LUTION OF THE OIL INDUSTRY

VICTOR ROSS

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The first oil well drilled near Titusville, Pa., on August 27, 1859, by Col. Edwin L. Drake, the pioneer man of the world

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BY
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PREFACE

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A glance at the chapter headings in this little book shows that it is an endeavour to present in succinct form a survey of a great and ever-expanding economic revolution—the interpenetration by petroleum of all industries, whether of the factory or the field, land or sea, war or peace. This phenomenon has been almost exclusively a development of the past six decades, and the United States of America have been the predominant factor in the innumerable changes wrought thereby. The narrative confines itself rigidly to historic records and material facts, undeniably romantic in themselves. But as the epic unfolds itself, it assumes a super-phase, the import of which cannot be measured by mere figures —a super-phase with invaluable applications to the problems of humanity in an industrial age.

Petroleum, it becomes clear, was the first natural product to which the abstract theory of order, as understood by modern social philosophers, was applied in a large and general sense. It must be accounted good fortune not only for America but for the world at large, that this movement, though gradual at the outset, commenced almost within a decade of the birth of the modern petroleum industry at Titusville, Pa., in 1859. The outcome has tended to influence economic thought the world over, especially since war on an unprecedented scale put all established systems, traditions, and institutions to the acid test.

Foreign observers and critics, friendly or unfriendly, admit that in one matter American foresight and enterprise have taught the older nations valuable lessons—and that is in respect of standardized production—or to put it in another way, organized industry. America's achievements in this domain during the past half century have represented incalculable and beneficial advancement beyond the industrial conditions of all past centuries. With this record of progress, the growth and expansion of the petroleum industry have been inseparably associated. The famous pioneers in organizing the production, refining and distribution of petroleum have also been pioneers in the application of the principle of order to industry; which, in essence, means the elimination of waste and misdirected energy from human effort.

Organized industry means something entirely different from a system aiming at quick and enormous profits. It is based on a definite theory of scientific effort, whereby all the possibilities of a given resource are developed to their fullest degree, so that waste ceases, the value of the worker's labour is increased with benefits to himself, and the consumer receives the blessings of nature's dower at the lowest reasonable cost. As the ensuing chapters show, the accomplishment of these objects in the case of petroleum has involved much more than the application of the physical sciences to manufacturing processes. It has meant the development of systematized methods in discovery and location, transportation and distribution, so that from the moment oil is "struck," in say a barren patch of prairie, until any one of the many products of crude petroleum is placed in the hands of the consumer—here, or in some distant isle of the sea—there shall be no waste and no injustice, and that all the hands through which it passes shall reap a just benefit.

The far-sighted Americans of the transition period in this country's history, who created the modern petroleum industry, and built up the machinery for its continuous expansion, began with the definite aim of involving order from chaos. They were from the outset reformers of business methods and enemies of waste. The latter had become colossal during the unsettled years that were marked by the duration and aftermath of civil war. The work of these business pioneers was gradual, but it developed an ever-increasing impetus; and as the years went on the ethical import of their mission became more and more apparent. It would be wide of the facts to say that the element of gain played no part in these developments. Little indeed would be accomplished in the way of progress were the incentive of personal gain in some form or other removed. On this point the Scottish economist, Adam Smith, spoke pertinently one hundred and fifty years or more ago: "By pursuing his own interest a man frequently promotes that of society more effectually than when he really intends to promote it." Nevertheless it is clear that in the case of some of the leaders most closely indentified with the organization of the petroleum industry, personal motive and energy were supplemented by a sincere desire to promote the prosperity and welfare of the American people as a whole.

Coming to the larger question of what the principle of order means to humanity in the abstract, it must be noted that all modern thinkers whether they be supporters of capitalism—the system on which all past industrial and national progress has been based—or intellectual socialists pin their faith to that principle as the sole means whereby mankind can be raised to a higher level. Moderate socialists are especially emphatic on this point and it is the key-note of their writings. They attribute the great mass of poverty and suffering which still exists in this world to lack of order—to the failure of mankind, in the individual and in the aggregate, adequately to realize its importance. The goal which all enlightened men, of whatever school of thought, desire to see attained, is the abolition of poverty; not the imaginary poverty of the man who chafes because he cannot have everything he desires; but the actual, galling poverty that is born of the worker's inability to produce sufficient to earn rewards that will enable him to live according to decent standards. It is to the eternal credit of the leaders of the petroleum industry in America that they have set a beacon of order and efficiency which lights the road by which that great end—the abolition of poverty—may be reached. It is a principle that runs like a golden thread through the vast and complex system that has grown up around petroleum.

The ensuing chapters show how much it has meant in prosperity and progress to the world at large to have a great natural resource like petroleum developed to the fullest degree of its potentialities, so that all who come in contact with it participate in some measure in the benefits. These considerations are obviously of greater importance than some others which have been impressed on the public mind in exaggerated terms. The fact that a few men of organizing genius may have reaped fortunes in consummating the aim of bringing order out of chaos and turning waste to profit is of slight significance in comparison with the certainty that millions of people have been benefited by their operations. It is one of the rooted axioms born of human experience that genius of whatever order, so long as it assists civilization, is entitled to exceptional rewards. Particularly is it true of that rare order of genius which lies back of directing minds. Without their leadership the efforts of humanity to advance itself would be in vain. What the extraordinarily efficient organization of the petroleum industry has meant in wealth to such leaders is in the aggregate but a drop in the bucket in comparison with the benefits conferred on the people as a whole—increasing rewards for the producer in every stage of its development, lowered costs for the consumer, and stimulus to countless forms of industrial activity.

Thus it can be truthfully maintained that the spirit of coöperation, honest endeavour and hatred of waste and slovenly methods by which the present condition of that industry has been achieved offers a valuable and well recognized message from America to the world at large, and suggests a solution for many of the ills that beset civilization to-day.

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CHAPTER I

PETROLEUM IN HISTORY AND LEGEND

WHILE the petroleum industry is in the fullest sense modern, it has been known to, and casually utilized by mankind for centuries. It is named in the earliest annals of the race; and allusions to it are abundant in the literature of the East, from which much of our Western literature had its inspiration. It was applied to the service of religion, and was a subject of superstition in times which are enshrouded in legend. In the authorized Bible and in the Apocrypha there are more than two hundred allusions to it. The legend of Noah speaks of his having used pitch to tighten the seams of his ark, which certainly indicates a familiarity with the uses of fluid bitumen available in the East. In Deuteronomy there is mention of "oil out of the flinty rock;" and Biblical students could cite countless other instances where the meaning clearly indicates a common use of the surface deposits of Western Asia.

It is believed to have been a strong factor in trade between Ancient Judea and Persia, which latter country has again in the twentieth century become a factor in oil production. It played its part in the worship not only of the Hebrews but of other Eastern nations, and to the primitive minds of those peoples assumed miraculous characteristics. The burning wells of Baku were the objective of religious pilgrimages among the prehistoric peoples; and despite the colossal waste of past ages these wells still flow and are a factor in commerce. The Zoroastrians, or Fire Worshippers, a sect of Persian origin, which gained many adherents in ancient India also, regarded these wells as the manifestations of a great imprisoned spirit, who was supposed to breathe inflammable vapour from his nostrils. Zoroaster has a temple at Baku, and students of folk-lore hold that these burning wells helped to confirm the belief in a literal Hell of fire, common to races of Semitic origin. The Macedonian conqueror of Asia, Alexander the Great, witnessed the burning lake of Ectabana in his march to the east, centuries before the Christian era. Marco Polo, the Italian explorer of the middle ages, among many fables, revealed to Europe the truth about the oil resources in

Baku, and had sufficient of the instincts of a trader to discern their commercial value. Well-founded belief in the medicinal properties of petroleum, common to all countries where it is found, was also prevalent among the ancient peoples.

The reference to its use in the construction of Noah's ark shows that the utility of pitch, as a binding material in building operations, was recognized. It is clearly this material that is meant by the "slime" which is stated to have been used as mortar for the erection of the Tower of Babel; and it is supposed to have played its part in more definitely authenticated structures like the palaces of Babylon and Nineveh, and the Temple of King Solomon.

Less familiar are the Greek legends relative to petroleum. Plutarch, in his life of Alexander the Great, after recording some experiments of the Macedonian conqueror with petroleum, in the course of which he nearly burned a favorite slave to death, suggests that it was the fluid signified in one of the legends of Medea. The story ran that Medea, wishing to destroy a successful rival in love, the daughter of King Creon, gave her a wreath and crown anointed with some inflammable liquid. As her victim approached the altar flame during a religious festival, the wreath and veil became ignited and the unfortunate princess was burned to ashes.

The ancient Egyptians undoubtedly used petroleum for embalming and medicinal purposes, and filled the cavities of dead bodies with asphaltum, so that nomadic Arabs in later times have been known to use mummies stolen from Egyptian tombs for fuel. Petroleum in its more fluid form is also supposed to have been used to preserve the ancient papyrus against the boring of insects and the rust and rot of time. To this extent at least historians and archæologists are indebted to this gift to man.

Rome, in her gradual conquest of the Western world, made all known oil supplies her own. Consequently allusions which obviously refer to petroleum are frequent to the Roman historians; and here once more it was applied to the use of religion.

The early records of Russia, the Scythian nation of ancient history, are obscure, but it is quite clear that the properties of petroleum were known to them for ages. When Igor descended on Greece, his vessels were destroyed by a fire that burned on water; which has led some modern historians to believe that petroleum entered into the composition of "Greek Fire," the secret of which is lost.

The Greeks, indeed, are said to have made ingenious use of petroleum at all times. Those who have read in Gustav Flaubert's "Salammbo" the story of the rising of the mercenary troops of Carthage after the first Punic war will recall the tactics of one of the Greek captains who turned back the Carthaginian elephant corps, by sending among them swine smeared with petroleum and ignited.

In later days the greatest of Russian Emperors, Peter the Great, showed himself alive to the commercial value of the Baku wells. When in 1723 he obtained from Persia control of the Baku Khanate, he ordered the seizure of as much white petroleum as possible, and directed that a refining master be sent there. "This," remarks a historian of petroleum, "is the first record of a vacancy for a manager of an oil refinery."

As we go farther east history becomes less exact and legend more quaint. In Burma the story of a sweet-smelling deposit of petroleum is the subject of a tale more than a thousand years old. It is related that King Alsungsithu was making progress through his realms with his seven wives and on his magic raft. At one point the ladies went ashore and finding sweet-smelling earth, anointed themselves.

and delayed so long that they forgot the hour appointed for their return. The angered king issued the decree "let the queens who love scented earth more than me, their Lord, be put to death." The doomed ladies replied "From too much love of this fragrant earth we must now die. Let it lose its fragrance and become an overflowing stream of foul-smelling oil, and let those who collect it pay us honour as their protecting deities." They were executed and became Nats or guardian spirits and belief in them is still preserved among workers in the Burmese oil fields. But if the legend could be accepted as true the slain women assuredly took a sad vengeance, for the only offense that can be charged against so beneficent an agent as crude petroleum is its odour, which assuredly belies its virtues.

There are the remains of very ancient oil workings in Burma, Japan and China. Indeed, China, a pioneer in many arts, was undoubtedly one in oil production. Boring in the modern sense was unknown to most of the ancient peoples but it was practised in China centuries ago, a fact which will come under consideration when we take up the mechanical phases of oil production. They had some deep wells at a time when other nations were merely utilizing surface accumulations, and eruptions.

A natural substance which has played so considerable a part in the literature and legend of Europeans and Asiatics did not fail to appear in the beliefs and practices of the aborigines of this country. From time unknown the red man has gathered and made medicinal use of the surface petroleum of the Oil Creek region of Pennsylvania; and its utility in more than one respect was known to the Indians of California and Mexico. The Senecas imparted to the French Jesuit missionaries—who in the seventeenth century, explored not only Eastern Canada but the Northern States and the Mississippi Valley—the curative virtues of oil; and two hundred years later it was known to the settlers of Northern New York State, Pennsylvania and Ohio as "Seneca Oil." The early Spanish missionaries to Mexico and California found the natives selling in their market places petroleum gathered from the surface of the water along the seashore, chiefly for burning purposes. Father Acosta, one of the early missionaries to Peru, noted petroleum floating in the water off Cape Blanco and, as early as 1692, the Spanish Government granted concessions for the collection of Peruvian oil.

In the years immediately prior to our war of Independence, allusions to the petroleum resources of what are now the United States became frequent; and the commercial value of the product was known to General Washington himself. Washington, who was a great believer in the future of the country, which was in his day called "the West," acquired three large tracts of land on the Ohio River bottoms. One of these was at Point Pleasant, the birthplace of General Grant; a second at Round Bottom, later the site of the City of Cincinnati; and a third at the mouth of the Kanawha River, rich in coal and oil. The father of his country had a singular prescience with regard to the element which was to play so great a part in modern American industry; for in his will, speaking of this third tract, he says: "This tract was taken up by General Lewis and myself on account of the bituminous spring which it contains, of so inflammable a nature as to burn freely as spirits and is nearly as difficult to extinguish." Certain of its immense future value, he requested his heirs not to dispose of this particular tract.

CHAPTER II

WHAT IS PETROLEUM?

PETROLEUM, or to use its comprehensive colloquial synonym, "oil," has come to play such a widespread part in every-day life that most people, the younger generation especially, take its existence for granted without further enquiry. Few pause to reflect that this basic essential of modern commerce is a comparatively new agent for the service of mankind. Its applications are so manifold that it is now recognized as indispensable; whereas in a period so recent as that of the advent of Lincoln in American history it was almost negligible as a contributor to the nation's wealth and productive power. The development of petroleum ranks third among the three great discoveries in the realm of applied science which have revolutionized industry in the past hundred years—the other elements being electricity and steam. In company with electricity, it has effected changes in methods of manufacture, and added to the comforts of civilization in ways that it would take volumes to relate. It has been a factor in revolutionizing warfare—as the recent great conflict proved—and it is essential to the arts of peace.

Like electricity, with which its development as a servant of man has been coincident, its utility consists in the fact that it is a source of light, heat and energy. But unlike electricity it is a passive as well as an active agent. For illustration, the same motor car which is propelled by one product of crude petroleum is also lubricated and enabled to travel by means of another product of the same commodity.

Petroleum is the latest of the earth's riches which man has learned to adapt to his needs. The use of iron, for instance, goes back to prehistoric times, and the same is true of nearly all metals, precious and otherwise, of salt and many other of our mineral products which the chemistry of creation has provided in the crust of this terrestrial sphere. But for countless centuries man went his way knowing of the existence of petroleum, yet utilizing it only in a sporadic and casual manner, until American ingenuity and adaptability—working in coöperation with scientists of other lands—made it the marvelous agent that it is to-day. And all this has happened since the grandfathers of most of the younger generation of the twentieth century were born.

The word petroleum comes from two Latin terms signifying "rock" and "oil". "Rock-oil," which was an early name given it on this continent, is accounted for by the fact that certain shales and coals possess oil as part of their constituents. It is one of the family of bitumens, which even in their natural state assume many forms. In its commercial sense the word "petroleum" is a generic term covering the whole group of hydro-carbons—the refined or manufactured products as well as the crude oil. But as yet scientists are divided in opinion as to its origin and the extent of the world's supply. All we know is that it is diffused over almost every section of the earth, and that new deposits—on the scientific development of which geologists are constantly at work—are ever being discovered.

One school of scientists holds that it is of inorganic origin, derived from metallic carbides lying below the porous strata which serve as Nature's reservoirs for the crude product that is "mined" by the modern oil producer. But the more widely accepted view is that crude petroleum is of organic origin, born of either animal or vegetable matter embedded in the earth's surface, which in the process of decay or transmutation has taken this form. Travellers state that in the neighbourhood of the Caspian Sea the conversion of such organic matter into petroleum is visibly in operation to-day. The British scientist, Sir Boverton Redwood, in explaining the natural process by which petroleum came into existence, has pointed out that in the comparatively deep and quiescent water along the margin of the land in past there would be abundant opportunity for the accumulation of deposits of the remains of marine animals and plants, as well as of vegetable matter from the land, borne down to the coast by water courses. The changes which the world has undergone would result in the burial of these accumulations under sedimentary strata, during the process of creating land where once was water.

During geological ages different parts of the earth's surface have alternately been raised and submerged. When above sea level they have been at times subjected to disintegration and removed by such agencies as water, wind, and glaciers, and when submerged the same localities have received deposits, as we now see being made under the ocean and at the mouths of rivers. As all the geological formations which are stratified have been deposited in their respective localities while that part of the earth's surface was under water, and as oil is, almost without exception, found in these formations, we are able to account for the fact that petroleum is frequently discovered in localities which are now at a great distance from the sea. It would also explain why oil is frequently found in association with salt—a circumstance which had its accidental bearing on the earlier development of the petroleum industry in the United States. Many other arguments have been adduced supporting a belief in the vegetable origin of petroleum that would be worth discussing at length, were this a scientific treatise. Much controversy still prevails. The holders of the inorganic theory who assume that petroleum could be formed by chemical reactions from minerals are for the most part chemists who base their conclusions on laboratory experiments; whereas the scientists who hold by the organic theory are geologists, who base their contentions on actual investigations of the earth's crust and the records of its changes as written in the rocks.

The assumption is that the organic matter, after being imprisoned in the sedimentary rock by the processes indicated, under the influence of heat and pressure in some cases assumed the form of coal; in other instances succumbed to decay; while in other cases it formed crude petroleum and gas. It is assumed that a mere fraction of the organic matter which was gradually imprisoned in the formation of sedimentary rock would have been sufficient to create incalculable stores of oil and gas. The mode of decomposition by which these elements were generated is one of Nature's secrets; and the stage in the history of oil-bearing rock in which the necessary chemical transformation took place is equally a matter of conjecture. As has been said, the presence of salt is a prevalent phenomenon in connection with oil deposits the world over. Not only is a strongly saline water commonly present in the vicinity of petroliferous rock, but in a number of fields oil is closely connected with large masses of rock-salt, gypsum and dolomite.

An important fact which makes definite conclusions difficult is that in its world-wide distribution petroleum is to be found in almost the whole range of strata which forms the earth's crust; from the earliest or Laurentian rocks to the most recent formations of what is known in geology as the Quarternary period.

It is, however, evident that oil has often moved from the formations in which it was made to other formations, generally loose or porous, which have served as natural reservoirs for stor ng the oil in the earth. It is probable that in most instances the migration took place by filtration or flowing through fissures or openings from one formation to another, while in some cases it is evident that a distillation took place and the migration probably was made in the form of vapor, which was ultimately condensed in a cooler formation and there stored.

Generally speaking, however, it reveals itself in commercial quantities chiefly in the Devonian and carboniferous formations which are comparatively old; or in the Tertiary rocks, aeons younger in geological evolution. The geographical distribution is as diverse as the geological; the deposits in many instances occur along well-defined lines and in association with mountain ranges, though this condition is by no means axiomatic. It is assumed that in the elevatory processes which obviously occurred while the earth's crust was attaining its present characteristics, certain folds were formed which arrested and collected the oil in productive belts.

Early misapprehensions with regard to the origin of petroleum are indicated by the familiar word "coal-oil," now used to signify one of the most popular products of crude petroleum; but originally derived from the fact that what we now know as kerosene or lamp oil was produced from the distillation of coal before petroleum became an important source from which the lamp oil was obtained. Over a century ago miners in Shropshire, England, observed oil trickling from fissures in coal veins and assumed that coal was the source of the liquid. This belief was intensified by the fact that the earliest discoveries in Pennsylvania, which resulted in the creation of the great modern petroleum industry of the United States, were in the vicinity of vast deposits of bituminous coal. Shortly afterward this belief was disproven by the discovery of valuable oil fields in the western part of the province of Ontario, Canada, where no coal exists; and other discoveries on this continent and elsewhere have furnished abundant proof that oil may exist in large volumes independently of coal.

In considering the two primary theories as to the origin of petroleum, whether inorganic—that is from chemical action on rocks forming part of the earth's crust, or whether organic, from the decay of vegetable and animal matter—there are many strong arguments for both theories and it is quite reasonable to believe that both may be correct. There are localities where petroleum exists in formations showing little evidence of animal or vegetable remains and little possibility of having reached these formations by migration. As a rule, the production in such formations is small, rarely in commercial quantities, and it is probably derived from inorganic sources. This possibility is further demonstrated by laboratory experiments.

On the other hand, it is probable that the greatest sources of petroleum are due to organic origin, more particularly in the carboniferous or the tertiary formations, where coal, cannel-coal, lignite, and other similar products are most frequently found. Hydrocarbons identical with most of the products of the distillation of petroleum, are so commonly obtained from the distillation of coal, lignite, and even bituminous shale and peat that in most cases the organic theory of the source of petroleum appears to be the correct one.

Natural gas usually exists in association with oil deposits and in a great measure has the same properties, its existence as a gas or a liquid being dependent on the temperature and pressure under which it is held. In recent years, before it is sold for consumption as natural gas, it has become the general practice of oil producers to compress and chill the gas to obtain a considerable yield of gasoline which exists in the natural gas as a vapor. Another process for extracting this gasoline is by absorption, that is, passing the gas under a comparatively low pressure through a heavy oil, which takes out a part of the gasoline from the gas. In both processes, but especially in the high compression system, there is a considerable percentage of very volatile gasoline obtained, which is highly explosive and difficult to retain as a liquid. Varying in different localities and under different conditions, natural gas yields commercially from one-half gallon to five gallons of gasoline per thousand cubic feet, although extreme cases show much wider range.

