that the compounded lubricant adhered better to metal surfaces in the presence of steam. Machine oils, when fortified with certain compounds, also clung more tenaciously to bearing surfaces. But could any compound be added to improve the viscosity index, oxidation resistance, acid resistance, detergency and other characteristics of a motor oil? Certainly the motor manufacturers hoped so, for their new high-speed diesel engines and sensitive high-power, high-compression gasoline motors were beginning to demand something better than the best.

For more than two decades, Union Oil's Research Department has been at the forefront of a spirited and highly competitive quest for additives. Our chemists have tested thousands of potentially useful compounds in an effort to identify those best suited to new and possible future demands of motor oils. And the quest has been highly successful. The compounds being added to our quality oils today, whether manufactured under Union Oil patents or obtained from other inventive sources, constitute the finest combination of additives available.

The composition of lube oil additives, some of which are of petroleum origin, is too involved a subject for this text. Nevertheless, we should like to mention the more important types now in use and indicate what each does to improve a motor oil.

Pour point depressants have the faculty of lowering the minimum temperature at which an oil will flow. Paraffinic oils in particular retain a few paraffinic molecules, which at extremely low temperatures tend to congeal into wax crystals. By keeping such paraffinic crystals dispersed, the oil is free to flow at a much lower temperature than otherwise. The additive is especially valuable for use in cold climates, for flying conditions at high altitudes, and for oils used in refrigerating plants and equipment.

Anti-oxidants retard oxidation of the oil itself, which oxidation would cause the formation of harmful sludges and corrosive compounds. Oils with this additive perform longer at higher temperatures. They greatly decrease engine maintenance problems formerly attributed to sludge. Furthermore, if it were not possible to thus inhibit oil oxidation, several of the world's newest and best bearing materials could not be used successfully.

Although oil has some cleansing characteristics of its own, these hardly match the clean-up job required in diesel engines and the newer types of gasoline motors. Consequently, a special *detergent* additive was sought and found. It greatly augments the oil's ability to keep engine surfaces free from combustion contaminants. Rather than accumulating into sludges and other heavy engine deposits, cleanings are held suspended in the oil in microscopic particles, preventing clogging and abrasive wear on engine parts.

Some detergents also have a quality known as *alkaline reserve*, which is helpful in neutralizing the acid by-products of fuel combustion.

A tendency of oils to foam in certain types of lubrication systems was aggravated by several of the newer compounds. Chemists, therefore, have formulated an *anti-foaming* agent to fully solve the problem.