Natural gas, in conjunction with hydraulic pressure, is the cause of what is known to oil operators as a "gusher" or flowing well. It is the compression and volatility of the gas imprisoned for ages in the rock that sends the oil spouting into the air and has been known to create a flow of 170,000 barrels in a single day. As a general practice, and probably due to the weight of overlying strata, the pressure of gas encountered in drilling into oil formations is proportional to the depth. This pressure is generally known as rock pressure and the flow of the wells is in part due to it. A principal factor in the production of oil or gas is the nature of the formations from which the production is derived—their thickness and porosity.

In some cases, notably in Mexico, the flow seems to be caused by the action of water. Here the formations are very porous, opposing little obstacle to the flow of the oil and gas through the formation. The production from the wells under these conditions is very great and, unlike most wells, a gradual decline in the yield is unusual, there being little sign of exhaustion until the moment when the well begins producing salt water in increasing proportions. After the appearance of the salt water the production of oil diminishes rapidly and for practical purposes soon ceases, due to the small production of oil and the fact that it comes out as an emulsion with the water, which is very difficult to utilize.

A characteristic of the Mexican wells is that the oil, and finally the salt water which follows it, are generally produced at a high temperature—from 115 to 145 degrees. Such gushers originally produced another fallacious belief that oil exists in subterranean pools or reservoirs; but investigation has shown that oil has been preserved in the rocks in a way somewhat similar to that in which water is retained in a sponge. A typical piece of oil rock examined under the microscope reveals millions of tiny interstices between different grains of sand. Porous, oil-bearing sandstone may contain one-tenth or one-eighth of its bulk in petroleum. The term "oil sands" is common in the oil industry and refers to the type of coarse grained porous rock which forms the best reservoir for petroleum; but limestone and some of the rocks described by geologists as conglomerates sometimes serve the same purpose. In every instance the oil-bearing stratum has been covered by a layer of non-porous rock, whose impervious qualities keep the oil and gas imprisoned until penetrated by the drill. Surface deposits are also a well-known phenomenon; and were the only type of deposits known to the world until modern times. About them has grown up much interesting history and legend which will be dealt with in a subsequent chapter.

The geographical distribution of petroleum is, as has been said, world-wide, and the oil prospector, followed by the capitalist, who make these discoveries available to the world, are constantly opening up new fields. Oil discoveries necessarily mean great commercial expansion for the localities in which they occur; and no small part of the enormous wealth of the United States has resulted both from the abundance of our deposits of crude, and from the manifold uses to which they have been applied in the improvement and standardization of manufacture. Though the United States is the greatest oil producing country in the world, production on modern commercial and scientific lines first began across the seas, in the little Kingdom of Roumania. There the industry in a modern sense had its birth in 1857. The United States entered the field by virtue of the Pennsylvania discoveries in 1859, and the original industry has attained enormous proportions through later discoveries in such scattered portions of our country as California, Oklahoma, Wyoming and Texas. Italy was the third entrant in the field of organized production in 1860, but her industry has never assumed large proportions. Other countries became producers in the following order: Canada, Russia, Galicia (then Austrian, now Polish), Japan, Germany, India (Burma), Dutch East Indies, Peru and Mexico. The Mexican industry dates back only to 1907 and that country is now recognized as one of the world's greatest fields.

In the United States when we speak of benzine, gasoline and naphtha we allude to the more volatile distillates of petroleum. Lamp oil, as it is called in England, and kerosene or coal oil, as it is known in America, constitutes another product. While petroleum refining is conducted primarily for the production of motor fuel, illuminating oil, lubricants, wax, gas oil, and fuel oil, of various grades, there are a host of specialty products obtained from petroleum which go into use in almost every phase of human activity. These include pharmaceutical preparations for internal and external use, in the form of medicinal oils, ointments, salves, and soaps; cements, including binders for briquetted fuels, water-proofing and saturating agents; special solvents, used to some extent in all chemical laboratories; and an imposing list of rare chemicals, such as higher alcohols of the nature of fusel-oil, and a large variety of organic sulphur compounds.

The word "naphtha" comes from Russia, where it is applied to all crude petroleum, and was supposedly derived from the Persian, nafata, to exude. Early Roman writers like Strabo and Pliny, who were acquainted with the burning and lighting properties of the surface oil deposits known to the ancients, spoke of it as bitumen and liquidum candidum. And other terms in Roman and Greek literature obviously signify the same substance.

Additional designations are: Ropa, ropianka, (Galician Polish) pacura (Roumanian), Huile de naphte and pétrole brut (French); erdoel, rohoel, rohnaphtha (German); yenan (Burmese); sekinoyn (Japanese) shi-yu (Chinese); chapapote (Mexican).

There are also a large number of names for such petroleum products as paraffine, or mineral wax, of which the Spanish brea is an example; and for asphalt, which is really petroleum in a dense form.

Surface indications of petroleum and natural gas are frequent and diversified. The most common is in the nature of seepages, which are generally found in what are geologically highly disturbed areas, underlain with petroleum deposits. These seepages most frequently occur where the oil-containing formations have been folded and exposed on the surface, either when the folding took place or subsequently through the cutting of water courses. From these formations the oil seeps out and is shown as a coating on the streams or, in case the quantity is great or the oil very heavy, it is shown as asphalt deposits, of which there are many in Mexico, and of which the best known are the pitch lakes in Trinidad and Venezuela.

It is a common occurrence in oil fields, more particularly those in the younger geological formations, to find mud volcanoes, probably caused by the escape of gas, bringing with it some water, which reaches the surface as mud. These mud volcanoes vary from a foot or two to several hundred feet in height in different localities and frequently cover an area of several acres.

Another evidence of petroleum is found in Galicia in the form of ozocerite, which is in many ways similar to paraffin, but has some distinctive characteristics. This ozocerite is found on the surface or in mines. It exists in nature frequently in the form of lumps of several pounds of weight and more commonly impregnating the shale from which it is removed by boiling and removed as a scum on the boiling water.

A temporary oil reservoir in Oklahoma. When petroleum is produced in advance of the erection of tanks it is held by earthen dams

Petroleum is found in different parts of the world and even in different formations in the same locality with widely different properties and composition. In some cases the oil is found almost white and varies through all the shades of amber and brown to black. It is found as highly liquid as gasoline and with a viscosity such that it will hardly run away from the hole—almost as viscous as the asphalt used for pavements.

It is also interesting to note that the crude oil from different localities, and even from different formations in the same locality, not only varies greatly in its own properties, but the manufactured products derived from different grades have very different properties as well. From some crude oils special lubricating oils can be made which cannot be manufactured from other oils. The same is true of the paraffins derived from different oils, some, for example, being especially desirable for one purpose while paraffin derived from another crude is more suitable for another purpose, due to its different properties and action under treatment. Thus, the refined oils from different crudes show a great variety, some lamp oils possessing much greater illuminating power than that derived from other crudes and this not due to the method of manufacture but to the actual difference in the properties of the refined oil derived from the different crudes.

In Roumania and Russia the wells produce enormous quantities of sand with the oil, particularly when they first start flowing. The Roumanian wells frequently start flowing sand as fine as flour and more like the dust of a country road. This sand may hardly smell of oil at first and at this stage it covers the ground like a volcanic ash, sometimes breaking in the roofs of neighbouring houses.

In the course of a few days the sand begins to show more oil but piles up around the mouth of the well, giving it the appearance of a small volcano. As the quantity of oil increases it reaches a stage where the oil and sand will flow away from the well together and the oil is settled out in dams before being pumped to the tanks. Later, the percentage of sand becomes less until it is almost negligible.

The action of the sharp sand is similar to that of a sand blast, necessitating much ingenuity in changing the pipes and valves for handling the well while it is flowing.

The diversity that is characteristic of petroleum in its geological and geographical distribution, and in its adaptability to the needs of humanity, is also to be found in the nature of the crude oil deposits. It differs in colour, density and other qualities in almost every field. In America, with which this book chiefly deals, three distinct basic types are recognized; the mixed base (paraffine and asphalt in combination) found in Ohio, Oklahoma and other States; the paraffine base, which is characteristic of the paler crudes of Pennsylvania and West Virginia; and the asphalt base common to the fields of California and Texas. The special qualities of the crude fix in a large measure, the character of the products each yields when subjected to refining and manufacturing processes.

CHAPTER III

DAWN OF AMERICA'S PETROLEUM INDUSTRY

THE words of Washington show that long before the actual birth of the petroleum industry in the United States, discerning minds were at work on the best means of turning the bituminous or petrolific deposits of this continent to practical commercial uses. In passing it may be said of Washington that he was the father of his country in a wider sense than that of having been the victorious general who made the Republic possible, and its first executive head. He was its earliest influential prophet of the power that was to be born of the unlimited natural resources of what was then the "hinterland" of the original commonwealth. During the first five decades of the nineteenth century there were a considerable number of Americans, less eminent than he—explorers, scientists and business men of imagination who looked to petroleum as a potential resource of national wealth. And speculations of this kind were not confined to the

United States. In Great Britain and other countries processes were patented for the refining of mineral oils. The main purpose in view was the development of a substitute for sperm oils in anticipation of the decline of the whaling industry, which had become the main source of illuminants and lubricants. In America, also, petroleum had its recognized medicinal uses, the traditions of which had been acquired from the Indians. Thus, in the thirties, "Seneca Oil" produced at Lake Seneca, New York; and "American Medicinal Oil," a Kentucky preparation were familiar household remedies, especially as embrocations for burns, sores and rheumatic affections.

The casual use of petroleum as a basis for proprietary medicines had, as will be seen, an interesting bearing on the future development of the industry; but the great factor which led to the production and utilization of petroleum on a large scale was a natural phenomenon already alluded to—its alliance with salt or brine deposits. Had not the growing American population been compelled to secure adequate quantities of salt by boring and establishing brine wells, it is possible that the Pennsylvania oil discoveries, with which the real history of the modern petroleum industry begins, might have been indefinitely delayed. During the first half of the nineteenth century five different states had salt industries based on the boring process—Pennsylvania, Ohio, West Virginia, Kentucky and Tennessee. In connection with most of these wells petroleum occasionally appeared, usually to the annoyance and embarrassment of the operators. In the light of future events it is interesting to note that sometimes the presence of the dark and evil-smelling liquid led to the abandonment and condemnation of a salt property. Nevertheless, it was the machinery devised for the purpose of boring for brine that enabled men like Drake and other petroleum pioneers to achieve their revolutionary discoveries.

The first American salt well of which there is any official record was begun in 1806 and completed in January, 1808, on the Great Kanawha River in what is now West Virginia. Charlestown, Va., was then the nearest town, and in the vicinity of this brine well the first burning gas spring had been discovered in 1773. At Tarentum, on the Allegheny River, Pennsylvania, salt wells were started in 1810 which also yielded petroleum in considerable quantities, and such pioneers as Col. Ferris and Samuel M. Kier endeavoured later to turn this by-product to commercial account. The first flowing oil well was drilled unintentionally in 1818 at the mouth of Troublesome Creek, on the Big South Fork of the Cumberland River, twenty-eight miles south-east of Monticello, Va., by one Martin Beatty, who was seeking brine. "The Devil's Tar" as he called it, was allowed to flow into the Cumberland River and covered its surface for a distance of thirty-five miles. The oil became ignited and an enormous conflagration ensued, which destroyed trees along the banks of the river, and also the salt works. What would to-day be regarded as a piece of stupendous good fortune was then accounted a disaster; though this particular well later supplied the chief ingredient for "American Medical Oil" a remunerative compound bottled at Burkeville, Kentucky.

The most enterprising man in utilizing this unwelcome by-product of his salt wells was Samuel M. Kier. Originally a chemist and druggist, he resolved in the later forties to ascertain its uses both as a medicine and as an illuminant. Experiments at distillation to secure a burning fluid for lighting purposes were a success, and his product attained some vogue in rivalry to a kerosene which was being extracted from oil shales in the province of New Brunswick, Canada. But Mr. Kier's chief business was that of the sale of petroleum for medicinal purposes—a compound he named "Kier's Rock Oil." He advertised it by imitations of an American greenback, which bore a vignette showing the plant at Tarentum with the derricks used in boring and pumping the brine wells—for it must be remembered that Kier was primarily a salt merchant who treated petroleum as a side-issue.

This imitation greenback was destined to influence the course of history. A prominent New Haven business man of the day was Mr. George H. Bissell, who had become interested in the possibilities of petroleum through his acquaintanceship with Prof. Crosby of Dartmouth College. The latter had received from a physician at Titusville, Pa., a historical city in connection with the coming industry, a bottle of petroleum, sent as a curiosity. Bissell was so interested that he, in company with friends, purchased for $5,000 a tract of one hundred acres at Titusville, with an oil spring on it. A company was founded, known as the Pennsylvania Rock Oil Company, with a nominal capital of $500,000 and a tentative start made at collecting the surface oil by digging and trenching. Prof. B. Silliman, of New Haven, made a favourable report on the fluid as an illuminant but the cost of production rendered the project commercially impracticable. Mr. Bissell was, therefore, left with the Titusville property on his hands. The story runs that one day in the summer of 1857 while in New York he saw in the window of a Broadway drug store one of Kier's imitation greenbacks, showing the picture of the derricks at Tarentum, Pa. The idea suddenly came to him of developing the Titusville property just as salt properties were developed by boring and pumping. Though short of capital, he set about obtaining backing for the attempt, and the final outcome was that a small syndicate was formed in New Haven, Conn., to work the Titusville oil lands. This syndicate engaged Edwin Laurencine Drake, the most historic figure in connection with the beginning of the American industry, to carry out the work. How he set about his task, and how he succeeded will be the subject of a subsequent chapter.

It is necessary to point out that unless the foundations had already been laid for refining and marketing the crude petroleum, Drake's discovery would have been almost as valueless as that in 1818, which resulted in the conflagration on the Cumberland River. Science, however, had been grappling with the problem of extracting from the crude a safe burning oil and eliminating the offensive odour. This latter was a very important consideration, and for years after petroleum began to assume the proportions of a large industry it encountered prejudice on this account. By the later 'fifties so much progress had been made that the possibilities had been created not merely for a large domestic trade in oil, but also for the development of an export market. Drake's discoveries at Titusville in August, 1859, may, therefore, be said to have come at the psychological moment.

CHAPTER IV

FOUNDER OF THE PETROLEUM INDUSTRY

ON OCTOBER 4, 1901, a magnificent monument was unveiled at Woodlawn Cemetery, Titusville, Pa., to the memory of Edwin Laurencine Drake at the expense of the late Henry H. Rogers, of the Standard Oil Company, himself a pioneer of the Pennsylvania oil fields in the boom days of the sixties. The inscription on the monument not only describes Drake as the "Founder of the Petroleum Industry" but gives an explicit review of what his services meant, not only to the people of the United States but to mankind at large. It runs as follows:-

Col. E. L. Drake, born at Greenville, N. Y., March 29, 1819; died at Bethlehem, Pennsylvania, November 8, 1884, Founder of the Petroleum Industry, The friend of man.

Called by circumstances to the solution of a great mining problem, he triumphantly vindicated American skill and near this spot laid the foundation of an industry that has enriched the State, benefited mankind, stimulated mechanic arts, enlarged the pharmacopoeia, and has attained world wide proportions. He sought for himself not wealth nor social distinction. Content to let others follow where he had led, at the threshold of his fame he retired to end his days in quieter pursuits.

His highest ambition the successful accomplishment of his task, his noble victory the conquest of the rock, bequeathing to posterity the fruits of his labour and his industry. His last days oppressed by ills—To want, no stranger—He died in obscurity.

This monument is erected by Henry Huttleson Rogers, in grateful recognition and remembrance.

Drake was in his fortieth year when, through friends in New Haven, he was appointed director and superintendent of the Titusville properties of the Pennsylvania Rock Oil Company and the Seneca Oil Company. As a youth he had led a wandering life and his education was such as he could pick up at odd moments. He had worked as a commercial traveller and hotel clerk, and was a railroad conductor at the time he took service with the Bissell syndicate, which had decided to experiment in drilling for oil. He himself was so thorough a believer in the project that he put all his small savings into it. The salary at which he was engaged was a thousand dollars a year, which signified considerably more in the later fifties than it does to-day. On reaching

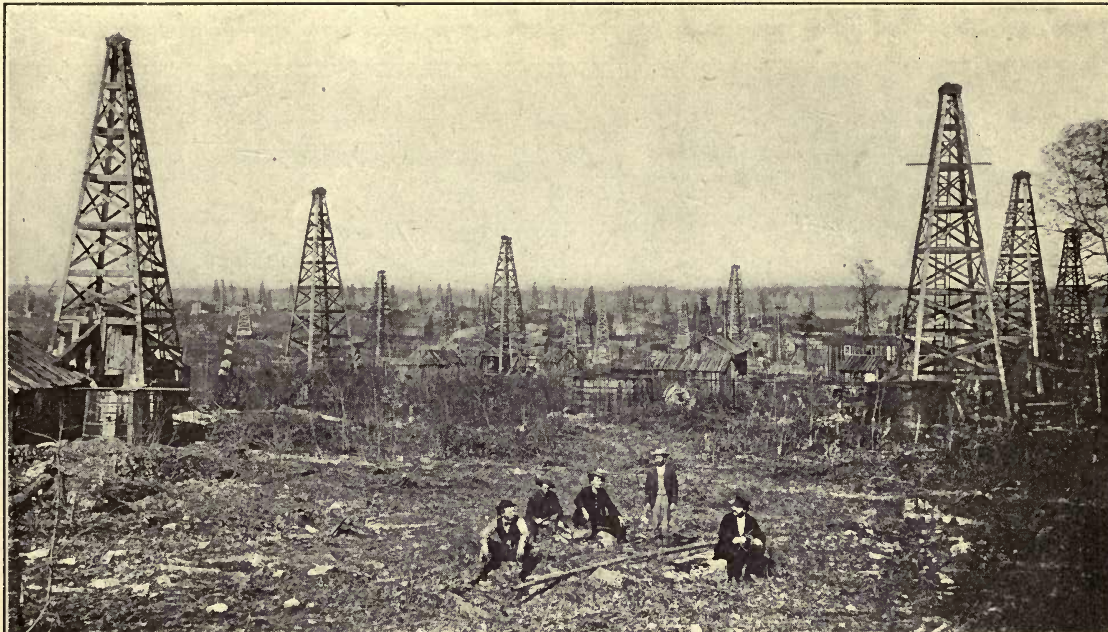
Titusville early in 1859 he soon realized that he was handicapped by lack of practical knowledge of drilling processes, and therefore sent for one William Smith, a man of long experience as a driller of brine wells, who came with his two sons to assist in the work. The method adopted was that of forcing cast iron pipe through the soil at a spot near the "old oil spring,"—well known to the farmers of the locality.

Operations were started in February and after many tedious delays rock was struck at a depth of thirty-six feet. If they were to go farther steam power was necessary, and by August 1st, this had been secured. In the meantime the drilling operations had been the joke of the countryside, but Drake literally could not afford to fail. With steam power it was found possible to drill through the rock at the rate of about three feet a day until toward the end of the month oil was struck at a depth of sixty-nine and a half feet. No record was kept of the exact date, though the New York Tribune a few weeks later fixed it at August 23rd. The well was not a free flowing one, but yielded to the pumping process.

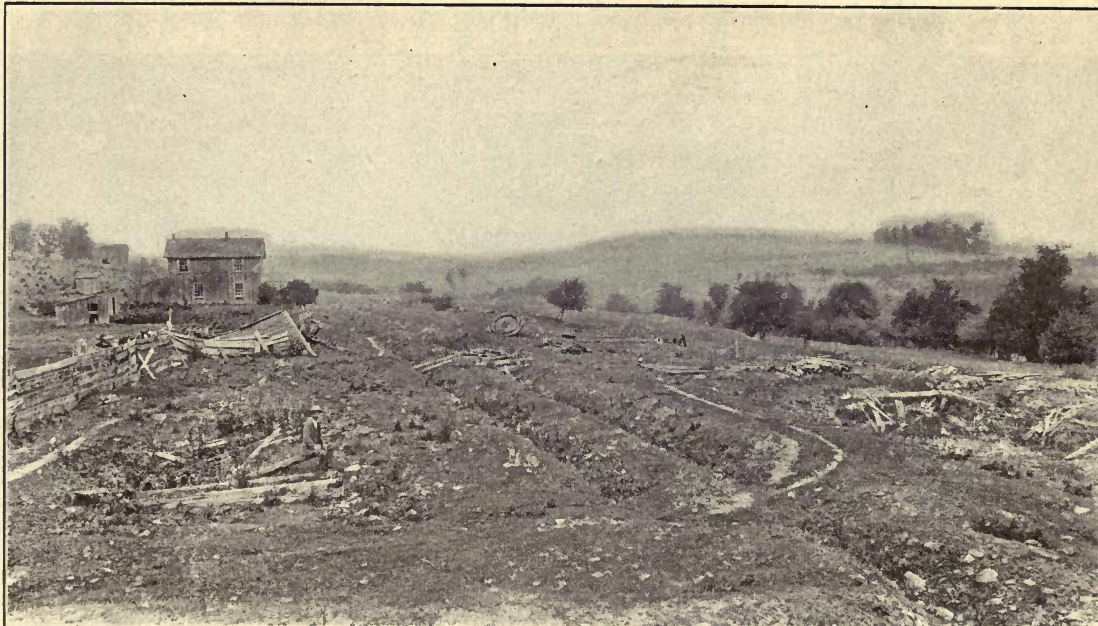
The discovery, momentous as it was, did not create much excitement except in the immediate locality. John Brown's raid, at Harper's Ferry, and the possibility of the Civil War, which was to ensue within less than two years, were the chief topics in the public mind of America. Shortly after the discovery a fire wiped out the existing plant but kindly neighbours, now satisfied that the experiment was no failure, assisted Drake, and when the well was again set in working order its flow was more promising than ever. In the view of experts, Drake's achievement as a pioneer may be regarded as limited to one great feat, the drilling with steam power of the first cased oil well. He ceased to be an active factor in the development of the newborn industry with the drilling of this first well. Following his inspiration, others organized it and in the course of a few years a great army of industrial workers, merchants, financiers and distributors of all classes became associated with petroleum and placed it in a foremost position among the world's industries. Drake himself finally left the oil regions in 1863 with about $15,000 savings, which he soon lost in other forms of speculation. In the stupendous events of the national conflict he was almost forgotten. In 1869, ten years after his discovery, the older oil men who had known him learned that he was sick and penniless, with a wife and family at the point of starvation. They raised among themselves a purse of $5,000 and later the State Legislature was prevailed upon to grant him an annual pension of $1,500, which maintained him in comparative comfort at his home in Bethlehem, Pennsylvania, until his death in 1884.

The scale on which petroleum production increased during the period immediately following Drake's discovery is indicated by the fact that though the total American production in 1859 was 2000 barrels, in 1869 it had risen to 4,215,000 barrels. It must be remembered that those who started the oil industry in the United States were in almost every instance poor men who attained wealth with its development. As the news of the new industry and its possibilities spread, more and more wells were sunk along Oil Creek and the Allegheny River; farm lands containing oil prospects began to command enormous sums, methods of extracting the crude petroleum from the depths of the earth improved and gradually American inventive genius began to be applied to the industry with enormously fruitful results. The Civil War undoubtedly interrupted development at the outset, and the new oil fields gave many a brave soldier to the Northern cause.

The really sensational developments in connection with the oil fields began as the Civil War was drawing to a close. Then they commenced to assume the romantic and fevered aspect of California in the days of the early gold rush a decade or more previous. Unfortunately, the oil fields possessed no Bret Harte, as did California, to write the epic of good-fortune and ill-fortune. The story of the City of Pithole, not far from Titusville, is, however, as romantic as anything in the annals of gold discovery. It sprang to full life in 1865, a mushroom city with all the vices and excitements of frontier life. Fabulous tales have been told of its population, which probably never exceeded 20,000 but 20,000 men and women all excited by the fever of speculation and money-getting gave life in Pithole a gusto not equalled at that time on any other part of the continent. Gamblers and adventurers flocked there in company with many legitimate oil men. In the speculation that ensued fortunes were made and lost daily. Then, after a year or two, the wells which had shown such riches began to decline and Pithole was quickly deserted. A few years later a visitor found only



Early activity; the famous Red Hot Oil Field near Shamburg, Pa., in 1870



Where Pithole stood—the main street of a Pennsylvania oil town, which had a population of 20,000 in 1870, as it looks to-day two inhabited houses in a city that had for a time been the home of thousands of restless mortals. Later still some of the abandoned wells were made productive by new processes, but the glory of the mushroom city had vanished forever. In other parts of this continent there have been oil crazes, but nothing approaching the story of Pithole. And it is famous for another reason; it was the scene of the establishment of one of the earliest pipe-lines, a system which has been an invaluable auxiliary to the growth of the American industry.

The success of the early oil men of the United States not only in grappling with the problem of crude production, but with those of conservation, transportation, refining and the development of new uses for the various elements of the treated crude, set an example to all the world.

From 1870 onward, though Pennsylvania continued to lead, American methods were copied in many other countries. The foundations of the trade which have made petroleum the most international of all commercial undertakings were at that time laid; and this brings us to a survey of the industry as a world interest.

CHAPTER V

PETROLEUM AS A WORLD INDUSTRY

THE standardization of the petroleum industry which began in America during the later sixties naturally excited emulation. Just previous to the Pennsylvania discoveries of 1859 something like a systematic industry had been established in connection with the Roumanian deposits, sixty years later destined to be a military objective of vital importance in the World War. But the actual sinking of oil wells by the boring process was a later development in Europe. As was natural, the first foreign country to profit by Drake's example was our neighbour Canada, which has long been an oil producing country, and to a still greater extent, thanks to friendly American initiative, an oil-refining country. Before speaking of the extent of the American branch of the industry in the twentieth century it is worth while briefly to scan the oil fields of other lands.

The most important are those of Russia, particularly the deposits of Baku, which, as has been related, figured in ancient history and legend. The unsettled condition of Russia renders an exact statement of the condition of its oil industry impossible at the present time, but prior to the war the Russian oil-fields had an output of approximately 72,000,000 barrels annually, or 15 per cent. of the then world's production. During the past fifty years the Russian fields have produced at least 1,650,000,000 barrels; but, though this aggregate seems large it represents less than half of the petroleum production of the United States during the same period. It is believed, however, that Russia possesses great wealth in undeveloped oil fields, particularly in the south-western Caucasus. As yet the main part of the production of this vast country has come from an area of about 4,000 acres in the Baku region, near the Caspian Sea. Prior to 1870 Russia's output of petroleum came from surface pits, dug by hand, rarely more than 50 feet deep. Boring by steam power after the American method was first systematically introduced by Robert Nobel, the famous scientist and expert in explosives, who went to Baku in 1873. Even in 1893 the number of bored wells in Russia was less than 500, but at the last census in 1911 wells of this type had increased to over 3,000. The Nobel brothers also assisted Russian oil production by introducing improved methods of transporting the crude oil, based on American experience, as well as improving refining processes through their own ingenuity. Many other companies operating in Russia prior to the Bolshevist régime have showed some disposition to follow their example, but the progressive spirit that has actuated the oil pioneers of North America has been lacking. One great obstacle to development which existed long before the Russian revolution of 1917 was the intractable character of the Russian workmen, encouraged, it must be admitted, by the reactionary spirit of the Russian capitalist. In contests between capital and labour much loss was sustained through incendiarism, and there are recorded instances where in a single night dozens of productive oil-wells, which had taken years to "bring in," owing to the special geological difficulties of the Russian fields, were destroyed. Such catastrophes of course represent economic loss to the whole people; and Americans have good reason to congratulate themselves that in the oil fields of the United States labour conditions have been such that conflicts have been almost unknown.

Roumania, geographically adjacent to Russia, was prior to its participation in the great war, producing about 11,000,000 barrels, or approximately 1,600,000 tons, of crude petroleum annually. The beginnings of her industry, already alluded to, were based on hand dug wells, three feet square and walled with horizontal oak planks, into which workmen would descend and bring up the oil in wooden buckets or bags of leather. Here, too, the oil area is comparatively small, and it was not until twenty years ago that mechanical equipment designed on the American model was introduced by foreign capitalists. Men trained in the oil-fields of this continent found employment there, although, when at the end of 1916 the exigencies of war compelled the Allies to adopt the policy of destroying the Roumanian wells, in order that the Central Empires should not obtain much needed supplies of oil, it was by English instructions and officers that the melancholy task was accomplished. Roumania has a great petroleum storage port at Constanza, fed by a trunk pipe-line of American model connecting it with the oil-fields.

Galicia or Austrian Poland, as it was once called, lies in the same geographical zone as Roumania, and possesses an oil area 200 miles in length and varying from 40 to 60 miles in width, although 90% of its production comes from the Boryslaw field. This field, which was the chief source of supply for the Central Empires during the war, necessarily suffered much in the conflict but ten years ago was producing about 1,900,000 tons of crude annually. It is now on the way to restoration. The development of the Galician industry on a large scale was directly due to the introduction of modern drilling methods in 1882. The petroleum wealth of that country lies very deep and wells of a depth of 4,000 feet are common.

Though the chief customer of the Galician fields for a considerable period, Germany also made efforts at developing a petroleum industry of her own, but, as in the case of Italy, her oil-fields, though not entirely negligible, do not bulk large in the statistics.

It is clear that Europe not only owes much to American ideas for her native developments but is also dependent on other continents and to sea-borne cargoes of oil for supplies adequate to her needs. This is particularly true of Great Britain and France, whose statesmen have emphatically expressed their gratitude for the indispensable aid in the prosecution of the war provided by the leaders of the

American oil industry, who organized a steady supply on an enormous scale.

The early efforts of British scientists to develop home supplies of oil from shales and other forms of oil bearing rock were productive of benefits through improved methods of refining, rather than by the development of a really important home industry. Thus the United States and all oil-producing countries owe a debt of gratitude to Dr. James Young of Renfrewshire, Scotland, whose improvements in the processes of manufacturing paraffine from shale oil, during the early part of the nineteenth century, were of infinite value in developing the uses of petroleum after its presence in large quantities was proven by the pioneers of Pennsylvania. Great Britain, realizing her own need, also helped the world's oil industry when she built the first oil-tank steamers on the River Tyne.

Though Great Britain, with the exception of a small well recently drilled, has no deposits of crude so far as known, she is at the present time experimenting with processes to distil petroleum from oil shales, coal, cannel coals, ironstones, lignite and peat; but more important still, she is encouraging the oil industry in various parts of her great Empire. Under the British flag, either as autonomous parts of that Empire or as countries which she holds a mandate to govern, are the important oil-fields in Burma, Persia, Egypt, Trinidad and Assam.

The Burma fields have of late years been developed in accordance with modern practice, and the producing area, long a subject of quaint legend, much extended, so that according to recent estimates the annual crude production from this source is upwards of one million tons. The Persian oil fields will be a factor to be reckoned with in future, and an oil port fed by a pipe line on the American model already exists at Abadan on the Persian Gulf. Egpyt has also a future as a petroleum producing country, for within the past ten years not only "gushers" but wells which give evidence of steady flowing qualities have been discovered, and plans for development are already well advanced.

Crossing to this hemisphere the name of the British colony Trinidad at once suggests itself. Its famous lake of pitch has long been a source of supply for that dense form of petroleum which is known as asphalt; while other deposits of crude yield surprising percentages of more volatile products like motor spirit.

And while on the subject of petroleum under the British flag, reference may be made to Canada, although the industry there is very closely allied with that of the United States. In Eastern Canada, oil has long been produced in limited quantities, but within recent years the prospects of great new oil areas in the foothills of the Rocky mountains and extending almost as far north as the Arctic circle have led to glowing hopes that may or may not be realized.

A more distant foreign field, which is gaining importance in the eyes of the world, is that of the Dutch Indies in the Far East. There has been considerable oil production in Borneo, Java, and Sumatra, in the development of which the services of American experts have been enlisted and indeed it may be said that the petroleum industry has done a great deal to make world-citizens or cosmopolites of many good Americans.

Japan's connection with oil is ancient and it has its own industry at Echigo; but like China, which also worked deposits of oil in prehistoric days, it is a large importer of American petroleum products, especially illuminating oils. The American travelling in remote parts of Asia is often reminded of home on seeing the tin containers that have crossed the Pacific from this country.

Returning to this continent we find that the Mexican oil fields have come into prominence more rapidly than those in any other land, for there the industry has existed only since 1907. The Mexican pools now rank after the United States as the second largest producing area in the world. Most of the latter-day sensations in the matter of petroleum have been provided by Mexico, where both American and British capitalists have acquired large interests. In 1908 the "Dos Bocas" gusher in Northern Vera Cruz was drilled. At a depth of 1,800 feet gas was encountered which blew out the drilling apparatus and presently, through a fissure which developed under the boiler room of the drilling plant, an eight-inch column of oil was spouting hundreds of feet into the air. Becoming ignited it burned for fifty-eight days, producing a column of flame a thousand feet in height and fifty feet in diameter. The well then began to produce hot salt water and is still producing probably a million barrels of salt water per day. In 1910 another great gusher, the "Potrero del Llano" was struck but fire was fortunately averted, and the daily flow was estimated at

125,000 barrels. Production on so magnificent a scale has never been known in any other part of the world. Before this well went to salt water, in 1919, it had produced more than 100,000,000 barrels of oil.

Another Latin American republic which has developed a very important oil industry in recent years is Peru, and it is supposed that other parts of South America will yield their riches in the future.

Despite the petroleum wealth of other lands, however, the United States far outdistances them, not only in the output of crude petroleum but in the manifold products extracted from it. The magnitude of the American industry may be gleaned from the fact that in the past year (1919) United States wells produced about 377,000,000 barrels, or over 65 per cent. of the world's supply. The lead of Pennsylvania as the chief oil-producing state and the pivotal point of the world's supply continued for many years, but has long since been superseded. For a number of years this state provided 98 per cent. of the oil production of this country. In 1891 the total production of Pennsylvania oil was 35,839,777 barrels, and in 1897 35,165,990 barrels, so that the maximum was reached in 1891. The greatest daily average production was during the month of November, 1891, when it reached 135,676 barrels. This pioneer territory suffered a gradual decline, and at the present time it is estimated that Pennsylvania produces about five per cent. of the American supply. Nevertheless, the output is considerably greater than in the boom days of the sixties when the phrase "Struck Ile" became an accepted synonym for the sudden acquirement of riches. As the importance of the industry grew, oil prospectors busied themselves in every part of the republic in probing for this source of wealth, and are still indefatigable after sixty years. What is known as the Mid-Continent fields, which includes such States as Kansas, Oklahoma and Wyoming, have developed enormous potentialities, while on the other side of the Rockies and the Sierras the California fields some years ago became one of the great sources of the world's supply. The California development is an example of the rapidity with which an oil field can become productive on an enormous scale under modern methods. The records of achievement there show that it is possible, with the modern system of rotary drilling, to get down nearly 4,000 feet below the surface within the period of a month, depending on the nature of the formations, and the experience in that state demonstrated a finer quality of crude at such depths than could be produced from deposits nearer to the surface. California too furnishes at certain points an illustration of the mechanical ingenuity of the modern oil worker; for there are to be seen oil wells sunk in the sea at a considerable distance from the shore, the encroachment of sea-water being overcome by carrying the casing above high-water mark.

Until a comparatively recent period the California fields held the record for production, but in 1918 the young State of Oklahoma forged to the front, with a production of more than 100,000,000 barrels in one year, and a large undeveloped territory which there is every reason to believe will prove rich in petroleum. Tulsa is the centre of the Oklahoma industry and is an example of a town which has grown suddenly from a small agricultural settlement to a thriving centre of metropolitan aspect as a result of the oil industry.

There are those who believe that Texas will very shortly attain eminence equal to that of both California and Oklahoma as a petroleum region. The gulf fields came into prominence about the dawn of the present century, and have perhaps witnessed more booms than other sections of this continent. Speculative eras in new fields which have been brought in by "wildcat" drilling, which term should not be confused with wildcat mining speculation, are however regarded by sane and conservative oil men as harmful rather than helpful to the petroleum industry. They invariably produce false inflation and subsequent depression; and involve in reproach one of the greatest economic blessings bestowed upon humanity.

Thus far we have surveyed petroleum in its many general aspects and the remainder of this treatise will be devoted to a description of its production, subsequent treatment and manifold application to the needs of present day commerce and civilization.

CHAPTER VI

LOCATING THE OIL WELL

WHEN Edwin Laurencine Drake went to Titusville, in 1859 the first question he asked of the natives was the location of "the oil spring" known to the Indians and the farmers who succeeded them. The modern oil seeker no longer concerns himself with surface indications.

In truth there is little or nothing in the contour of the latter-day oil-fields to suggest oil to the eyes of the uninitiated. But geologists first located probable oil bearing formations and have made calculations of the formations two or three thousand feet below and the drilling sites are located in accordance with them. Roughly, the theory upon which such operations are based is that the sub-surface rocks undulate, and that the presence of oil is most assured at the highest points of the undulations. By measuring dips at given points they calculate the distance in a certain direction to what they deem the most favourable site and surveyors proceed to fix and designate it. In cases, not infrequent when the lease which conveys the right of drilling is limited in area, it is the business of the surveyor to see that the site chosen is well within the boundaries of the plot acquired for drilling purposes.

On the subject of present-day methods of location a recent contributor to "The Lamp," an American oil journal, provides much interesting data. Oil geology, he points out, is not an exact science but it enables one to focus exact information upon the creation of a theory regarding the probable structure of an untested area. In Oklahoma, for instance, geological investigations made within the past five years resulted in the discovery of many of the new pools. All drilling is in some sense speculative, or to use the oil man's phrase, a "wild cat," at the outset; but in Oklahoma it was found that the proportion of dry holes on territory recommended by the geologists was less than one-third of the failures that resulted before that science was invoked. The speculative nature of the oil business in its initial stages is indicated by the fact that less than one per cent. of the area of the oil region of Pennsylvania is producing territory, although it has probably been more thoroughly drilled than any field in the world. The limited extent of even the permanently productive fields is one of the phenomena of petroleum. More than one-half of the production of the State of Wyoming is found within an area of not more than six square miles. The famous Tepetate-Casiano pool of Mexico, which produced more than seventy-five million barrels of oil from 1910 to 1918, is about one-half mile wide and three miles long. When we compare the acreage of oil areas with that of the continent, the analogy of the needle in the haystack at once suggests itself.

The geologist draws the certain deduction that oil migrates through some porous formation from its original source and concentrates itself in detached "pools" of comparatively small dimensions. It is the oil pioneer's business to find these pools. Again, there may be several successive deposits of what are known as "oil sands," separated from each other by hundreds of feet of barren formation. The depth of a well in itself means nothing. The operator must know in what strata he expects to find the oil. If these beds prove dry, then he abandons the test, regardless of whether the drilling has reached 1,000 or 4,000 feet.

Past experience has taught the geologist that oil-bearing formations manifest themselves by certain surface indications, such as gas springs, and surface seepages of oil or asphalt. In an untested field the expert studies the character of the successive formations along such outcroppings. In any mountainous region earthcrust upheavals during past ages have exposed a series of formations, similar to those which lie deep below the surface of the plains. Thus it is possible to predict with a fair degree of accuracy just what the formations will be for a considerable depth from geological indications. Geologists have also learned to recognize certain types of structures favourable to the accumulation of oil pools, known as anticlines, synclines, salt domes, monoclines and so forth. Thus it is sometimes possible to make in advance of drilling a surprisingly accurate forecast of what these operations will reveal.

Because for the most part oil fields exist in rather sparsely populated districts, remote from centres of commercial and industrial activity, the general reader has probably very little knowledge of the unceasing efforts that are being made in many parts of this country to maintain the supply of crude oil at an adequate level through new discoveries. The spirit of enterprise and initiative is even more alive to-day than it was in the time of Drake and the pioneers who followed him in the Pennsylvania field. The hopeful speculative spirit is as ever necessary; the capital fulfils an ever-growing function in this source of prosperity and employment for the community at large.

In the oil industry any well drilled outside the narrow limits of a producing "pool" is regarded as a "wild cat" test. The element of a gamble is inevitably present, but has been materially reduced by science. An old established company in an important field is constantly adding to its land holdings in advance of the trend of development, and out of the profits from its developed productions sets aside a certain amount to expend for speculative ventures, to protect its investment in pipe lines, refineries, etc. The company also continues to drill in the vicinity of a producing pool until it is entirely surrounded by dry holes, and its limits demonstrated. Consequently, in an established oil field development work and prospecting are one and the same thing.

The matter of opening up new fields in regions where there have been no previous wells to serve as a guide presents a very different phase of speculative enterprise. The pioneer producer must make a very substantial financial investment for roads and equipment. He must have the courage and grit to continue his efforts, even though he at the outset obtains negative and unsatisfactory results; sometimes for a period of years. Nor do his troubles end when he has made an important discovery, for then land hitherto almost valueless becomes much sought after by competitors, and legal complications involving titles and taxes are not slow to develop. If he has been fortunate enough to open up a real oil-field his exploration work must be of sufficiently broad scope to determine the location of the principal belt of favourable territory, the approximate depth and character of the oil bearing formations, and the possibilities of permanence in the wells themselves. The quality of the crude petroleum "mined" may be less important than the quantity.

Though it is obvious that the obstacles that confront the pioneer operator are not insurmountable, the conditions described show why the history of oil discovery is bestrewn with failures. This has been particularly true of the Latin American fields of Venezuela, Colombia, Argentina and Costa Rica, and of many Asiatic attempts. Even in the great gusher field of Mexico the first tests were drilled in 1869, yet it was not until 1902 that any important production indicative of the great future of that region resulted. More than 50 wells drilled in a space of 33 years were failures.

It is, therefore, apparent that detailed, scientific information on which to proceed is almost as important in the initial steps as strong financial backing, and efficient organization. The methods used in the early days of the Appalachian fields of Pennsylvania depended absolutely on "fool's luck" and steadfast optimism. As this field extended down into West Virginia and Kentucky, and over into Ohio, the ever-increasing number of failures caused the operators to cast about for some sort of a working formula in choosing locations. From the crude efforts of these early investigators the fundamentals of modern oil-geology were developed. The old-fashioned operators' creed contained this axiom: "If you wild-cat enough in an oil field, you will make money in the long run." But this no longer is a safe working motto. The steadily increased cost of drilling has made it of paramount importance to make careful selection beforehand. The modern oil operator realizes that Mother Earth provides many clues and hints which he cannot afford to disregard. The oil geologist interprets the surface indications and such other information relating to a given area as is available; and is ever on guard against the over-optimism of the promoter.