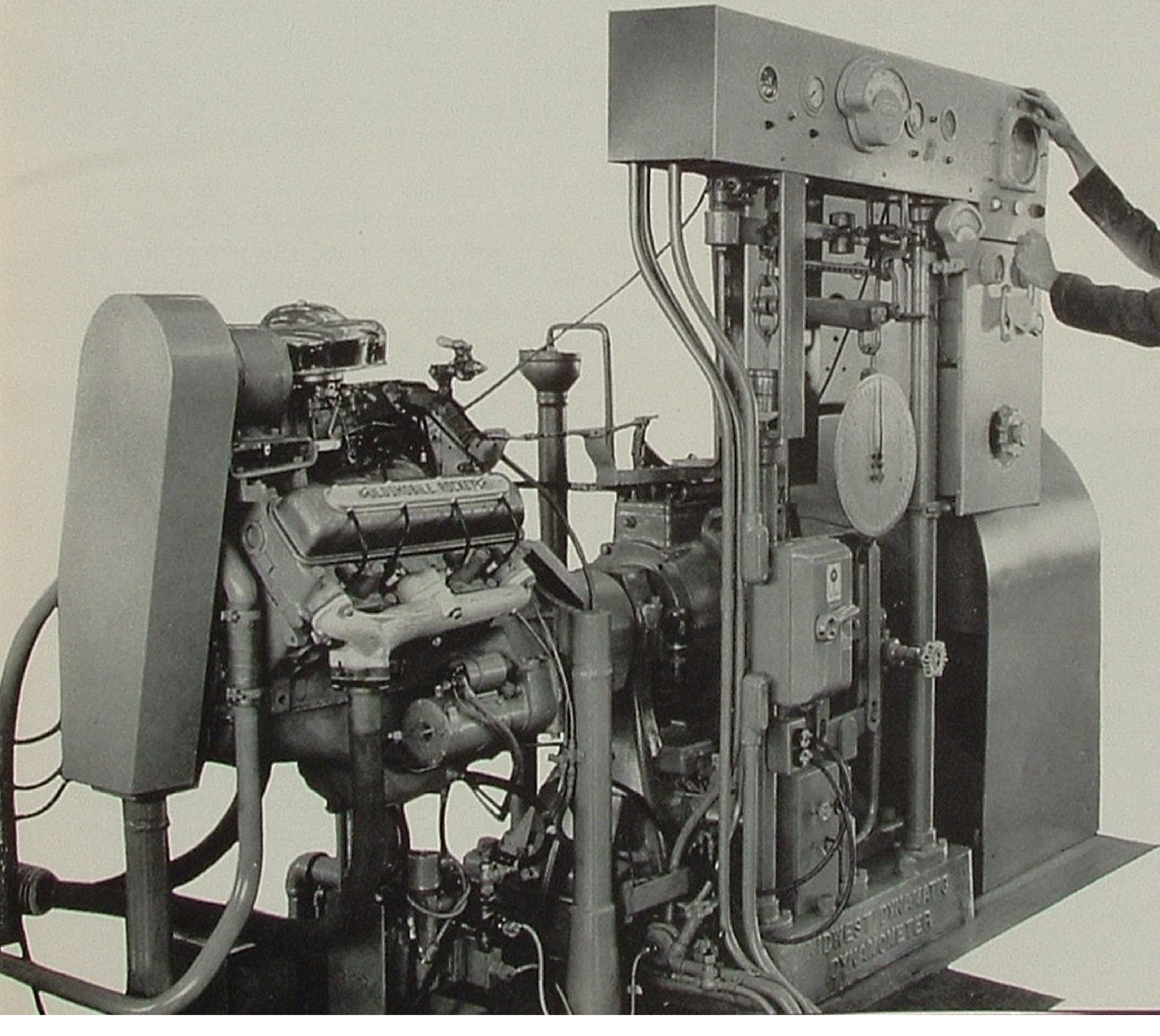
Unlike the previously described anti-oxidants, which retard the oxidation of oil, other types of additives, called *corrosion inhibitors*, prevent the chemical deterioration of metals in bearings, etc. These inhibitors do their work by actually combining chemically with the surface of a bearing.

Rust preventives are especially valuable for the protection of engines that operate only on occasion or of equipment being placed in storage for a long period. The additive helps to coat a metal surface, sealing out moisture that would in time cause the metal to rust.

Viscosity index improvers are effective in making an oil's viscosity more resistant to temperature changes. In other words, such additives lessen a motor oil's tendency to thicken at low temperatures when a motor is cold, or to thin out beyond the oil's proper operating viscosity when the motor is running at high temperatures. Similarly, a viscosity index improver can lessen the need for changing grades of oil in conformity with seasonal extremes.

Even the knocking tendency of cars can be retarded with scientifically compounded oil. Right, Royal Triton 5-20 proved this fact in tests with various grades of gasoline.

In the Research Department's engine lab, finished oils are placed in conventional motors and subjected to many of the extreme operating conditions oils may encounter.



The Royal Family

In conclusion, may we introduce several representative members of the "Royal" family by briefly describing the realm of public service in which each is engaged?

In general it should be remembered that these oils come from the same basic paraffinic stock of highest petroleum lineage. All are solvent refined—scientifically perfected — thoroughly tested. All are compounded lubricants. But each has individual values and qualities due to varying types and amounts of additives used in the final compounding.

TRITON MOTOR OIL, pioneer of the group and of the industry's new solvent refining era, has kept pace year after year with advancing techniques and continues to hold an enviable place among competitive oils. It was our first 100 per cent paraffin base oil and our first compounded motor oil available to the motorist. Its gradual improvement with additives has brought increased engine efficiency and important economies to thousands of consumers.

Neatly packaged in metal containers, Union Oil lubricants, including the "Royal" family, are assembled in an Oleum warehouse, awaiting orders to report for service.

ROYAL TRITON is our extra-quality motor oil. Its superiority to Triton is achieved through heavier compounding. The additives used in Royal Triton were in part the outgrowth of governmental pleas for lubricants that would stand up under extremely abusive military operations. Our compounded oils, built to military specifications or better, acquitted themselves so well during war years as to make their peacetime acceptance largely a matter of availability. Royal's purple color is traced to an additive used during early formulation tests. This outstanding oil is designed for the most exacting requirements of the most advanced automotive engines now being produced. It provides an added margin of protection for motors subjected to severe usage and conditions. To buyers of extra-quality products, it brings peace of mind at very little extra cost.