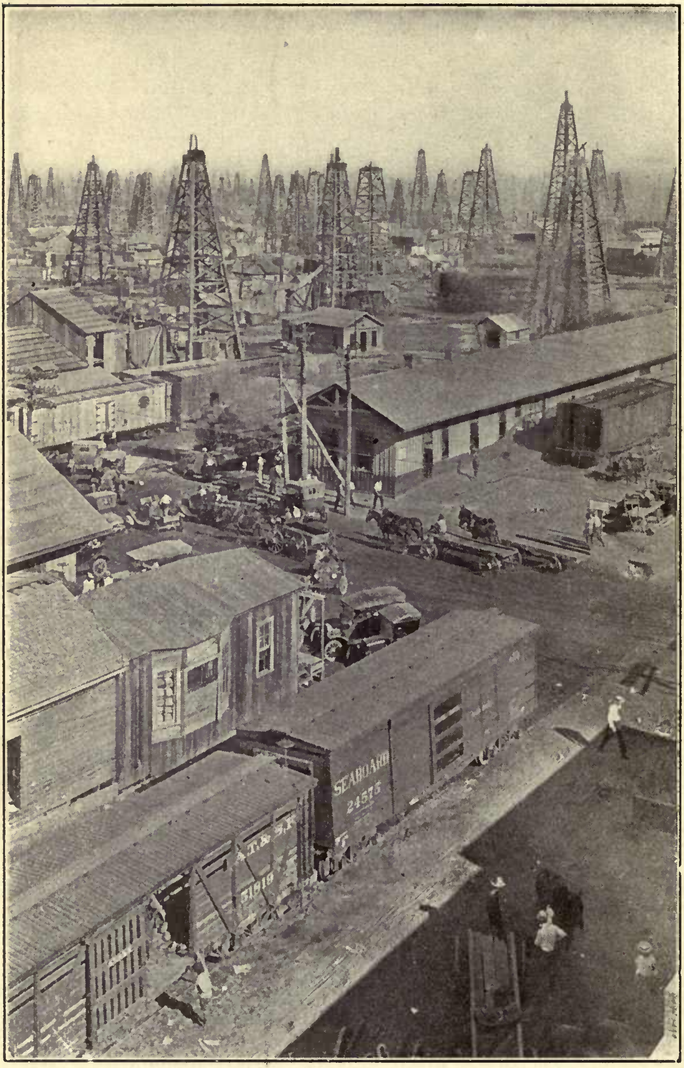
CHAPTER VII

DRILLING THE OIL WELL

METHODS of well drilling differ in various regions in accordance with the special problems to be encountered and perhaps no other industry furnishes more examples of mechanical ingenuity in the solution of physical difficulties. Drake went about the business of drilling the first well by using the traditional methods of boring for salt. Improvement was inevitable, however, and the Canadian wells of Western Ontario, which came into existence almost contemporaneously with those of Pennsylvania, were fruitful of inventions which have influenced drilling practices in many parts of the world. If we go back to the origins of oil and salt drilling mechanisms we find ourselves in China centuries before the Christian era. The Chinese used an auger attached to a pole that was held in a vertical position from a cross pole supported on a post. The end of the cross pole was fastened to a lever while a driller guided the cable to which an auger or boring tool was attached. Several coolies jumped from a platform on to the reverse side of the board, so that the tool would be jerked up and would plunge down and thus deepen the hole with each stroke. The deeper the hole became, the more coolies required for the task of "kicking down." Jumpers were not a part of the staff of an oil-drilling organization in America in the early days but foot power was sometimes employed for the same purpose of driving the drilling tools into the ground. To-day labour-saving machinery plays as great a part in well drilling as in other branches of industry.

Let us suppose then that an oil company, or an individual with the requisite capital at his back, has advanced through the preliminaries which must precede drilling operations; the geologists have made a favourable declaration as to the prospective site; the leases and royalties have been arranged and the title is secure. When it is decided to start drilling, roads are built, water lines laid, and the lumber, casing machinery and other equipment are hauled to the location (often under very primitive and difficult conditions). The apparatus most commonly installed under these circumstances is the Pennsylvania cable system, which consists of a standard

The Drader Well in the Moreni field, Roumania. This well was producing 20,000 barrels daily when it caught fire



Burkburnett in northern Texas, showing development since August, 1918 derrick or rig, built of wood or steel, about eighty feet in height, having a twenty-foot base and a four-foot top. The strength of the derrick is conditioned entirely by the size and depth of the well the operator wishes to drill, for nowadays nothing is left to chance. The size of the hole necessary in starting a well depends upon the physical formation. If it is soft, it is necessary to start with a hole of large diameter, to overcome the disabilities produced by caving. It sometimes happens that soft formations cave so much that it is necessary to insert several columns of casing before the required depth is reached. A hole with a large diameter is also used in deep drilling.

The drilling equipment is called by the oil workers a "string of tools." It consists of a rope socket, a stem or sinker about thirty feet long and five inches or more in diameter, depending on the size of the hole to be drilled, with a bit at the bottom. Attached to a string of tools is a set of what are known as "jars," which take their name from their function of enabling the driller to jar the sinker loose. Manila or wire cable is wound upon a large reel known as the "bull wheel" which is placed in the base of the derrick and a section of this cable passes over a crown pulley at the top of the derrick and is fastened to the rope socket and "string of tools." The drilling movement is created by a power-driven walking beam which is a heavy timber working on an axis. This walking beam rocks up and down, with a stroke of three or four feet; thus the tools are raised and dropped at regular intervals, their great weight giving them a stroke equal in force to a steam hammer. The power used is ordinarily steam and the cable is connected with the walking beam by a temper screw, which enables the driller to lower the tools and handle them with ease and accuracy.

Another method of growing importance is the rotary system, perfected within the present century in the Gulf Coast field of Texas and Louisiana and which in many sections is coming into common use. Its special advantage is speed in soft or caving formations. It consists of a perforated fish-tail bit screwed to a string of drill pipe, which projects up through the derrick platform and is rotated at the rate of about two hundred revolutions per minute by a turn-table. The top or "grip" joint of the pipe is usually made square, or hexagonal, to supply a good bearing surface for the turn-table. The tools are suspended by means of a swivel at the top of the grip joint. This swivel also has a hose connection through which thin mud is pumped down to the bottom of the hole. The circulation of this mud carries out the cuttings made by the fish-tail bit, and also serves to plaster up the side of the hole and thus prevent caving. The column of mud in the hole exerts a hydrostatic pressure which absolutely prevents quicksand from running in and causing the hole to collapse. A rotary appliance has been known to drill two hundred feet or more in twelve hours, but usually so high a rate of speed is impossible, since the pipe stem has to be pulled out at frequent intervals and the bit replaced. The fact that the delicate fish-tale bit grows smaller with wear creates this necessity.

Another periodical process that must be carried on in the intervals of drilling is that of lining the hole with casing, in order that water and caving strata may be cased off before the oil sands are reached. After a well is operating, the lower part of the casing may rust through, causing leakage. To meet this difficulty an inner casing is put in place with a casing shoe, on the outside of which is lead or other soft material which expands under pressure from above to make a snug fit. Not infrequently, it is necessary to decrease the size of the hole with packers in this way four or five times, though it is kept as large as is practicable all the way down.

When oil is struck it is sometimes suddenly driven to the surface by imprisoned gas, and another gusher, a comparatively common phenomenon in Mexico, is recorded. But if this condition does not arise, tubing and pump are inserted and the oil is drawn to the surface. Not infrequently, however, the oil sands at the outset do not yield an adequate flow and in a great number of cases what is known as "shooting" with nitro-glycerine, an interesting and once dangerous process, is resorted to. In the early days before oil production had been reduced to scientific formulas the obtaining of crude was often attended with serious hazards to life. Ignorance of the properties of petroleum also created imaginary dangers for the pioneers. In 1860 the people of Western Pennsylvania were thrown into a panic by the proposal of a stranger, claiming to be a European scientist, to shoot a white-hot bolt into the bowels of the earth through an iron pipe driven to a great depth for the purpose. By the ignition of inflammable gases thought to exist in the great cavities beneath the earth's crust the promoter expected to produce a sufficient explosion to lay bare the subterranean reservoirs of oil. The Pennsylvania populace, instead of viewing this proposal with the apathy usually accorded to the first essays of inventive minds, possessed sufficient imagination to picture the possible results, and were so convinced that the alleged scientist minimized the possibilities of his project that they selected a small but determined committee to lynch him. Because he threatened to undermine not merely the foundations of society but the ground on which society subsisted, he was taken into custody by the authorities and solemnly warned to desist.

Less than a year afterward nitro-glycerine was being exploded in large quantities down deep in the earth to shatter the oil-bearing rock and make wells flow, without noticeable public or physical disturbance. Any one who has watched farmers blow up tree stumps with dynamite may imagine what effect eighty quarts of nitro-glycerine would produce at the bottom of a deep eight-inch well. The "oil-shooters" are necessarily men of steady nerve and extreme caution. A shot will vary from ten quarts to as much as three hundred quarts, as the well to be treated may seem to require. For this purpose the nitro-glycerine is contained in tin tubes or shells five feet long and two inches or more in diameter, pointed at the lower end and having bail handles at the top. From five to fifteen shells, as the case may be, are lowered into the hole with extreme delicacy, and then the "go-devil"—a five-pound pointed shell—is released point downward. Nowadays, it is customary to use a nitro-glycerine squib wound with a long fuse more often than a "go-devil," since the lowering of the cans of explosives may loosen earth which forms a cushion above the shells. An example of the presence of mind of a well shooter was provided a few years ago. Just after the first shell had been lowered, the rope suddenly slackened. This could only mean that the well had unexpectedly begun to flow and that in the space of a few seconds the shell containing six quarts of deadly explosive would be hurled from the well mouth. There was no time to run and the only thing that could be done this "well shooter" did. Bracing himself directly over the well he grasped the shell as it came to the surface, and although the impetus with which it had ascended threw him across the derrick and dislocated his shoulder, he held it free from contact and saved the lives of the entire crew.

Under the careful arrangements now made, a well is controlled with no more loss of oil than the driller thinks necessary to flush out the dirt and debris caused by the explosion.

The early or flush production of a well is usually of considerably greater volume than its normal or settled flow after it has been in operation for a few weeks. This decline in production is often as much as 50% in the first 30 days. Where wells do not flow naturally, various devices can be used to stimulate the output. Gas pressure has much to do with the problem. As a general rule the well of low gas pressure must be pumped from the beginning. The "gusher" which is the result of high gas pressure usually recedes rapidly in the matter of flow and becomes what is known as a "pumper," the name given to wells when pumping is resorted to.

The minimum of flow at which a well ceases to be profitable varies according to location, and is fixed by many conditions of which transportation and quality are the most important. Thus, in Mexico, a well yielding only fifty or one hundred barrels per day is usually abandoned as uncommercial, whereas in Pennsylvania and West Virginia, where the facilities for handling are better, there are thousands of old "pumpers" in operation producing a superior grade of oil, many of which supply only one-fourth of a barrel per day.

The production of the first well drilled on a new location fixes the policy to be pursued with regard to the rest of the acreage under lease. After it has been tested and proven to be satisfactory the remainder of the property is drilled as quickly as possible. If the field is shallow and the wells are all "pumpers," a central power station operated by gas or gasoline is sometimes installed which may provide the energy for pumping as many as a dozen wells. The shackle-rods spread out over the field like a spider's web, and the rythmical "chug-chug" is music to the ears of the oil man and also to the farmer who has leased the oil rights to him—for the song of the pumping plant symbolizes fat royalties.

It will be clear to the reader that even in the initial process the production of crude petroleum under modern standardized processes which eliminate, so far as possible, waste of labour or of product, involves a considerable capital expenditure. The cost of a well in a new district, where the depth is likely to be in the neighbourhood of three thousand feet, may amount to considerably more than $50,000 and a year may pass in the process of drilling. In the case of deep wells a permanent derrick is built, but in earlier days, for shallower holes a portable drilling machine was used, and with good fortune oil was often reached within a short time and the cost kept well within a margin of $5,000. It will be remembered that in the original Drake well at Titusville, oil was struck at sixty nine and a half feet and that it took seven months to drill the well; a concrete illustration of the improvement in methods which has transpired in sixty years. But the days of cheap drilling have passed into the limbo of half-forgotten things and there is practically no oil production at the present time which does not represent a very considerable initial outlay.

CHAPTER VIII

COLLECTING AND TRANSPORTING CRUDE: THE PIPE LINE

WHEN a new lease or area proves itself to be commercially productive, marketing the product becomes the next consideration. In the earliest stages of recovery and storage of petroleum there were great losses through lack of facilities, but modern mechanical science has largely eliminated the appalling waste of early days.

The crude is pumped into small flowtanks, and from there run either to a pipe line station or to a "tank farm." The problem of saving the flow of gushing wells at one time presented serious difficulties; and one of the most valuable of the early inventions was the clay underground tank. The petroleum is directed into a sump-hole lined (wherever possible) with clay, which, because of its close texture, makes an absolutely leakage proof reservoir. From the sump-hole it is pumped to the tanks, but this is usually but a temporary shift. When the gushing process ceases, pumps are installed and direct pipe connection with the storage tanks is established. The modern pump which lifts the oil from the oil-bearing strata to the surface is a very powerful mechanism. One of these will handle a column of oil as high as four thousand feet, and deliver it into pipes. As has been mentioned in alluding to the California seacoast fields, the intervening ocean itself constitutes no obstacle to operations. Not infrequently the walking beam, used in the drilling, is brought into commission for pumping purposes. It is rather a cumbersome system but has this advantage, that it enables the operator to begin production immediately and realize cash for his output.

In what is known as the field tank, situated adjacent to the derricks and pumps, the oil operator deposits his daily production, which is later pumped to the "tank farm" for shipment. The capacity of a tank is known to a gallon. So many inches or feet of petroleum in a tank represent so many barrels. The gauger drops a steel tape into the oil until it touches bottom, and the location of the oil showing on this steel is the measure of the contents. Then the valves are opened and a portion of the contents flows away to the pump station or "tank farm." A second measurement is taken, and the difference between the first and second measurement reveals the quantity of oil drawn off. The gauger then issues to the producer a credit certificate or "run ticket" representing the quantity of the crude received at that particular time.

There are other complications, however, before the oil reaches the market. If the wells are gaseous in any considerable degree, the oil must pass through a gas separator before it enters the tanks. The gauger must measure and draw off any water present, which, owing to the proverbial incompatability of oil and water, is not difficult, and in calculating the amount of the credit slip he sees to it that no water is inadvertently paid for.

Gas itself is not infrequently an important by-product of an oil lease. Almost invariably gas is associated with oil, although oil is not always found where gas is available. From many wells immense quantities of gas escape while drilling is in progress, and may occasionally wreck the machinery. Drillers have become expert in handling these difficulties and in casing off the gas and corking it up for future use. In many of the oil districts of the South and Middle West, natural gas from the producing areas has become the fuel of countless people who will never return to the use of coal, so long as this cheap and cleanly source of heat and light is available. Some wells yield as much as 25,000,000 feet of gas per day.

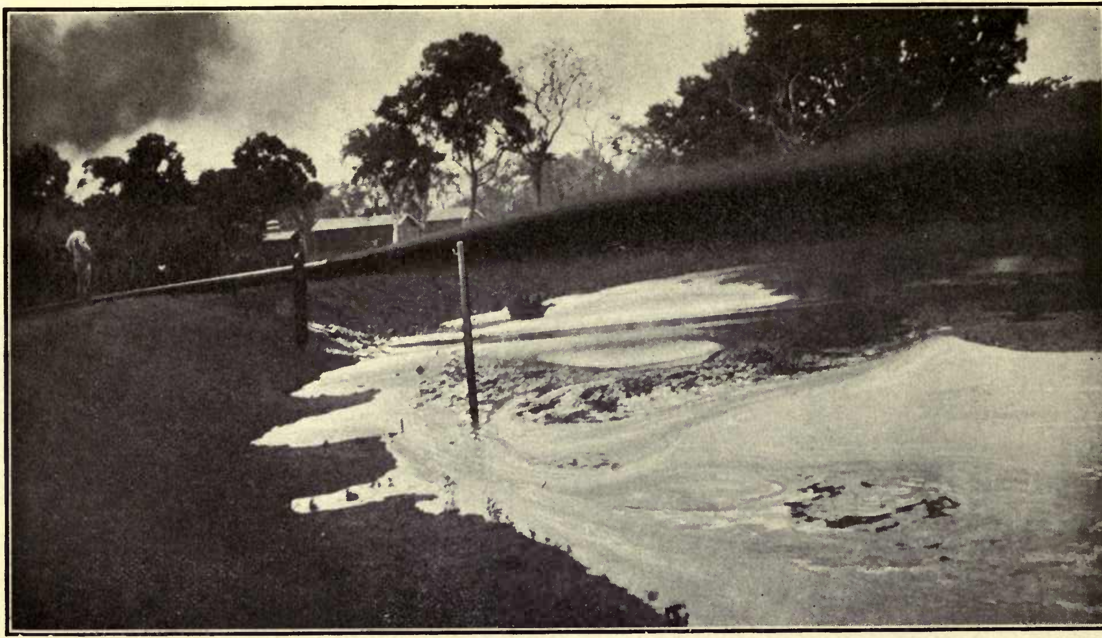
With gas and water eliminated, the crude oil is pumped from the "field tank" to the "tank farm," a collection of great containers built near the oil fields to take care of the output of wells which produce oil faster than the pipe lines carry it to the refineries. These containers are built of sheet steel and have a standard capacity of about 55,000 barrels in most cases, although some are constructed to contain 80,000 barrels. They are riveted and must be absolutely proof against leakage. Incidentally, it may be mentioned that one of the difficulties which human ingenuity cannot combat is the tendency of lightning to become attracted by these steel constructions on the open prairies. Great havoc and waste sometimes result. Another convulsion of nature also dreaded by the oil man of the Middle West is the cyclone, which at times is especially disastrous to derricks and pumping plants.

There is but one more stage through which the crude petroleum passes on its way to the refinery, but this stage is so important and has been such a vital factor in the organization of the American oil industry, as well as in those of other countries which have emulated the system, that it demands extended reference. It is the pipe-line system which has done more to make the products of petroleum available to all at reasonable prices than any other innovation in connection with the industry. It is in reality like the waterworks system which reaches under the streets of modern towns and cities, but extending beneath the surface of millions of square miles of territory.

When, as a result of the Pennsylvania discoveries, petroleum became a commercial commodity, and opened up sources of untold wealth to the people of this continent, little thought was at first given to the transportation problem. The earlier wells on Oil Creek were situated so close to the navigable water that barrels of oil could without difficulty be loaded upon barges or smaller craft and floated down the river. In periods of drought when the water was too low to float such craft, oil boats would be assembled on a mill pond near the wells and the water dammed back while the loading was in progress. Then the gates would be opened, and the fleet, carried on the flood and guided by pilots, would be rushed down Oil Creek to the Allegheny River.

As production increased, and new districts without convenient water transportation were successfully drilled, it was necessary to devise new methods. The production of some wells, inaccessible by water, became a drug on the market and in 1862 crude oil prices at such wells fell as low as 10 cents a barrel. To meet the difficulty, a system of teaming was adopted and great caravans of the oil wagons became a familiar sight in inland oil regions. Such a caravan in the days before the pipe-lines would sometimes consist of no less than 6,000 wagons drawn by two horses each, and carrying from five to seven barrels of oil. Travellers of the early sixties encountering this spectacle were amazed at the endless stream of vehicles. Work was thus provided for a large number of men, who, with a team, could earn from $10 to $25 per day conveying petroleum from the wells to the nearest point of shipment. Roads were in many cases so bad that they tore down fences and made new thoroughfares to suit their convenience and they were a lawless set, as later events proved.

The inspiration of constructing a pipe-line which would obviate teaming, and by which oil could be made to flow direct to the shipping point or the refinery, is credited to a Jerseyman named Hutchings, who laid a short pipe line from some wells in which he was interested. The first test of conveying crude oil in pipes was through a two-inch iron pipe in process of being laid February 19, 1863 from the Tarr Farm to the Humboldt Refinery at Plumer, Pa., about six miles northeast of Oil City, Pa. The distance was two and a half miles. The teamsters, forseeing that their earnings would be diminished and perhaps disappear, if the system were generally adopted, destroyed the line and warned other producers against similar attempts. Hutchings was obstinate and built a second line. Again the teamsters completely destroyed his work. Undaunted, he tried again, with no better luck, and in the end died a broken and penniless man. But his idea did not die with him. In 1865 one Henry Harley commenced to lay a pipe line to the terminus of the Oil Creek railroad but the teamsters not only cut his pipes but burned his collection tanks. The State authorities, however, gave him armed protection and his line was completed. It was of



A big yield well in Mexico flowing into a temporary storage pond

Laying a pipe line through a Louisiana forest two-inch diameter, with a rated daily capacity of 800 barrels.

J. D. Henry, one of the most eminent historians of petroleum, asserts that the first commercially successful pipe line was constructed in the summer of 1865 by Samual Van Syckel of Titusville, from the mushroom city of Pithole, Pa., to the nearest railway station, Miller Farm, a distance of four miles. Van Syckel had the backing of New York capital, and the basis of his success, after similar projects had been abandoned as visionary, was due to better mechanical arrangements. Van Syckel's line does not appear to have suffered from the lawlessness of teamsters. On the completion of Harley's second line in the same neighbourhood, both proved so commercially successful that capitalists bought and amalgamated the two. Teamsters continued to give trouble and effect damage but protective measures were successful in securing the performance of the enterprise.

From that time onward the mileage of pipe-lines has steadily multiplied, and by means of them the crude petroleum collected at a "tank farm" on the prairies is conveyed to refineries many hundreds of miles away. The first pipe-line of considerable length was laid in 1880 from Butler County, Penn. to Cleveland, Ohio, a distance of over 100 miles. Almost immediately after trunk lines from Bradford, Pa. to the Atlantic seaboard were commenced. By 1893 there were 3,000 miles of pipe lines in the Eastern states with storage facilities for 35,000,000 barrels of oil.

British and French historians of petroleum, viewing the development of the industry from the standpoint of impartial observers, regard the year 1883 as an epochal one in its history, because it marked the initiation of a comprehensive policy with regard to pipelines, under the inspiration of John D. Rockefeller. Mr. Rockefeller, originally a produce merchant, became interested in the oil business as early as 1862 by the purchase of an interest in a small refinery at Cleveland, and by 1865, had become so convinced of the possibilities of the petroleum industry that he devoted himself exclusively to the refining and shipping business. In 1870 this business became incorporated as the Standard Oil Company.

Of the events of 1883 Alfred Lidgett, a noted British oil expert and editor of the *Petroleum Times* (London, England), says in his book "Petroleum," published in 1919: "Then a few master minds came to the front, and loyally supported by John D. Rockefeller, they undertook the herculean task of practically girdling the United States with a system of oil pipe-lines that has no parallel anywhere. They eliminated the jaded horses, oil boats, wooden tankage and slow freights, tedious methods, and questionable practice of handling petroleum, and substituted therefor the steam pump, the iron conduit, the steel tank storage, and systematic and business-like methods which soon commanded the confidence and respect of all oil-producers. They extended their pipe-lines to almost every producing well and established a transportation system which serves the industry to-day as no other on earth is served. The advantages of the modern pipe-line to the oil-producer are obvious."

The pipe-line connection to the producer's well and tanks ensures prompt clearance of the crude and a steady cash market for his output, under the system defined in the last chapter. The elimination of waste and the reduction of cost in connection with transportation, of course, resulted in great material benefits to the consumer of petroleum products. It is indeed quite clear that without this

Napoleonic organization of the pipe-line service the boon of petroleum could not have been adequately utilized by humanity at large.

In conveying oil through the pipe lines both gravity and pumping are used. The pumping station at the "tank farm" forces the crude into pipes through which it commences its long journey to the refinery. This pumping equipment is in itself a wonderful mechanism and drives the oil over heights where gravity cannot assist. The pipe at the field lines where the journey starts varies in diameter from 2 to 8 inches and the joints are screw threaded. The main trunk lines are from 6 to 12 inches in diameter and pumping stations to continue the driving process are located at necessary intervals along the route. In some fields the oil is heavier than in others and then the stations have to be located nearer to each other, while in the case of certain very heavy crudes, heat is applied to promote the flow before it enters the pipe-line.

By this system the amount of oil that flows under the soil of the United States to distant points exceeds half a million barrels daily. Concealed and unobtrusive, these lines do their work so well that millions of people whom they serve are unaware of their existence. Everyone knows of the freight train that links up the small town factory with the central distributing point, and of the grain car which carries the farmer's wheat to the seaboard; but little attention is paid to this great but inconspicuous transportation adjunct of American industry, the petroleum pipe-line.

As the system has grown, handling in tank cars of anything but refined product has become more and more nearly obsolete, for economic reasons. Once installed, the pipe-line system is cheap and easily maintained. It would, indeed, be quite impossible to conduct the American oil industry of to-day by the use of railroads, even though they were greatly multiplied. The crude oil which flows daily, east of the Rocky Mountains, through pipe-lines would fill over 2,500 tank cars. Since, on the average, a barrel of crude travels 1,000 miles before it reaches its destination, it would require approximately 75,000 tank cars to do the daily work of transportation effected by the pipe-lines, not to mention approximately 900 engines which it is estimated would be required to move them. Leaving out all the possibilities of congestion in stormy weather, it will be seen that such a task is one that railroads could not hope to carry out. In its present dimensions the oil industry, therefore, owes as much to the pipe-line as to the actual existence of oil deposits themselves. The work they perform is infinitely more even and uninterrupted than that of any system of railroad or water transportation. The pipe-lines run to full capacity, winter and summer, day and night, the year round, making possible the existence of great central refining plants where the crude can be treated in bulk at the lowest possible cost, and where distribution can be effected at the lightest impost on the ultimate consumer.

CHAPTER IX

REFINING AND MANUFACTURING PETROLEUM PRODUCTS

AS HAS already been intimated, the Pennsylvania oil discoveries of fifty years ago would have been relatively valueless if methods of refining had not advanced sufficiently to develop the marketable possibilities. If the reader has followed this narrative he will not have failed to note that it was the optimism of experimental chemists, who discerned in petroleum the possibilities of an illuminant which would take the place of whale oil and other fats, which first suggested to pioneer investors like Bissell the idea of developing America's oil fields by the boring system. Certain crude traditional methods of refining petroleum had prevailed for centuries in the East, but they had not produced an illuminant that would be acceptable to our civilization.

The advancement of science, which gradually enabled the early American refiners to produce a comparatively odourless, safe, and free-burning oil from the crude, gave the necessary stimulus to the new industry. The American refining system has since become one of the greatest examples of standardized industry, fascinating in its minutiae, and amazing in the efficiency and economy of its organization. The pipe-line system has promoted the establishment of great central refineries whither the crude travels distances of anywhere from five hundred to fifteen hundred miles, and which, by treating it in vast quantities, are enabled to provide the world with the products of petroleum at the lowest possible cost.

It is the purpose of the refining process to produce from the crude petroleum marketable products and this involves two stages. First: The separation of the crude petroleum into its constituent parts, corresponding in general to gasoline, kerosene, lubricating oil, etc., and, subsequently, the purification of each of these roughly separated products to bring them into marketable condition.

The process might be best understood by likening the crude petroleum to gravel scooped from out of the hillside. Such gravel would consist of a mixture of sand, fine gravel, coarse gravel, rocks and boulders. In this condition it would be unmarketable, except perhaps to fill up marshy land. By analogy the crude petroleum consists of a mixture of many different compounds and the mixture itself is unmarketable and of no value except as a fuel, at once troublesome and dangerous.

To prepare the freshly mined or "crude" gravel for the market it would be sifted through a series of screens which would separate it into its component sizes. As a result of the sifting operation there would be produced builders' sand suitable for use in mortar, fine and coarse gravel desirable for concrete, rough rock for road foundations, and boulders for masonry structures.

The crude petroleum oil is a liquid and cannot be sifted on screens as is the crude gravel, but nature has given it properties in consequence of which it may be separated into its constituents almost as easily as is the gravel. These properties are the different boiling points of the several constituents. Thus, when water or any other single liquid is heated it continues to increase in temperature until boiling begins, after which its temperature remains the same, no matter how rapidly the heat is applied, until all of the liquid has been boiled away. When petroleum is heated, however, it begins to boil at a very low temperature, a temperature hardly hot enough to injure the skin, in some cases. It is not the whole of the petroleum which is boiling, however, but only the very lightest part of it, that is, the gasoline or naphtha. If the temperature were to be held constant for a short length of time all of the gasoline would have been boiled off, and although the liquid would be just as hot as it was before, the boiling would cease entirely. If the heating is now continued, however, and the temperature of the oil raised to some higher figure, it again begins to boil and now it is the kerosene constituent of the crude petroleum which is being converted into vapour and driven out of the liquid. After a time all of this kerosene will be gone, and as before, the liquid, although sti l at the same temperature at which it has just previously been actively boiling, remains quiescent. In this fashion the various constituents of the crude petroleum may be separated from one another by a "sifting" operation somewhat similar to that used to separate sand from gravel and gravel from rock, except that instead of employing screens to effect the separation there is employed an apparatus in which the heat of the oil can be gradually increased and the products, which are successively driven off in this fashion, separated from one another.

The apparatus commonly employed for this purpose is called a "still" and consists merely of a steel receptacle, usually in the form of a horizontal cylinder, much like a simple steam boiler. These stills have been developed to large capacity, some of them holding upwards of 50,000 wine gallons of oil at one time. The still is mounted over a furnace which is usually heated by coal just as an ordinary steam boiler. In this still the temperature of the crude petroleum is gradually raised and with each elevation in temperature a different product is boiled or driven off the mass of liquid until finally nothing remains in the still except a small quantity of black residue which is known as petroleum coke.

It remains, therefore, to cool and condense these vapours. This is accomplished by an apparatus called a "condenser" which is connected to each still. An elementary condenser consists merely of a coil of pipe submerged in a tank of cold water. The vapour leaving the still passes through the submerged coils in which the vapour by cooling is caused to return to a liquid condition. Into one end of the condenser coil, therefore, the vapour from the still enters and from the other end there flows the condensed liquid.

The first and most important step in the process of refining all crude petroleum is conducted in the fashion above described. A refinery of large size will have perhaps 100 of those crude stills which are generally arranged in groups or batteries, each battery containing a dozen or more stills. From each still the condenser pipes are led to a "receiving house" which is located in some central position. In this manner it becomes possible for a single responsible supervisor to observe and control the operation of a large number of stills. The supervisor is called the "stillsman" and upon him rests the responsibility for directing the initial process of separation or sifting by which the crude petroleum received at the refinery is roughly separated into different "fractions" or parts, each of which by further refining becomes a marketable petroleum product. As generally conducted, this first distillation process separates the crude petroleum oil into four major fractions.

The fraction which has the lowest boiling point and is therefore the first to be driven off from the crude petroleum in the still as the latter is heated, is the naphtha or gasoline fraction. When all the naphtha or gasoline from any particular still has been driven off, the stillsman, stationed in the receiving house and able to observe constantly the character of the condensed liquid, which is delivered by the pipe from the condenser coil to the house, will change the connections in the receiving house so that the next "distillate" to be received will flow to a separate tank. This second distillate which comes into the receiving house and is thus diverted to a separate tank will be the illuminating oil distillate or, in refinery parlance, the "refined oil distillate." It is interesting to note that "refined oil" to a petroleum refiner still means kerosene illuminating oil, since in the original petroleum industry this illuminating product was the only fraction of the crude oil which was highly purified or refined. The entire remainder of the crude petroleum, including gasoline and the lubricating oils and other products heavier than kerosene, were either discarded wholly or else sold for whatever they would bring in an unrefined or very poorly refined condition.

The next product which is driven off from the crude oil after all of the kerosene has been removed is a somewhat heavy and discoloured, but free flowing oil, known as "gas oil." Gas oil is seldom sold at retail and the general public has very little knowledge of it. Its main use is for the manufacture of city gas, auxiliary to coal, the products of which form the base of city gas.

The next product after the gas oil and the last important product of crude petroleum is the lubricating oil distillate, which is known as "paraffine distillate" for the reason that it contains the paraffine wax.

With the exception of the gas oil, which by reason of the uses to which it is put does not usually require any further treatment, the products thus roughly separated from the crude petroleum each need not only further separation, but actual chemical purification to prepare them for the market.

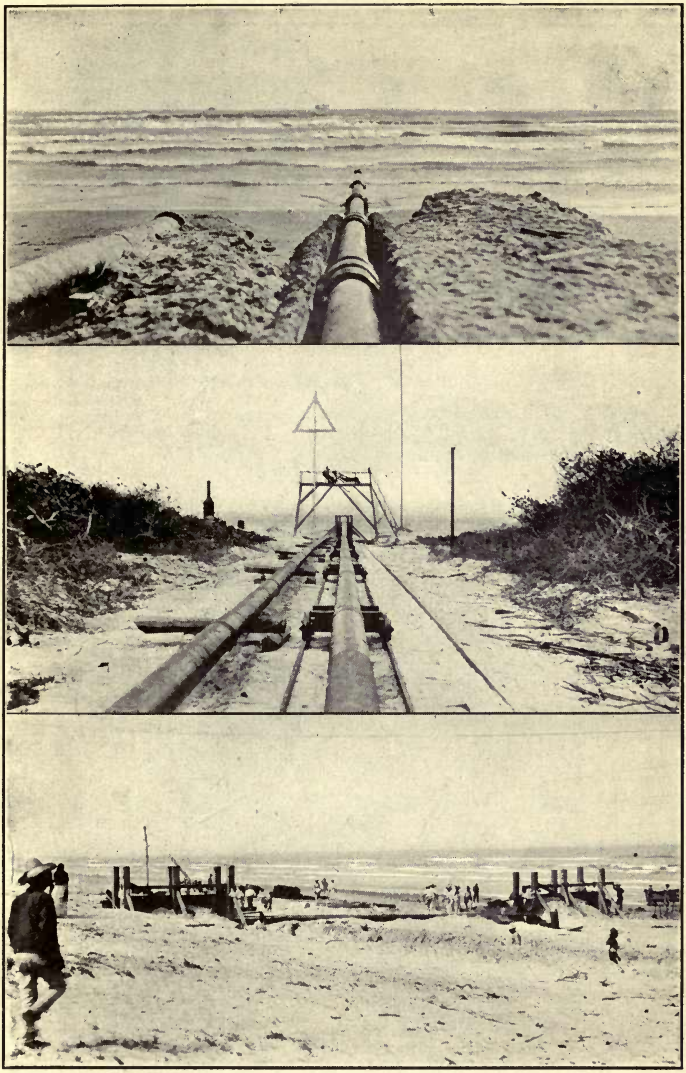
Considering these products in the order in which they are derived from the crude petroleum, the gasoline or naphtha fraction is often subjected to a second distillation by which it is further "sifted" into light, intermediate and heavy naphthas. It is customary to conduct this second distillation process by steam heat instead of by fire, since the gasoline or naphtha fraction boils at such a low temperature that it is unnecessary to resort to a furnace and furthermore, the quality of the product is thought to be better if the second distillation is conducted with steam. Following this second distillation the naphtha or gasoline is subjected to chemical purification which involves treatment with sulphuric acid, with sodium hydrate, sodium plumate and filtration through Fuller's Earth—a species of clay which has been found to have not only a mechanical but probably also a chemical purifying and decolourizing action. There is a considerable variation in the purification or refining method employed by the different refiners, but the foregoing treatments are the principal ones now in vogue. The marketable products produced from the crude gasoline or naphtha distillate by this redistillation and purification process are principally as stated—light naphthas, intermediate naphthas and heavy naphthas. The light naphthas range from petroleum ether, an exceedingly sweet-smelling and volatile liquid to aviation gasoline, especially suitable for use in aeroplane motors under extreme conditions of temperature and power development. The intermediate naphtha is the ordinary gasoline of commerce, principally used as fuel for automobile engines. The heavy naphtha is that often sold under the name of benzine, cleaners' naphtha, solvent naphtha or varnish makers' and painters' naphtha.

As these names indicate, the heavy naphtha is principally used in the manufacture of paints and varnishes, for dry-cleaning and as a solvent in the chemical industries.

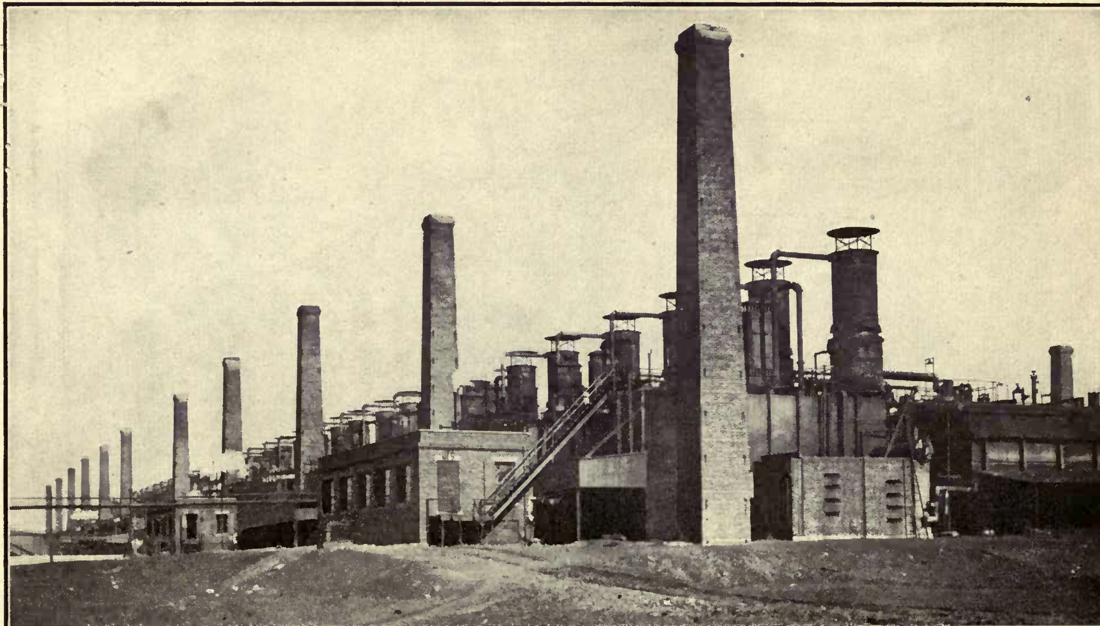
The second fraction of the crude petroleum, the kerosene, illuminating oil, or "refined oil," is likewise ordinarily subjected to a second distilling operation, the main purpose of which is to separate it from any traces of gasoline which would tend to make it highly explosive and dangerous when used in lamps. This re-distillation is followed by a chemical purification, producing the kerosene of commerce, which is not only so safe that it may be heated to a temperature well above 100° F. without danger of giving off any explosive vapour, but is also water-white in colour, crystal clear, and of such purity that it may be burned in a lamp in a closed room without producing offensive odours or smoke.

The third major fraction of the crude petroleum is the gas oil which has previously been referred to. In general this product may be marketed without further treatment.

The next and last major fraction is perhaps the most interesting of all. It is from this fraction that the host of lubricating products are obtained and



Lines for loading oil on vessels anchored from one to two miles off shore. This is a regular practice in Mexico where a deep harbour is not available



Battery of crude stills at the Bayway Refinery, Linden, N. J.

also the paraffine wax which has almost entirely superseded animal and vegetable waxes, not only for candles, but for laundry use, for producing water-proof paper, for sealing preserve jars and for a multitude of minor uses. The first step in the treatment of this "paraffine distillate" or lubricating oil distillate fraction of the crude petroleum is to separate from it the paraffine wax which it carries in solution. This is accomplished by chilling the oil to a very low temperature through the use of refrigerating apparatus. When the oil is thus chilled the dissolved wax therein crystalizes so that the mixture resembles nothing more than slush or mush ice. Having caused the dissolved paraffine to freeze and come out in the form of slush in this fashion, it remains to separate it from the oil. This is accomplished by filtering the mush, still held at its low temperature, through canvas cloths. The oily part of the mush passes freely through the cloth while the solidified particles of wax remain on the face of the fabric. The first two products separated by the chilling and filtering processes are therefore a wax-free oil and an impure paraffine wax.

The impure paraffine wax is known as "slack wax" and is melted and poured in a liquid condition into shallow pans, where upon cooling, it solidifies. The pans are then slowly and cautiously heated, and as the temperature of the wax rises, the small quantity of oil which it still carries sweats out of the wax, just as though the wax were actually perspiring.

As a result of this sweating operation there is produced "crude scale wax," the ordinary wax of commerce. It is yellow to ivory in colour, contains only a small proportion of oil and is almost odourless and tasteless. The crude scale wax is very commonly further refined by the general methods used throughout the oil industry, i.e. by treatment with acid and alkali, and by filtration, to produce refined paraffine wax of pure white colour, free from oil, and without odour or taste. It is this refined grade of wax which is commonly met with in the retail market.

Returning to the wax-free oil which passes through the canvas filters, leaving behind the impure wax, we find that this is the product from which lubricating oils are obtained. It is an oil of dark brown or amber colour, considerably heavier than kerosene and has a very greasy feeling which is indicative of its value for lubricating purposes.

Elaborate methods have been devised for accurately determining and gauging this greasiness or viscosity, which is the property of the oil upon which its lubricating value is most dependent. In general, this oil is in part re-distilled, that is, it is charged into a still and subjected to a temperature which is sufficient to drive off, in the form of vapour, some portion, though not all of the oil under treatment. This process, accurately described as "reducing" the oil, serves to concentrate in the residue remaining in the still, the heavier or more greasy or viscous constituents, the grade or viscosity of the lubricating oil depending on the extent to which this reduction is carried. As in the case of the other petroleum products, it is customary to carry out a chemical purification process and to filter the oil subsequent to the redistillation. As a result of such further chemical purification and filtration, the colour of the oil is improved, any suspended solids or dirt which it may contain are removed, and any chemical constituents which it may contain and which may be detrimental to its use, are destroyed.

The refining process above described is that which is most largely employed in this country, being a typical process for obtaining gasoline, kerosene, gas oil, lubricating oils and paraffine wax from the grade of crude petroleum produced from the central and central western states of the United States. The process is considerably varied, however, in dealing with crude petroleum of different characteristics. For example—there is produced in Mexico and imported into this country for refining in the plants located on the Atlantic Coast a very large amount of petroleum oil which is little more than thin asphalt. Oil of this character is not generally used for the production of lubricating oils or wax, but is instead merely refined for the production of gasoline, kerosene, and fuel oil, or for gasoline and fuel oil only. It will be understood that the term "fuel oil" merely indicates any heavy petroleum oil free from dirt and water, and fluid enough to be readily pumped through a pipe, and containing no constituents which would make it apt to give explosive mixtures with air. Fuel oil of this description is largely replacing coal as a fuel for steamships.

The State of California produces a considerable quantity of this "asphalt base" crude petroleum, which, like the crude petroleum from Mexico, is subjected to refining processes very much simpler and yielding mainly gasoline, kerosene and fuel oil.

It is usually also from crude petroleum of this character that the artificial asphalts which supplement the supply of natural asphalt for paving material are produced. These artificial asphalts in general represent the heavier constituents of crude petroleums, such as those of Mexico and California. The term artificial asphalt is perhaps a misnomer, for, although the properties of the asphalt are somewhat modified by the refining operation, the asphalt exists as such in the crude petroleum oil and the main purpose of the refining operation is merely to separate it from the fluid constituents of the oil in which it is dissolved.