T5X is the industrial equivalent of Royal Triton. Like the latter, it is more heavily fortified with compounds that greatly bolster an oil's detergency and alkaline reserve. Operators of diesel trucks, large gasoline-powered equipment, tractors and stationary industrial engines are most enthusiastic about T5X, which originally proved its worth in heavy equipment of the U. S. military forces.

Brand-new members of our quality line are **ROYAL TRITON 5-20 AND ROYAL TRITON 10-30.** You have heard perhaps that a large amount of wear takes place in internal combustion engines during the warm-up period, when the oil is too cold and viscous to reach every engine part. If a light oil of SAE 5W or 10W grade is used, start-up wear is minimized. But older oils of such light viscosity were inclined to thin out too much when heated to a motor's normal operating temperature. So our Research people recently turned again to additives for a possible answer. Through the use of a selected neutral oil and special compounds, they have now accomplished a remarkable advance. The two new oils

But even the finest oils must be used to be appreciated, and that is where salesmanship comes in. Most of our quality products are sold by the gallon and quart through a service station system rated also as America's finest.

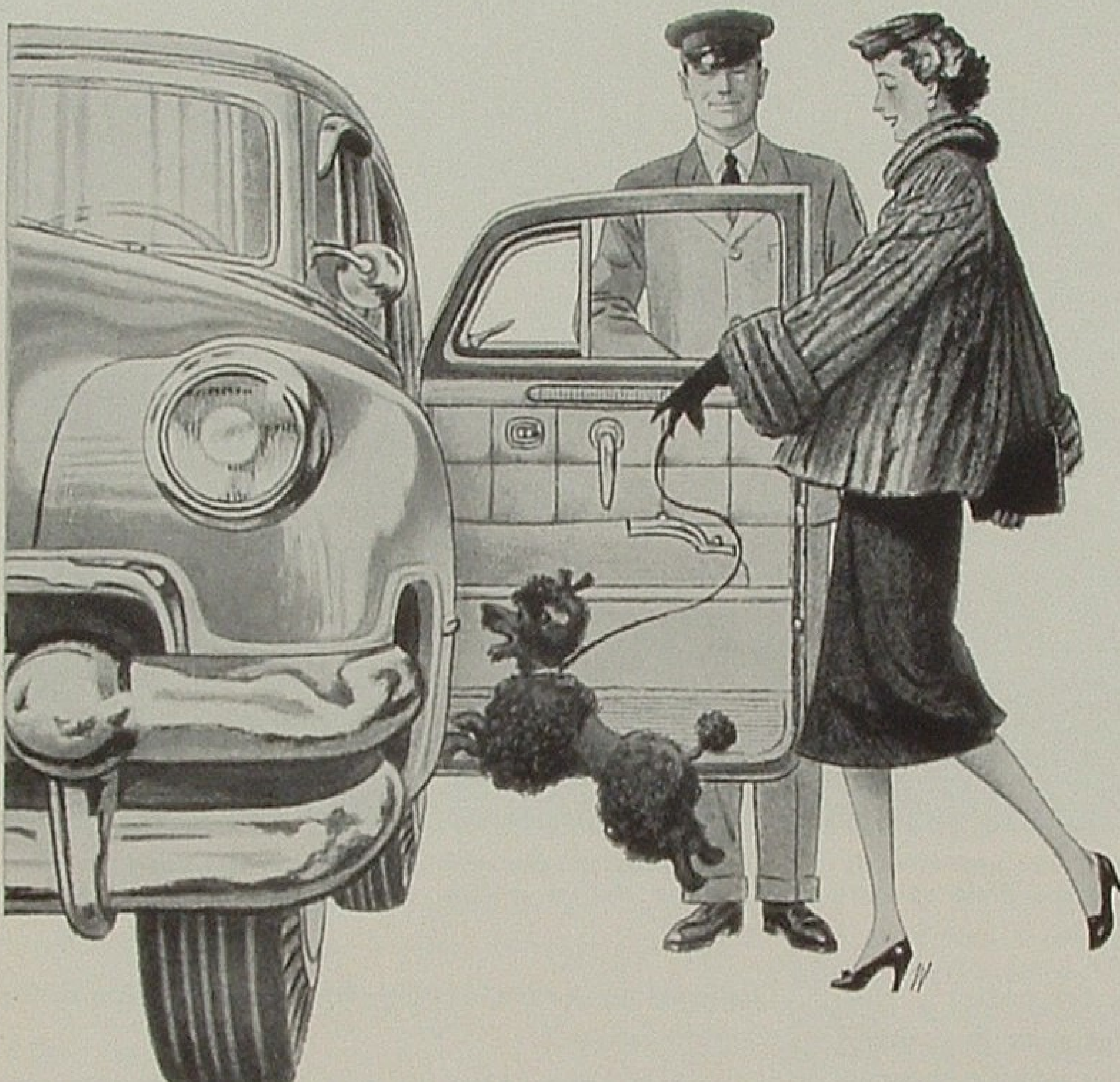
flow like SAE 5W or 10W grades the instant a cold motor is started, yet do not thin out more than would an SAE 20 or 30 grade oil at high operating temperatures. The numerals identifying each of the new products therefore refer to the oil's viscosity characteristics while lubricating either a cold or warmed-up motor.