There is also a large amount of oil produced in the United States, mainly in Pennsylvania, which is of a character especially suited to the production of high grade lubricants by a simple refining method. With oil of this character the lubricating constituents do not require distillation to separate them from impurities. The crude petroleum may be directly reduced by distillation, taking off the three major fractions, that is, gasoline, kerosene and gas oil, and leaving behind in the still a very good grade of lubricating oil which, however, contains paraffine wax. To separate this wax from the lubricating oil, in which it is dissolved, an ingenious process called cold settling is resorted to. According to this process, the mixture of lubricating oil and wax is diluted with gasoline, enough gasoline being employed to make a very thin liquid, and the mixture is then chilled to a low temperature. From the chilled mixture the paraffine separates out in the form of a thick grease which settles to the bottom of the chilling tank. This grease is subsequently refined to produce the various grades of petroleum jelly. The lubricating oil diluted with naphtha and separated from the paraffine or grease as described is subjected to redistillation for the separation of the naphtha and forms a base for the production of a wide variety of high grade lubricants.

Returning to the analogy by which we compared crude petroleum oil to crude gravel mined from the hillsides, it will be noted as in the case of the gravel, the various crude petroleums differ in character considerably, according to their origin, and that the refining process must be modified to suit the character of the oil.

The analogy may be pursued one step further to explain one of the most interesting developments of the modern petroleum industry, i. e., the manufacture of gasoline not naturally contained in crude petroleum. This process of *manufacturing gasoline* is called "cracking."

Let us assume that we desire to obtain from crude gravel, mined from the ground, a maximum amount of fine gravel. We would first use all of the fine gravel which was naturally contained in the crude gravel and then we might pass the remainder of the gravel, which is too large for our use, through crushing rollers which would crush or crack it, thus producing an additional quantity of fine gravel. An analogous process has now been successfully developed for the treatment of petroleum oils. According to this process, a heavier constituent of the crude petroleum oil, for example, kerosene or gas oil, may be subjected to distillation at high temperatures, and under high pressure in special stills designed for this process, thus securing increased quantities of gasoline. In this operation a certain proportion of the heavier oil treated is caused to break down into gasoline. The U. S. Bureau of Mines estimates that in 1919 some 15% of the country's total gasoline production was obtained by this process.

CHAPTER X

PETROLEUM AND OTHER INDUSTRIES

PETROLEUM products not only enter as an essential into great industries; but their manufacture and distribution have given birth to many allied industries directly connected with the oil business. The plant of a modern refinery, for instance, by no means begins and ends with equipment for the distillation and treatment of oil. We have seen that the petroleum industry has given birth to an underground transportation system entirely unique, which accomplishes something impossible to railroads, under any conceivable organization. The architectural breadth and completeness of detail which characterize the petroleum industry, as now organized, also extend to many mechanical trades. The modern refinery is a self-contained institution. It goes outside its own organization for little. Besides its still hands and other types of oil workers it has its corps of carpenters, pattern makers, machinists, acetylene welders, boilermakers, sheet iron workers, riveters, blacksmiths and the like. A modern refinery of the large type is a complex industrial unit, astonishing in its diversity of duties and pursuits. Among them this army of workers construct almost everything that is necessary to carry out the work of storage and distribution. Steel, delivered from the rolling mills in immense plates, emerges in the form of tank wagons, stills, condensers, tanks and all the varied equipment of the refining industry. Highly technical and intricate mechanical operations are carried out in connection with the manufacture of these accessories. The lay visitor to such an institution will find himself amazed by the sight of roller shears that cut out half an inch of iron neatly and easily. Punching a four inch washer out of solid half-inch steel is a relatively light operation with the power available. By means of the multiple punch a row of holes is cut in a sheet of steel within fewer seconds than it would have taken the village blacksmith of the olden time hours to execute. The hydraulic press pats the steel plates into the required shape with a stroke of several tons. Cutting steel with an acetylene flame is a familiar sight, and the man who operates this torch could cut a hole in the side of a battleship in short order. Electric cranes toss beams weighing twenty tons or more about as though they were jack-straws. By such processes a tank capable of holding 55,000 barrels of oil comes into being with astonishing expedition. The production of the barrels, boxes and innumerable subsidiary requirements of a great manufacturing industry are all a part of the plant's activities. Refineries also provide a considerable portion of their own fuel. The gas produced in the refining process is collected to run gas engines which provide power for various mechanical operations.

Although the refinery is self contained, the various branches of oil production, transportation and treatment have been a stimulus to many industries. Invention has been applied to the construction of improved oil drilling and pumping machinery; the pump lines themselves are prefaced by mechanical production of the requisite piping. Of the petroleum industry was born the tank steamer and the tank car. Though the crude reaches the refinery largely by means of its own transportation system, its various transformations leave by other routes. Most of the gasoline and other products that are consumed on this continent find their way from the refinery to the distributing stations in tank cars, which have become an institution on American railways. Solid trains of them leave the great refineries every day; without them it would be impossible to deliver the various petroleum products, indispensable to industry, to consumers so expeditiously as now.

Petroleum's faculty, as a standardized industry, of attracting to itself subsidiary trades is, however, but a negligible consideration in comparison with its relation to industry and commerce in the larger sense of these terms. The noted English publicist, Sydney Brooks, has drawn a pen picture of the marvellous interpenetration of the world's industrial fabric which has taken place within the past fifty years.

"To-day" says Brooks, "petroleum enters into our daily life under the guise of at least 250 different and marketable commodities. It lights our lamps and stoves; it cleans our clothes; it prepares our varnishes; it acts as a substitute for turpentine in the printing, dyeing and painting industries; it invades our tables in the form of artificial butter, confectionery and a number of other edibles; it supplies us with our wax, our candles, our chewing gum, and a vast array of ointments, salves and drugs; it furnishes the dressing table with perfumes and the smoking room with matches; it imparts the final lustre to our collars and shirts; and the textile trades use enormous quantities of it for finishing soft goods; it medicates our bodies and gives to preserved fruits their peculiarly toothsome appearance; it blends with animal and vegetable oils in a range of combinations almost infinite; its residue can be burned as coke, or used in the manufacture of electric arc-lights, or employed in road making as a rival to asphalt; it lubricates our machinery and drives our motor cars, our ships, our aeroplanes, our locomotives, our ploughs and tractors. By means of it every form of transportation on land, in the air, on the seas and below the sea, has been immeasurably extended and in many instances revolutionized. There must be at least a hundred trades that now use oil for heat and power purposes where ten or fifteen years ago they used nothing but coal. The demands for it are indeed illimitable."

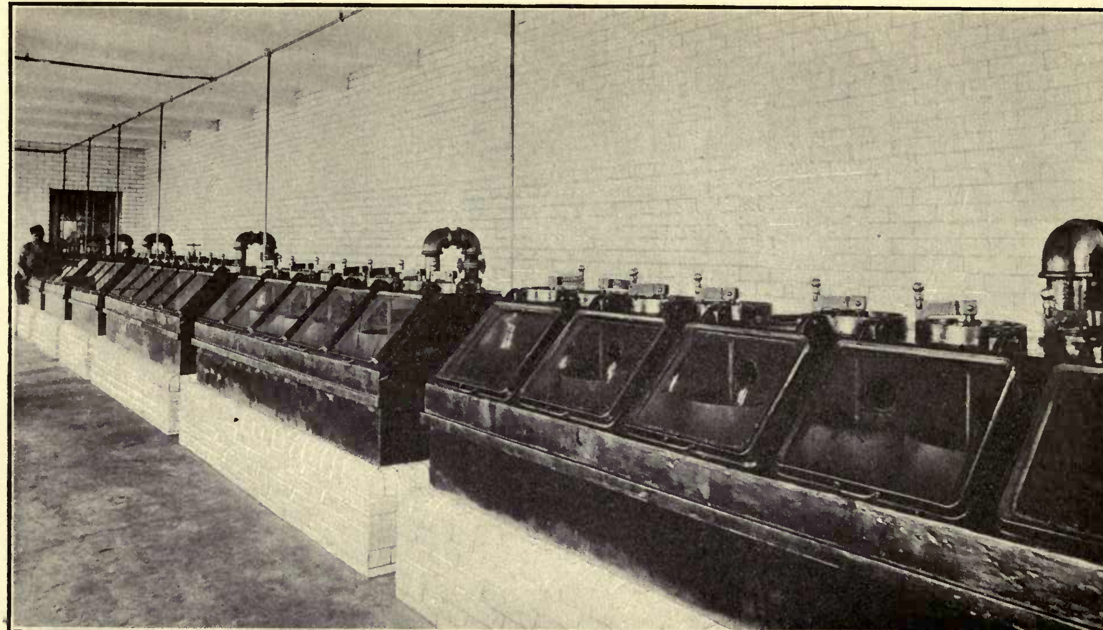
Mr. Brooks is speaking exclusively of the part that petroleum plays in the industrial and social life of Great Britain. In the United States its applications are wider still. Were it necessary, it would be possible to dilate on the relation of petroleum to agriculture in this country, where the farmer who operates a large acreage in the middle west or in Texas and California, by means of tractors finds petroleum an indispensable ally. In this sense petroleum has helped enormously to increase the food supplies of the world and the national wealth of the United States.

One of the greatest, if not the greatest of modern industries on this continent—the manufacture of motor cars—would to all intents and purposes be non-existent were it not for one offspring of petroleum (once regarded as almost the least valuable product of the refinery) gasoline. Invention has reacted radically on the oil industry, from decade to decade, and especially on its refining phase. Until the advent of what is known as the "internal combustion" engine, for instance, the demand for gasoline was so limited that when produced, as was inevitable in the distillation of many types of crude, it represented but a fraction of its present value. To-day this engine, which lives and functions by gasoline, has created an ever-increasing demand for that fluid which taxes the energy of all refineries to meet.

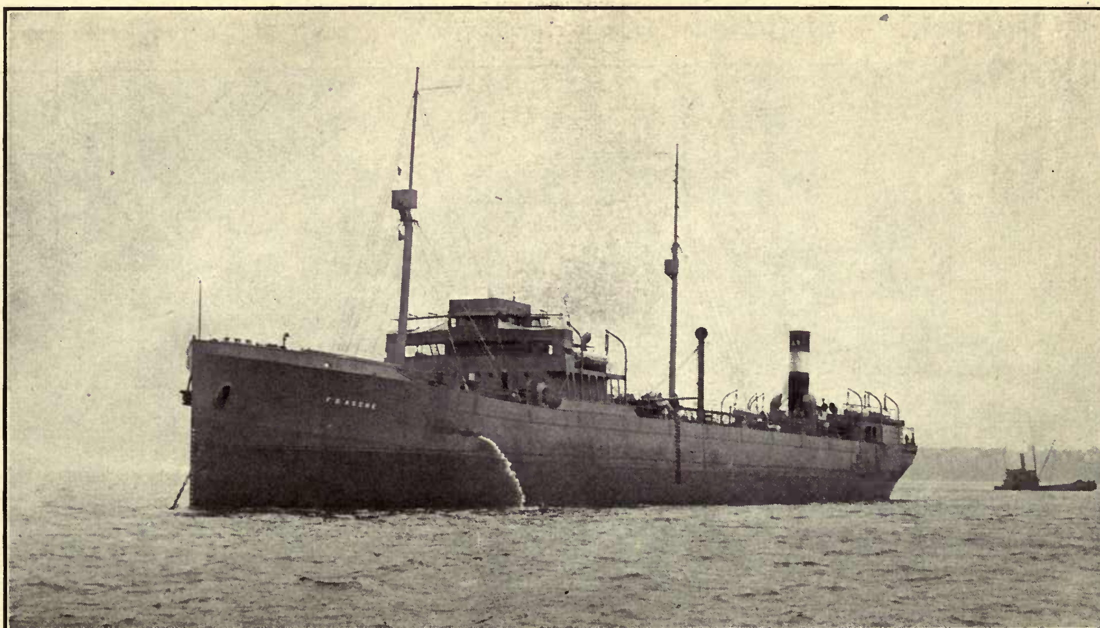
The internal combustion engine with the assistance of petroleum has indeed exercised such a powerful influence in changing the face of civilization as to demand fuller reference. It not only made the automobile practicable, but the aeroplane, the dirigible air-ship, the submarine and a host of other craft possible. When, during the autumn of 1919, the entire railroad system of Great Britain was paralyzed by a general strike, and the people of its great and overcrowded cities were face to face with starvation, it was admittedly the internal combustion engine, operated by gasoline (commonly known overseas as motor spirit or petrol)—that saved the situation. To understand its appellation the reader should note the fact that the older forms of engines were operated by steam generated in boilers, heated by external combustion—a process familiar to everyone. The internal combustion engine, on the contrary, runs by fuel (usually gasoline) which is introduced directly into the contrivance itself. There it is vaporized and mixed with air so as to become an explosive substance with great powers of propulsion. It is not difficult to grasp the immense saving of weight and space which is involved by the elimination of the boiler from the mechanism of an engine. During the war especially, the minds of all mechanical experts were applied to improvements that would result in an engine being made lighter and lighter with each new model, while at the same time meeting enormous power demands. Without such space-saving contrivances the flying machine would never have reached its modern development, and the motor car would not have come into general use. The revolution effected by automatic traction alone, with the co-operation of petroleum, would have seemed incredible a generation ago. The pioneer users of motor cars bought their gasoline at drug stores. To-day the "gas" stations in every country village and in connection with every large garage and auto-livery give testimony to the part a single product of petroleum plays in the social and commercial life of the American people. The automobile industry, which could hardly have been born without petroleum as an auxiliary, now represents an enormous investment in this and other countries giving employment to innumerable workmen of all classes.

Oil as a source of power is to all intents and purposes an outgrowth of the twentieth century. Its function as a source of light and heat is historical. Lighting by means of oil lamps has in itself undergone great improvements since the early days and the use of oil as a fuel in a manner distinct from its application to automobiles, aeroplanes and other inventions operated by gasoline engines, is steadily increasing. It is taking its place as a substitute for coal, not only in the United States but to a marked extent in other countries. For some of them it may be said to have proved a solution for railroad problems that were at one time almost insuperable. Russia, for instance, for the last thirty years, and up to the time when internal conditions disrupted her industrial organization, utilized her own petroleum for fuel. The railroads of Mexico, Argentina, Brazil and other Latin American countries as well as in Roumania are now served by oil burning locomotives where a decade or so ago coal or wood was employed. In this country the Southern Pacific Railroad and other well known transportation corporations have demonstrated that the locomotive run by liquid fuel is an economic success; in 1919 the amount of fuel oil used for this purpose in the United States was approximately 50,000,000 barrels. Railroad experts have discovered that the steaming capacity of a locomotive running on fuel oil is so materially increased that it is possible to haul with it a greater tonnage at a much increased speed than would be possible with a coal fired engine.

Oil as a domestic fuel is gradually making its way because of the advantages it gives in the matter of



"Look boxes" in the "Still House," where the grades of oil are separated according to gravity, the process being known as the separation of "cuts"



A modern tanker carrying 4,000,000 gallons of oil cleanliness. Even the time-honoured oil stove has been subjected to such improvements as to be a vastly more acceptable inmate of the home than it was in days gone by. The use of petroleum as a fuel for stationary engines in manufacturing plants has also kept pace with its employment in other directions and here again its superior heating power, the elimination of dust and the saving of labour involved are economic factors of first importance.

The invention of new devices for the utilization of oil have necessarily proven a stimulus to manufacture. Indeed, it would be impossible to trace the myriad paths by which petroleum enters into the public and domestic economy of the civilized world. So far we have left untouched one of its most pregnant applications; its relation to sea power and to maritime commerce, which is so wide and important as to justify a separate chapter.

CHAPTER XI

PETROLEUM ON THE SEVEN SEAS

THE intimate connection between petroleum and maritime commerce became assured from the day it was recognized that the United States had resources destined to make her the chief reservoir of the world's supply. An interesting discourse could be written on the manner in which the people of many nations have for centuries depended on ships and seamen for light. The function of the old whaling ships in the world's economy is now performed by the modern oil-tankers—although carrying the means of light to other lands is but a minor part of the service of these latter day vessels. The relation of petroleum to the sea may be approached from several angles. The necessity of conveying vast quantities of oil across the oceans of the world has, for instance, produced a form of maritime architecture almost as unique in its kind as is the pipe-line in land transportation. Then again, oil has within recent years tended to revolutionize the fuelling of both the merchant marine and the war fleets of this and other countries. Petroleum's relation to naval activity in time of war is so important that it will be dealt with in a separate chapter. As a stimulus to international relations it has played a stupendous part in the evolution of the United States from a great but isolated nation into a world power.

One of the most important factors in the early development of the petroleum industry in America was the realization that there existed an almost limitless market overseas awaiting this new product. American petroleum met an ever-growing need. Owing to the decline in the annual catch of whales the world was being searched for substitutes for whale oil and in the matter of lubricants for machinery there was something like famine. Within two or three years after the sinking of Drake's well, Europe was eagerly seeking to purchase not only the crude but the refined products, and the demand has grown apace ever since, despite the development of oil fields in other parts of the world. In the annals of the oil industry the name of Dr. A. F. Crawford, who in 1861 was U. S. Consul at Antwerp, holds an honourable place. In that year he arranged that a shipment of forty barrels of refined oil should be sent to the industrial country of Belgium and thus export to the continent of Europe was begun. Great Britain, which had been trying to develop Scottish shale oil production, was also quick to avail herself of the American discoveries. From the outset the problem of how to carry large quantities of petroleum products without waste, danger or injury to other cargoes, occupied the minds of shipping men. The earlier shipments were in the nature of samples despatched in ordinary cargo vessels, usually from the port of Philadelphia.

In November of 1861 Messrs. Peter Wright and Sons, a well known shipping firm of that city, chartered a small sailing vessel, the *Elizabeth Watts*, to carry oil exclusively and to deliver her cargo in London. So great was the apprehension among sailors of the dangers of sailing on an oil-ship that to get a crew the old-fashioned plan of kidnapping seamen under the influence of drink was resorted to; and the crew reached London without other disaster than the injury to their sensibilities involved. The success of this voyage prompted other shipowners to embark in the business, so that by 1864 shipments of oil from various Atlantic ports had grown to a very respectable total. Casks or barrels were used for transport, entailing a very great waste of oil, time and labour. The casks themselves called for a large initial outlay and leakages were a source of loss, damage and possible danger. In 1863 the thought of carrying oil in bulk in vessels, specially designed for that purpose, appears to have occurred almost simultaneously to importers in different parts of England. Henry Duncan of Bromley, Kent, is generally admitted to have been the father of the idea. He chartered a schooner at Chicago, fitted her to carry oil in bulk and in her hold and loaded her at Sarnia, Canada, then as now, an oil shipping point of inland America. The experiment was ill-fated, for the schooner was lost in the Gulf of St. Lawrence before entering on the high seas. But the scheme of carrying oil in the holds of wooden ships in bulk was later successfully adopted by other shipowners and continued in practice until 1878.

The genesis of the modern tanker dates from the launching of the *Atlantic* at St. Peter's on the Tyne, Yorkshire, in August 1863. In the record of this launching it was set forth that the vessel was specifically designed to carry petroleum in bulk "without the aid of casks" but there is no evidence that she was ever put into commission. The real beginning seems to have been made with the Belgian ship, the *Charles*, which is believed to have been the first ocean going ship to be fitted with iron tanks for the transport of petroleum and to be equipped with pumps for unloading the cargo. She was a sailing vessel and her capacity has been estimated as high as 7000 barrels in bulk. Between 1869 and 1872 she plied between New York and European ports. By 1878 the business of carrying oil in iron ships specially built for that purpose, or in converted vessels like the *Charles* had become definitely established and barrel-carrying ships had practically disappeared from American harbours. At first oil was carried only on sailing vessels, owing to the supposed danger of fire; but gradually adjustments were made which rendered it feasible to propel oil ships by steam.

The growth of the petroleum industry in the 'eighties made it clear that the converted oil ship was uneconomical and somewhat dangerous. Leakages in such vessels produced gases that sometimes caused explosions; and one curious fact was demonstrated, namely, that there was greater menace in an empty oil ship than in a full one, for the reason that the exposed surface from which explosive gases might emanate was infinitely greater. When an oil ship of scientific model was filled to capacity the only danger points were the hatches through which it had been filled; whereas when empty, especially if there had been carelessness in unloading, the explosive area and the possible formation of gas-producing deposits was greatly increased. With the converted ships the chances of leakage were necessarily many, owing to numerous and inaccessible waste spaces outside the tanks. This led shippers to insist on improved tankers built in such a way that absolute control could be exercised over every drop of oil on board the vessel, and over every emanation of gas given off by that oil. Much ingenuity was displayed by ship-builders in meeting this requirement and the modern tanker has the two great merits of being absolutely free from the risks of waste and danger.

For a good many years past the construction of oil tankers has been one of the important branches of industry in the leading shipbuilding countries; and they carry not only the predominating American product, but that of all the scattered oil fields of the world. They bring crude to our seaboard refineries, but they carry little crude away; their business is that of conveying the finished oils to other lands.

The shipment of the crude product of American wells overseas has long since ceased as a result of the stupendous development of our refining industry, but Mexico has lately come into prominence as an exporter of crude. In comparison with the earlier oil ships the modern tanker shows the same ratio of growth which characterizes all phases of petroleum development. The place of the tiny craft of the 'sixties and 'seventies has been taken to-day by the tanker which runs to dimensions of more than 500 feet in length and correspondingly wide beam. Whereas the little Belgian ship, the *Charles*, fifty years ago carried a maximum of 295,000 gallons, one of the larger types of modern oil tankers will carry more than 4,500,000 gallons.

The greater petroleum organizations do not depend on private shipping firms to carry their products, but build their own vessels. The great American tankers of to-day are equipped with ample deck space so that the officers and sailors have more freedom of movement than do many city-dwellers in their own home. The impulse that the petroleum industry has given to the American merchant marine as a whole is developing a seafaring spirit among American youths that was non-existent a generation ago. Many of the American tankers are among the largest that fly the Stars and Stripes. Such giant vessels coming up the fairway of a foreign port constitute a graphic advertisement for the United States, and serve as the symbol of an industrial nation standing at the head of the world's commerce. It is fitting that the American flag should have been carried to every port of the seven seas in connection with petroleum, the American product which has revolutionized the world's industry. These great vessels carry the source of light, heat and industrial energy to peoples of every language and every colour. Great progress has been made in economizing time and labour in connection with cargoes. Where but a few years ago it required days to load or unload a ten-thousand ton ship, the task is now performed in a few hours. The oil is handled by the use of powerful pumps or by gravity, when possible. Owing to the speed with which oil cargoes are handled no other ships on the ocean do so much sailing, or spend so little time in port as the oil tanker.

So far in this chapter we have dealt solely with the development of the sea-transportation of oil itself; but even larger vistas are opened when we come to its growing relation to all forms of maritime commerce and naval activity. This arises from the rapidly increasing use of oil as a marine fuel. In that respect it holds very high potentialities for America's seaborne trade. The oil tankers we have been describing are oil burning, and the same system is being applied to many other types of vessels which constitute the arteries of the world's trade. Until quite recently the supremacy of Great Britain in maritime commerce was in a considerable measure due to her plentiful supplies of bunker coal obtainable at low cost in ports like Swansea, Wales. But the definite advantages of oil as a fuel for the navigation of steamships are changing the whole maritime equilibrium. As an English writer has said, the position that oil has captured for itself in this respect has been fairly won on its merits. Oil fuel has one and a half times the heating power of steam coal, so that weight for weight carried, the radius of action is extended fifty per cent. A vessel equipped with a modern internal combustion engine consuming fuel oil may make a voyage of fifty seven days without replenishment, whereas the same vessel operated by the old type of coal-fuelled steam engine would be obliged to re-fill its bunkers at the end of fifteen days. In 1912 an Oil Congress was held in London, England, when statistics were presented containing a comparison between coal and fuel oil on the great Cunard Liner the *Mauretania*. It was shown that for the round trip from Liverpool to New York and back there would be a saving of at least 5000 tons of fuel and that the force of stokers required could be reduced from 300 to 30 men working under much less difficult conditions. The resultant increase in available space for cargo and passengers is of enormous importance to ship-owners. The relative values of oil and coal for marine use are not limited to the superiority of oil engines over the old-fashioned steam engines. The caloric or steam-raising power of oil is so much greater than that of coal as to produce a fifty per cent. superiority. Another factor is that of cleanliness. Coal is not merely bulky and prolific of many inconveniences in the confined space of a ship, but it is unquestionably dirty, as every harbour bears ample testimony. Oil is clean, smokeless and leaves no ashes and clinkers. It can be pumped on board from a tender while both ships are making considerable speed. The late war furnished innumerable demonstrations of the superiority of oil as a source of motive power at sea, which will be presently dealt with; as an aid to peaceful commerce its influence during the next few years is certain to be revolutionary and incalculable in its benefits.

The future of the oil-burning ship depends directly upon the supply of fuel, a question that at the moment is giving both the oil men and the steamship operators a good deal of concern. In recent months, owing principally to the changes effected by the intrusion of salt water in the Mexican fields, it has been a difficult matter for vessels not protected by contracts to obtain fuel oil. The advantages of this method of raising steam are so considerable that it will prove a great economic loss if, through failing supplies, it becomes necessary for oil-burning ships to revert to coal.

It would be a mistake to think that other great commercial powers are not alive to the possibilities of oil on the seven seas, but Americans may take pride in the fact that their own business men are playing a foremost part in the sea-chapters of the wonderful epic of the petroleum industry. Through their foresight and enterprise the oil bunkering station is being established at home and abroad to perform the same function that coaling stations have performed for the world's maritime commerce in the past. Although displacement of coal by oil in any wide measure is perhaps the most recent development in the story of petroleum; and the construction of oil-burning in place of coal-burning ships is the latest phase of maritime architecture, American oil producers have already anticipated the change in events by establishing oil-bunkering stations in various parts of the world. Here again American enterprise has shown itself alive to the needs of international trade by providing supply depots at ports where American oil-bunkering ships are likely to call. It is highly important that vessels under the Stars and Stripes should not be wholly dependent upon foreign agencies for filling their tanks. The United States Shipping Board has shown much interest in the development of an organized plan whereby bunkering facilities shall exist to render American ships independent of the vexatious restrictions sometimes imposed by governments in other parts of the world.

A glance at the list of such stations as it stood at the end of the year 1919 shows how much petroleum has done to extend the influence of the United States of America on the sea. Exclusive of the domestic establishments on the Atlantic seaboard and in the Gulf of Mexico, bunkering stations have been established by American initiative at all the chief ports of Canada, whether on the Atlantic or on the Pacific Coast, the Great Lakes, or the Gulf of St. Lawrence, in South America, at Rio de Janeiro, Brazil; Montevideo, Uruguay; Campana and Buenos Aires, Argentina; at Valparaiso and five other ports on the long coast line of Chile; and at three ports in Peru. Bunkering facilities have also been established at both approaches to the Panama Canal and at many points in the West Indies, including Bermuda. There are nine such stations in Great Britain; three in Norway; two in Sweden and three in Denmark, covering effectively the North Sea and the Baltic. Those on the Mediterranean include five in Italy; one in Tunis (Bizerta) and one in Egypt (Port Said).

These stations are designed to promote those peaceful and happy relations which should follow on the development of international trade, and to assure facilities for America's expanding seaborne commerce.

CHAPTER XII

PETROLEUM IN THE GREAT WAR

NO SURVEY of the place that petroleum holds in the social and industrial organization of the world would be complete without some reference of the role it played in the late war. It was inevitable that in a crisis where all the scientific, mechanical and organizing genius of the leading nations was concentrated on instrumentalities to strengthen themselves and weaken or destroy the foe, a product of so many applications should prove a tremendous factor. It would be indeed possible to write a lengthy volume on the influence of petroleum on history, based on actual deductions drawn from the incidents of that greatest of conflicts. It was an indispensable factor in the new methods of warfare that were developed; it influenced the military and diplomatic strategy of all belligerents; it was a stupendous contributor to the victory of the Allied and Associated powers. Earl Curzon of Kedleston, a member of the British War Cabinet, stated the fact tersely when he said, shortly after the signing of the armistice—"The Allies floated to victory on a sea of oil."

This was intended as a direct commentary on the assistance rendered by the United States to that cause and was a just acknowledgment of one phase of this country's contribution.

In the preceding chapter the growing maritime importance of petroleum has been shown, and it was therefore inevitable that in a conflict in which sea power was so decisive an influence that it should have been closely related to naval effort. Even if the uses of petroleum had been confined to one instrument of warfare merely—the submarine—it would have influenced the course of history and the fate of nations. Without petroleum the submarine as an effective agent in war could not have come into existence, and the whole story of the conflict from the winter of 1915 onward would have been different. Again, without petroleum no air-craft could have left terra firma, and military tactics based on the powers of observation provided by these "eyes of the army" would not have come into existence. It must also be admitted that the toll of destruction both on land and sea would not have been so great. It would not have been possible for any country to embark on a diabolical policy of destroying unarmed ships and unfortified cities, and wreaking vengeance on helpless non-combatants. But these crimes cannot be charged against petroleum itself, but rather against the ingenuity of men bent on destruction.

These were but two instances of the part petroleum played in the war. It is no exaggeration to say that there was no phase of belligerent activity in which it was not an active agent. From the very outset of hostilities in August, 1914, discerning men in Allied countries foresaw that victory must rest with the side which commanded the greater reserves of petroleum. Thus from the beginning America, as the chief source of the world's supply, was recognized as a factor of inestimable importance in the ultimate decision. Germany was as fully alive to this circumstance as her enemies. The high commands of the warring nations, from the very outset, took into consideration the desirability of securing possession of the oil fields in other lands. It was one of the aims of the British navy in driving German ships from the seas to prevent oil reaching the Central Empires from the Western Hemisphere. Later, when the blockade of

Germany was definitely established and pressure was brought to bear against countries suspected of enabling Germany to obtain various classes of supplies by indirect purchase, petroleum products were regarded as the most important items in the extended list of contraband of war.

On land, oil constantly influenced the thoughts of generals. The great and lengthy Russian offensive against Lemberg in Galicia aimed at cutting off Germany and Austria from recourse to the oil fields of that region. The long drawn out diplomatic embroglio with regard to Roumania all centred around the oil fields of that country. Germany was determined that Roumania should be forced into the war, either as an ally or an enemy; for in either case it would give her a pretext to seize the oil fields. In the end a British military mission destroyed the wells to prevent their utilization by the German invaders. In the operations of Turkey against Russia the oil wells of Baku were the objective. The early British operations in Mesopotamia were chiefly intended as a precautionary measure for the protection of oil fields of which the Persian Gulf is the outlet. Citations such as these from the history of the war on all fronts could be multiplied to show

how closely the petroleum question was interlocked with belligerent action.

It is admitted by candid historians that at the outset of the war the British Government did not appear sufficiently to appreciate the grave importance of petroleum products in the prosecution of war. The conflict had not been in progress for more than a few months, however, when the disruption of the European fields and the obstacles to obtaining regular supplies from the far East caused grave alarm both in London and Paris. It was then that the friendship of the American people for the Allied cause made itself felt in practical form. Had American oil interests then proved hostile or indifferent; had the Government of this country yielded to Germanic pressure and placed an embargo on oil shipments, the cause of the Allies would have been doomed. In 1917 it was admitted in the British House of Commons that adequate supplies of petroleum products were quite as essential as men and munitions. This was almost an understatement, because without the aid of petroleum the necessary maximum of effort in other respects would have been impossible.

Apart from naval and aerial needs, a reminiscent picture of the Western Front during the three or four years of trench warfare reveals the predominant importance of petroleum. It proved a decisive factor as early as the Battle of the Marne. It will be recalled that one of the greatest factors in Marshal Joffre's victory was the feat of General Gallieni in transporting a fresh army from the Paris area to the front by commandeering nearly every motor car and taxicab in Paris. Thus, petrol transport hastily improvised saved Paris and turned the scale of the 1914 campaign against the Germans. It will be recalled that the conflict then settled down to a prolonged era of trench warfare. The Allies commenced the construction of strategic railways to support the armies of the line, but between the railheads and the actual battlefront in the long stretch from the North Sea to the borders of Switzerland, transport was almost wholly dependent on motor spirit or gasoline. Innumerable heavy motor lorries carried food, guns and ammunition to the fighting forces. But the function of petroleum products on land did not end in its association with commissariat and supply. It was an aggressive instrument. The greatest new factor in land fighting that the war developed was the "tank"—a land battle cruiser, first introduced by the British at the Battle of the Somme in July, 1916, and afterwards adopted by all armies. This great instrument of war was wholly dependent on petroleum products for its power of movement. Without the internal combustion engine operated by gasoline it would have been an immobile toy. Again, when liquid fire came into use petroleum was the basis; and in another great destructive agent—the explosive, known as T. N. T.—toluol, which is found in some of the heavier grades of petroleum, was a basic constituent.

Though petroleum in the hands of inventors became an agent of terrible destruction, it had its beneficent uses in battle as well as in periods of tranquility. Armies organized on so vast a scale could not have been fed without it. When the battle raged the Red Cross vehicles which performed the work of transporting the wounded to the dressing stations and field hospitals were propelled by gasoline. And when darkness had fallen on the fray the oil lamp and the paraffine candle were lighted to cheer the tired soldiers. An English writer who visited the front in 1917 wrote of the all-pervading uses of petroleum: "It was to be found wherever there was a vestige of life in those zones of battle; the soldiers in their, at times, lonely dug-outs, used oil for cooking as well as light, and all traffic was guided from disaster along the roads by the use of oil, which also offered the only source of artificial light in the Red Cross vehicles. What an immense organization it was which depended for its ceaseless activities upon the products of petroleum."

The British established a petroleum depot at Calais of an immensity previously unprecedented, where all products required for the organization of transport were stored; and it must be noted that lubricants of all kinds were as essential as gasoline itself, to keep moving the wheels of the innumerable motors that were employed by the various arms of the service.

If petroleum was the life blood of activity in the battle areas, it was not less so of the munition factories where the means of offense were fabricated. Had a real petroleum famine arisen during the days when factories in Britain and France were straining every effort to keep their armies supplied with the means of combat it would have been an incalculable catastrophe. Though the Allies, once they really awakened to the dangers of the situation, had pursued the policy of piling up reserves of petroleum products there were times when the failure of a single tanker to arrive on schedule time from this side of the Atlantic caused grave apprehension; and when in April, 1917, the United States entered the war, reserve supplies had fallen dangerously low.

If only because it placed the entire oil resources of America at the disposal of the Allies, the entry of the United States into the conflict proved the salvation of their cause; and the story of what the oil interests of this country did to strengthen the hands of the fighting men is one of the brightest chapters in the history of the war. After the armistice, Marshal Foch summarized that achievement in these words: "No military operation of the Allies on sea, on land, under sea or in the air was ever interrupted by the lack of petroleum supplies."

Unquestionably one of the motives which actuated Germany when, in February 1917, she decreed unrestricted submarine warfare and ordered the Stars and Stripes off the seas, was the hope of cutting off the petroleum supplies of her foes. Even before President Wilson declared war, several American tankers had been sunk by German U-boats. The German Government fully understood that a cessation of oil shipments from American ports would mean an almost immediate paralysis of belligerent effectiveness in her foes and the "German Peace," for which they had long been manoeuvring, would have been accomplished. When activity was keenest on the Western front eighty per cent. of the oil and oil fuel used by the Allies came from the United States. After the war was over it was revealed that forty-eight per cent. of the fighting force of the British navy was dependent on oil for fuel and any delay in the supply would have brought the Allies down with a crash.

It is now admitted that in the Spring of 1917 the Allies were closer to disaster than was known to any, save a few men at the head of affairs. It was a turning point in the world's history. Next to man-power and munitions the resources needed above all others were petroleum and its products. The French coal fields had been lost. There was a labour shortage in Great Britain; Russian, Roumanian and Galician sources of supply were now definitely in the hands of the enemy. The Mediterranean Sea, through which the Far Eastern supplies must come, was a hot-bed of submarines; and indeed losses of oil steamers in all dangerous waters were so great as to show that they had been named as special targets by the German high command.

An exchange of confidence between the Allies and the United States naturally followed the decision of this country to defend the freedom of the seas. Immediately after President Wilson's declaration of war, urgent despatches from Great Britain warned our government that reserve supplies of petroleum in Europe were so low that unless immediate assistance were rendered, a partial demobilization of the British fleet must ensue. "We must have oil" said Marshal Foch, whose prescience had not yet been rewarded by elevation to the Supreme Command, "or we shall lose the war." Italy was in no better position, fuel oil, aviation naphtha, gasoline and lubricants had been so seriously depleted.

When the secret of the situation was confidentially communicated to the leaders of the American oil industry, there was an instant response. The National Petroleum War Service Committee was formed, with Mr. A. C. Bedford, Chairman of the Board of the Standard Oil Company, (N. J.) as its presiding officer. The organization embraced all the oil companies of the United States. Those who had been life-long keen business rivals joined hands to keep the great war machine in Europe in action. Profits became a minor consideration. Agreements to stabilize prices and curb speculation were formulated and observed. Production on a scale previously unprecedented in this land of enormous oil production was organized. Soon it was recognized that the work of the National Petroleum War Service Committee, though unostentatiously performed, was the most efficient and the most fruitful in results for the cause of democracy of any industrial institution in the war. It achieved the remarkable feat of meeting every war demand for petroleum products of all kinds, of conveying these products across the Atlantic, despite the submarine scourge. When the war came to an end there were larger stocks on hand in Great Britain and European countries for the use of the armies and navies of America and her allies than at any previous time in history. These results were achieved by the voluntary efforts of thousands of men serving in every phase of the oil industry, crude production, refining and transportation. After the armistice the Government of France, in recognition of what had been accomplished, conferred on Mr. Bedford the Cross of the Legion of Honour.

Co-ordination having been arranged, the problems to be dealt with came under two heads, (1) Increased production; (2) Sea-transport. The first constitutes a record of highly organized endeavour never surpassed in the history of industry; the second one of actual heroism.

Plans for increased production were well under way by the summer of 1917 and it must be remembered that the entrance of the United States into the war and our resolve to create an immense and fully equipped army greatly increased domestic necessities in addition to the obligation to keep our allies in Europe supplied. The thoughts of all were fixed on the great blows which were to end the war in 1918. When the winter of 1917–8 arrived it seemed as though the elements were fighting on the side of the Hohenzollerns. The extraordinary severity of that winter, complicated by a coal shortage, all but paralyzed railroad traffic. Thus, deliveries of the finished products necessary to war industry and belligerent activity were embarrassed in a degree that caused the greatest anxiety to the National Petroleum Committee. Yet somehow or other it performed its task and the refineries trebled their pre-war output, expanding their capacities like an accordion. In addition to the vast quantities consumed at home, shipments abroad arose to stupendous figures. In the year 1918, 2,628,961 tons of fuel oil alone were shipped from the Eastern seaboard for the use of allied navies; and in the same year more than one million tons of high distillates and other petroleum products also crossed the Atlantic, entailing more than 500 tank steamer loadings.

This was accomplished in the face of a shipping shortage that appalled those in the secret of its extent and in the face of the submarine activity virulently directed against oil cargoes. It was in this matter that the sailors of the American merchant marine showed a heroism not excelled by soldiers in the field or the seamen of any nation. The great value to civilization of the fleet of tank steamers built up by American oil exporters was also demonstrated. When President Wilson declared war one great company had already lost three big vessels through submarine attack, and during the war these losses were augmented by seven more, representing a loss of more than 75,000 deadweight tons and a toll of many lives. To meet its losses this particular company undertook to build a new ship for each sunk, and so efficiently was this policy carried out that its fleet, which had totalled 445,975 tons at the commencement of unrestricted submarine warfare in February, 1917, had grown to 492,080 tons under the American flag when the armistice was signed in November, 1918. Nor was the problem of shipping limited to that of carrying petroleum across the Atlantic. Much was required for coastwise trade in North and South America.

The resourcefulness of the oil men of America was not confined to mastering the seemingly insuperable problems of increased production and transport. A minor contribution to the efficient prosecution of the war was the construction of a pipe line across Scotland to supply the British and American navies in the North Sea and avoid sending tank steamers through the dangerous sea routes leading to the naval bases on that body of water. This work was carried out by Mr. Forrest M. Towl, President of the Southern and other pipe line companies, and was in full operation shortly before the armistice was signed. In this work both the American navy and the British Admiralty coöperated.

Even apart from its wonderful assistance to belligerent action on land, it is clear that petroleum played a vital part in winning the war at sea. The following succinct statement of what it accomplished was given by a well-known oil man conversant with all phases of the subject, shortly after the armistice.

"Oil and internal combustion engine made possible the submarine, enabling Germany to stave off defeat as long as she did, but oil burned under boilers gave us the increased efficiency of the destroyer, which conquered the submarine. It was the ability of the Allies to obtain a constant, ample supply of oil and the superiority of oil over coal as fuel for naval operations that finally turned the tide of battle and proved a decisive factor in the war.

"The destroyers that broke down the morale of Germany's undersea crews were oil burners of such remarkable flexibility and speed as to bring about a sharp change in naval practice. It took some time to bring the number of destroyers up to the work laid out for them by Germany's early advantage, but the fate of the undersea boat was sealed with the arrival of the first oil-fired destroyer in the waters where the submarine preyed. The original fleet of war vessels which the United States despatched to convey merchant vessels and hunt U-boats were all 16,250 horse power, which at top speed could show 32 to 35 knots an hour. Later on we had destroyers developing 27,000 horse power but the small boats had already proved the case for oil fuel in war.

"One of the reasons for the success of the destroyer in keeping the lanes of travel reasonably free from the undersea menace was the ability of the oil-fired warships to take on fuel in the open sea. The American flotilla had a tank supply vessel stationed at longitude 36 degrees West, from which oil was taken on by the destroyers at the rate of 40,000 gallons an hour, without interruption even in the roughest weather. Indeed, there were times when bunkering was done with both vessels travelling at six knots an hour. Similarly oil gave the larger warships increased speed and independence in the matter of fuel stations.

"The British battle cruisers with which Admiral Sturdee destroyed the German fleet at the Falkland Islands were oil burners. To-day, modern war vessels are using liquid fuel almost exclusively, the United States having definitely abandoned coal-fired boilers in its construction plans some time ago."