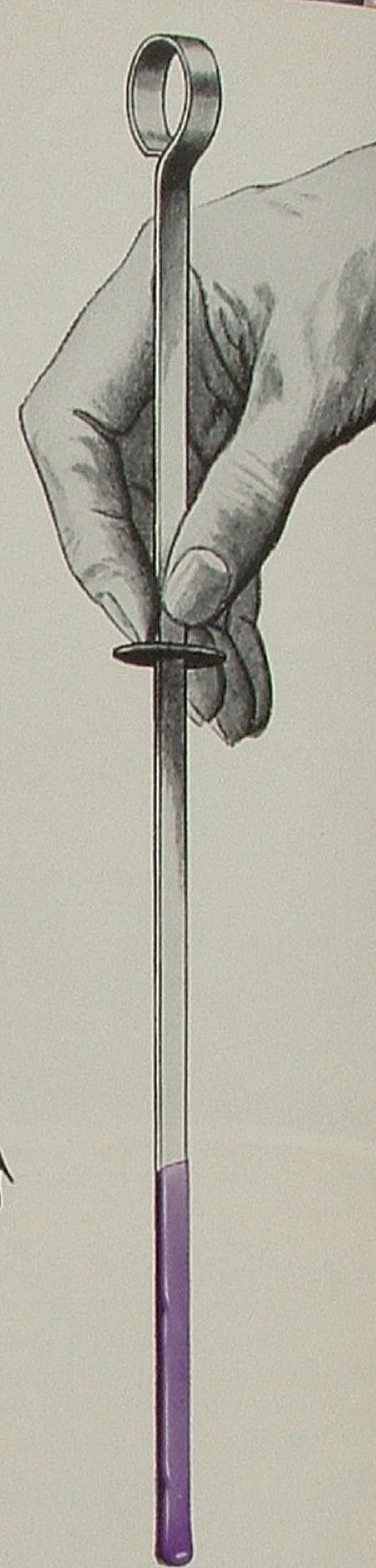
Royal Triton 5-20 and Royal Triton 10-30 lead one of the greatest advances being made today in prolonging both peak engine performance and engine life through motor oil improvement. Their superior properties as all-season, all-weather lubricants should be obvious.

Last and most heavily compounded of the quality lubricating oils we have chosen to mention is **GUARDOL.** It is an industrial specialist of the Royal family—heavily armed with special compounds required for the efficient operation of diesel engines using low grade fuels. Originally developed for the supercharged diesel engine, GUARDOL is now distinguishing itself in other fields of lubrication service where fuels of higher-sulfur content are used.

The Company's selection of such words as "Royal" and "The Finest" to describe our Union Oil line of top quality lubricants was, therefore, no mere figment of advertising. Rather, the products have merited their distinction and all the good things we are inclined to say about them. They come from the *finest* types of paraffinic stock to be found anywhere. They are processed in the *finest* manufacturing and compounding units known to the petroleum industry. They are enriched with the *finest* compounds science can devise. They have passed with *finest* distinction every scientific test of the laboratory and every practical test of the open road. And behind the accomplishments, or carrying them forward toward new heights of achievement, are the *finest* talents, *finest* skills and *finest* efforts of Union Oil people—in our opinion some of the *finest* members of American royalty.

The measure of protection in America's Finest cars





Purple Royal Triton

AMERICA'S FINEST MOTOR OIL

When your engine's dipstick shows the royal purple of Royal Triton motor oil you're certain your car has the finest lubrication money can buy.

For Royal Triton is made without compromise to do more, far more, to protect your car's engine. That's why—though it is one of the world's costliest motor oils—it is the least expensive life insurance *your* car can have.

Purple Royal Triton motor oil. Now available in the amazing new all-weather 5-20 and 10-30 grades at car dealers and service stations in most areas of the United States and Canada, and Union 76 stations throughout the West.

UNION OIL 76 COMPANY OF CALIFORNIA

The West's Oldest and Largest Independent Oil Company