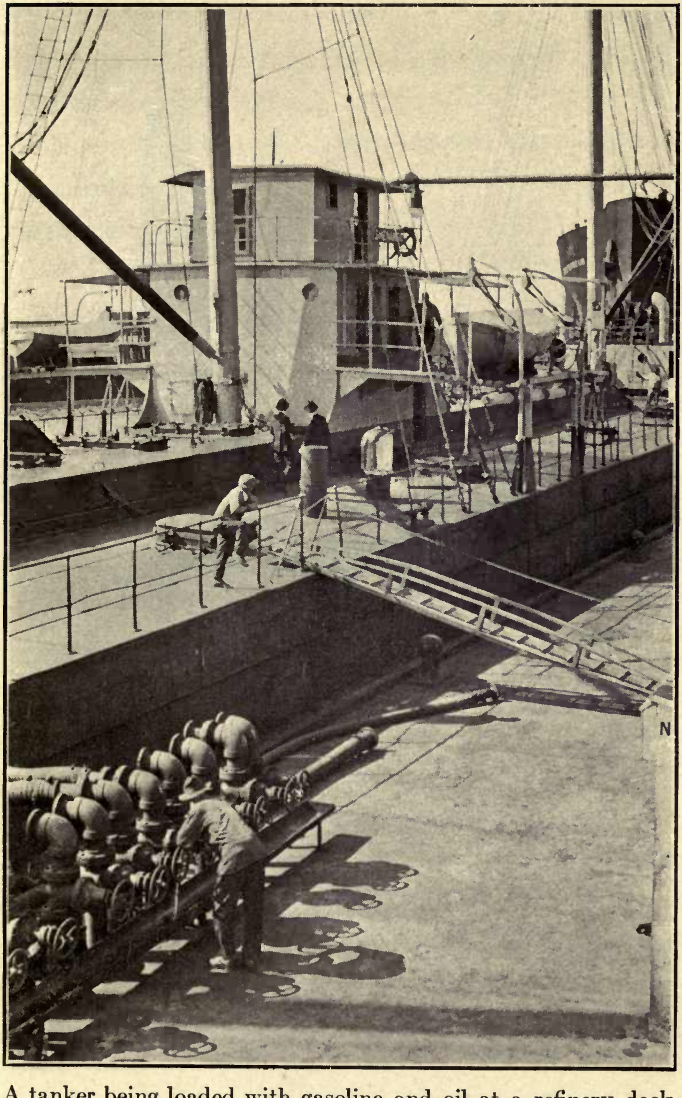
In addition to other advantages it carried, the use of oil fuel in the War was of great practical value, for the following principal reasons:

A lesser tonnage of oil replaced the amount of coal required for the same steaming radius, or an equal tonnage of oil gave the men-of-war a greatly increased steaming radius.

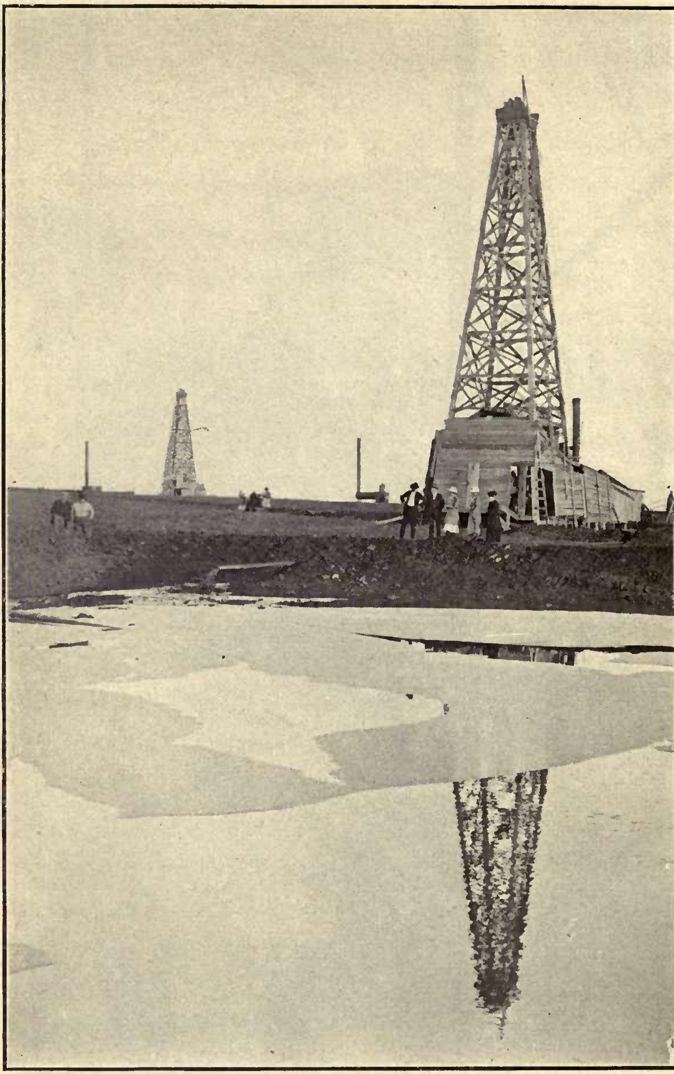
Boilers fired by oil have a much greater steaming capacity than with coal, so that the actual speed of a ship converted to use oil fuel is materially increased without any change in boilers or engines.

In war operations the oil burners can lay down a heavy smoke screen at will by turning more oil into the burners than can be consumed with the air supply admitted. This results in a heavy bank of smoke which destroyers throw out to hide the larger ships from the enemy, or which merchant ships produce to conceal their whereabouts from submarines.

Petroleum thus proved an indispensable factor in saving the world from autocratic domination, just as during the previous half century it had become an incalculable influence in the arts of civilization, and had effected a beneficent revolution not only in the industrial but the social life of countless communities. By American methods of business organization it has been made to yield its highest potentialities for



A tanker being loaded with gasoline and oil at a refinery dock at Port Arthur, Texas, one of the large Gulf oil ports



Kansas wells flowing oil into a temporary sump, or earthen reservoir the good of humanity, both in peace and war. If this little book brings to any reader a fuller knowledge of the romance and all-penetrating importance of this great birth-right of the American people it will have served its purpose.

CHAPTER XIII

AMERICA'S INVESTMENT IN PETROLEUM

A PERUSAL of the foregoing chapters should correct any vague impression in the mind of the reader that the oil business is a lucky adventurer's game like placer-mining, where a man may find a pocket of nuggets, wash them in his pan, and thus become possessed of sudden wealth. This used to be the popular impression in the days when the phrase "Struck Ile" was synonymous with a sudden stroke of luck. Undoubtedly the man who chances to own lands on which oil in paying quantities is discovered is blessed with good fortune, especially under modern conditions whereby fair and generous treatment is assured to him. But he contributes nothing to the expensive processes by which the precious liquid is extracted from mother earth, and risks no capital in the experiment.

Perhaps more prevalent and fraught with infinitely greater possibilities in loss and disappointment is the delusion that oil is a speculator's game;

that the very words "oil" or "petroleum" in a promoter's advertisement are a guarantee of large dividends and soaring values. This delusion has no doubt been nourished by the fact that some large private fortunes in the United States have been accumulated almost entirely in the oil business. Countless people of a speculative tendency have loosely associated oil with great riches, and cherished the theory that whoever became associated with the production or refining of petroleum was necessarily, as if by magic, assured of large and easily acquired profits. The oil fortunes loom large in the public mind because they have been concentrated in comparatively few hands; and the fact is overlooked that these fortunes have been based not merely on the raw product, but on progressive methods of distribution and the elimination of waste. It is obvious that when the vast scope of the industry is considered and the fortunes arising from it are set off against the volume of sales, the financial returns are not spectacular. For every man who has made a fortune in oil, there are dozens who have earned but a bare subsistence from it, and others who have failed even in that, for they have sacrificed all in efforts to locate new wells.

In previous chapters the arduous and costly labours which precede the process of distribution that begins with the conveyance of oil into the pipelines have been described. It should be borne in mind that more often than not these labours are unproductive. Oil does not bubble forth from springs; it conceals itself in the bowels of the earth and it is rarely that it even betrays its presence unmistakably by surface indications. When the subsequent outlay in handling the product of even a gusher is considered, the vast capital outlay involved can be visualized. The investment required by initial measures for locating and producing crude petroleum is so great that competent authorities can name more than one locality in which the money put into leases, construction, drilling and plant exceeds the gross value of the oil that has been obtained or can ever be forthcoming from these fields.

Many millions of dollars during recent months have been poured into oil company flotations that in all likelihood will never yield any return whatever. Even well-organized companies, directed by men of experience, seldom prove bonanzas in a day when leases command very high prices; the exception arising where the company happens to be the first comer in the field that later develops important production. The oil business partakes of the nature of most other industries; it yields profits when fortunately located and economically operated. But there is no certainty that even the company which possesses leases in established fields will prove profitable. Under the circumstances it is ridiculous to assume that mushroom promotions, by men with no actual experience in the oil business, and whose talents lie rather in the direction of writing advertisements, can yield profits to those foolish enough to invest in them.

The experience of one of the large producing companies, operating in the best fields of this country, financed exclusively by oil men and directed by some of the ablest men in the business, may be cited as an instance of the uncertainty of profits. This company produced about five million barrels of crude oil in 1919 and sold at the relatively high prices then being obtained. Nevertheless, the company's profit and loss statement for the year showed a net loss of approximately $1,000,000. This does not mean, of course, that this company is a liability to its owners. It may have expended in work that could not properly be capitalized, large sums of money that will eventually be repaid out of production. It is easily conceivable that without any material increase in its investment its yield of oil might be so augmented by 1921 as to make its business show a very handsome profit. What this case does prove is that something more than good leases, experienced men and ample capital is needed to insure large returns from money put into oil promotions.

People who clamour against the prices exacted by producers of crude oil overlook the fact that wells have an unfailing habit of playing out. This means that a producing company must never cease drilling and exploring. To do so would mean an early decline in its production and eventual failure even of its best wells. The monetary return from a big producer must not only offset the cost of that well but repay the owner the cost of drilling a large number of dry holes, abandoned after large expenditures.

Production in the United States is only kept up by the work of the "wild-catter" in locating new pools and by more intensive drilling of the old fields. Both involve heavy costs. There were drilled in this country last year no fewer than twenty-nine thousand new wells, but the net increase in production over 1918 was but twenty-two million barrels of crude. The declining yield of wells necessitates amortization to cover the cost of new wells to take their place.

Figures purporting to show the aggregate by which the investors of the United States have enabled this country to become the dominant factor in world production must be considered in light of the fact that such totals are in a large measure merely estimates. It is not possible to obtain detailed statistics covering the cost of drilling that has gone for naught; but an approximately accurate estimate can be reached by striking an average based on the experience of leading companies.

It is fair to estimate production at $1,000 per barrel of daily yield, multiplied by the current price for that grade of crude. On this basis Oklahoma leads all other fields with production valued at $958,517,000. The fields in north and central Texas are worth on this basis $617,690,000 while California is third with a total of $456,443,000. On the basis of the country's production in February, 1920, California produced almost exactly the amount of crude derived from Oklahoma, 274,966 barrels per day, in the one case, as against 273,862 in the other, but the posted price of Oklahoma crude was $3.50 per barrel as compared with $1.66 for the lower grade

California product. The daily average production in February, taking the country as a whole, was 1,130,759 barrels, and the value of that oil at the current price was $3,541,511. This would give an approximate valuation of the country's production, on the basis assumed, of $3,541,511,000.

Discovery of a new pool means a race to lay pipe-lines in the field to relieve the temporary storage tanks which are generally of limited capacity. Oftentimes, a considerable investment made in anticipation of large production is rendered almost valueless by the early exhaustion of new wells or by their failure to maintain anything like their flush production. These lines in the different fields are known as gathering pipe-lines. They are connected with main trunk pipe-lines running to the various refining centres. According to the Bureau of Mines, there are at this time approximately thirty-two thousand miles of trunk pipe-lines and eleven thousand five hundred miles of gathering lines. At the present day replacement cost, this mileage is worth, respectively, $360,000,000 and $40,000,000, a total of $400,000,000. The money actually invested for the existing pipe-lines is probably considerably less than this sum by reason of the fact that a great deal of mileage was built prior to the present era of high costs, but it is a safe assumption that the pipe line system represents an actual investment of not less than $300,000,000.

The United States is over-equipped with refineries, measured by their ability to obtain the necessary crude oil to operate them to capacity, but it is not over-supplied from the standpoint of the potential demand for refined products. On the first of January, 1920 there were three hundred and seventy-three refineries, with a daily capacity of 1,530,565 barrels. Since that date there have been completed ninety-nine more refineries, adding 263,500 barrels to the daily capacity. Even before the completion of these new refineries, it was estimated in the report made by the United States Geological Survey that the country had a surplus refining capacity of 177,000 barrels per day over the production and importation of crude oil. Since that time the surplus capacity has been increased to about 500,000 barrels daily. Averaging the cost of the complete refineries with those of the much less costly skimming plants, the refineries of the United States represent a total investment of about $1,795,000,000. This total includes real estate and much equipment not ordinarily associated in the public's mind with the business of refining. There is, for instance, at several of the larger refineries valuable wharf and railroad terminal property, extensive manufacturing plants for the production of tin containers, factories for the manufacturing of steel and wooden barrels, foundries, machine shops, pattern shops, etc.

As a reserve between the current daily production and the refineries' consumption there is always above ground a stock of crude petroleum awaiting its turn to pass through the pipe lines, this stock varying greatly according to the demands of the refineries and the rate of production in the fields. In April, 1920, the crude stocks on hand totalled 124,873,000 barrels, which was worth at the prices quoted in the different fields at that time, $393,724,580. In addition, there were large quantities of refined stocks in the course of treatment at the plants. The gasoline alone reported on hand March 31st was valued at more than $125,000,000, while the kerosene on hand as of the same date was worth approximately $35,000,000. Lubricating oils, fuel and gas oil, wax, coke, asphalt, crude oil awaiting distillation and miscellaneous products on hand brought the total value of the refinery stocks up to $370,000,000.

There is, of course, a very large investment in the fleets required both for bringing crude oil to the refineries in this country and for carrying finished products to the markets of the world. On January 1, 1920, there were six hundred and seventy-eight tankers engaged either in the oil business or as supply ships for the navies of the world, and of these, three hundred and ninety-four, with a deadweight tonnage of approximately 1,500,000, were under the American flag. This fleet represents an investment of $250,000,000.

The minor phases of oil marketing are represented by the multitude of stations, warehouses, bulk barges, tugs, motor trucks and tank wagons, tank cars, private railroad sidings, storage tanks, etc. in all parts of the United States. It is customary to allow an investment of $4.00 per barrel for the real estate and equipment needed to do a retail marketing business, and $1.00 per barrel for the tanks and docks required in the fuel oil department. On this basis the domestic marketing equipment for the country represents a total investment of approximately $660,000,000.

No attempt has been made here to bring in the investment by American oil companies in other lands. The principal item under this head is, of course, the huge sums that have been expended in drilling and the acquisition of producing properties, leases for development and for surveys, etc., in Canada, Mexico, South America, Roumania, and other countries. The value of the tankers used for foreign service has been estimated but no allowance is included for stations and other equipment to handle petroleum products abroad.

We have here an aggregate investment in the production, transportation, refining, and distribution of petroleum and its products of $7,310,000,000. With this equipment, the United States last year produced 377,000,000 barrels of crude oil from within its borders and imported 55,000,000 barrels more, chiefly from Mexico. We exported 366,000,000 gallons of gasoline, 965,000,000 gallons of kerosene, 1,175,000,000 gallons of gas and fuel oil and 276,000,000 gallons of lubricating oil. Against that may be set our domestic consumption, showing that while we produced in this country more than two-thirds of all of the world's petroleum, we consume in almost the same ratio. There was marketed in the United States last year 3,426,000,000 gallons of gasoline, 1,397,000,000 gallons of kerosene, 6,290,000,000 gallons of gas and fuel oil, and 568,000,000 gallons of lubricating oil.

These figures show not only the immensity of the oil industry but also make clear the vast extent and variety of the auxiliary investment it calls for. Clearly it is no speculator's game, but one in which the most expert knowledge and economic discretion are entailed if it is to yield profits at all.

CHAPTER XIV

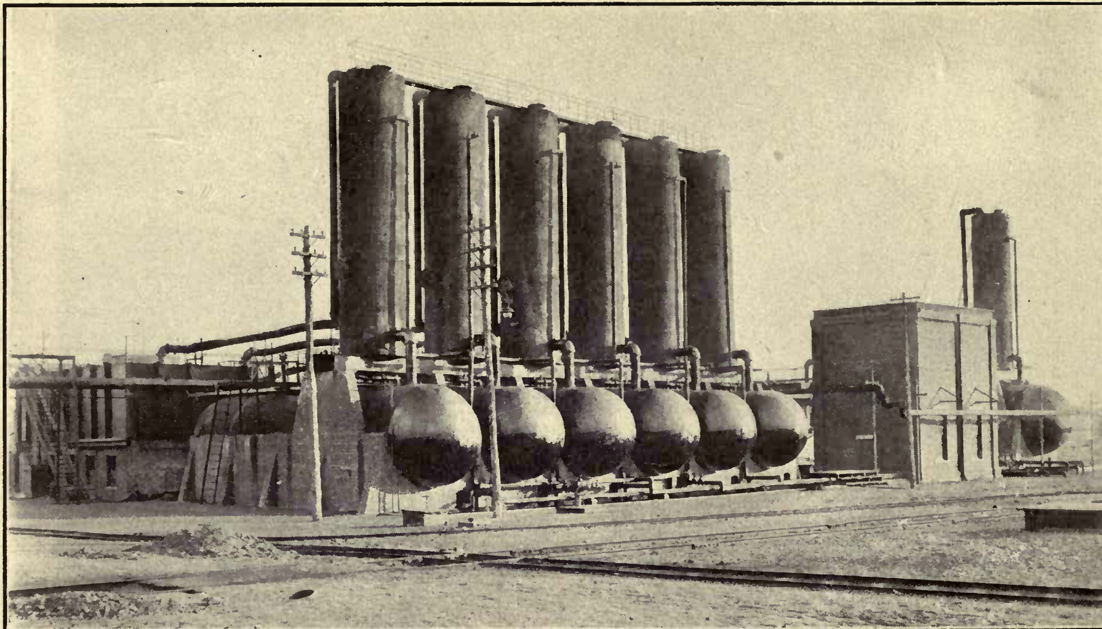
PETROLEUM IN THE FUTURE

IN THESE chapters an effort has been made to place before the reader the story of the development of petroleum from a negligible and unappreciated product to its present basic and essential position in the world's industrial and economic structure. Having attempted to portray the part it plays in the arts of war and peace, and its intimate relation to civilization as now organized, it is fitting that something should be said as to the future of petroleum.

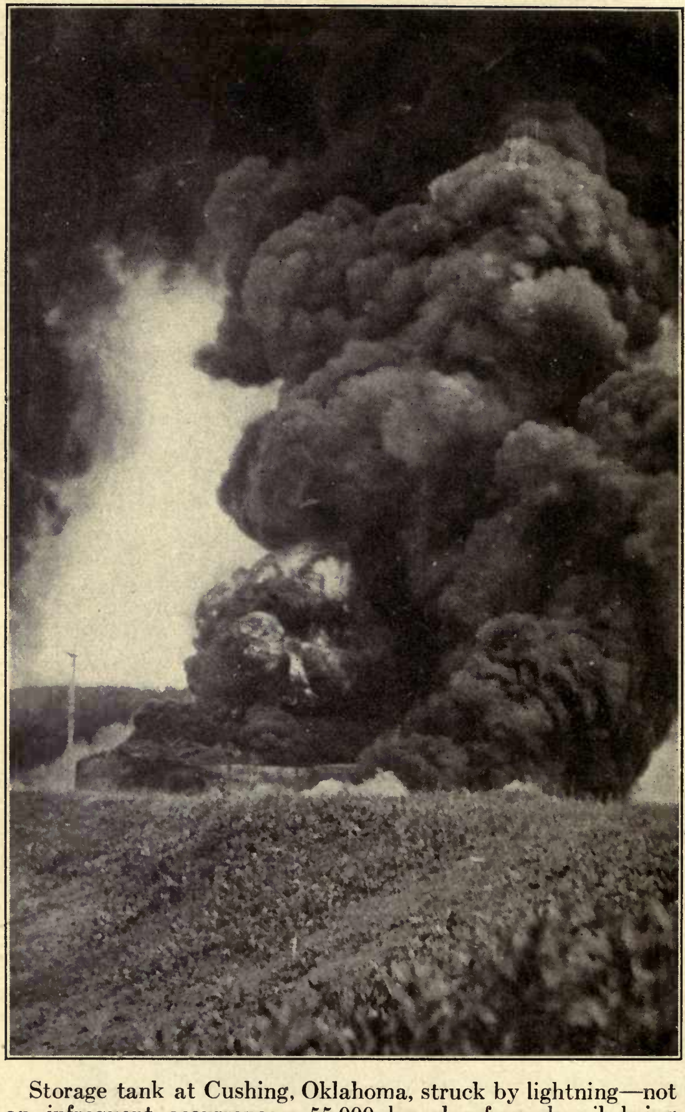
To those who have read the preceding chapters—particularly those relating to shipping and all other classes of transportation—it will be clear that this constitutes an international as well as a national problem. The course of events in connection with the world industry may even be said to have a paradoxical aspect. American petroleum became an international institution when, shortly after the Pennsylvania discoveries, the eagerness of other nations to secure it was evinced. The increase of production was so rapid that for years the supply far exceeded the domestic demand, and made the creation of foreign markets necessary to the American oil interests. These foreign markets have contributed materially to American national wealth and are now an important factor in the country's favourable trade balance; exports of petroleum products from the United States for the year 1919 representing a value of $343,776,385, and ranking fourth in order of importance of the country's exports.

Our oil companies have been international traders for several decades, but their operations have been entirely based on private initiative and have rarely benefitted by official coöperation. The phenomenal growth of inventions and manufactures pivoting on the products of petroleum, which has transpired during the twentieth century, has, however, entirely reversed the situation that existed in the year 1900. Though the United States provides almost seventy per cent. of the world's production from wells on her own soil, she is to-day actually an importer of crude oil to meet the needs of the domestic market, combined with those of the foreign market for the manufactured products of petroleum, which yield vast revenues to American wage-earners engaged in their creation.

To the American people, who use six times as much petroleum per capita as the citizens of any other country, and who own ninety per cent. of the motor vehicles in operation in the world to-day, the question of future supplies is vital. In the face of an ever-increasing demand for petroleum and its products—through the many channels that have been described in this book—the ratio of production to consumption has become so altered that it is apparent that the United States must in a steadily expanding degree look to other lands for its future requirements. Statisticians and scientists differ as to how long the stores of petroleum still lying untapped in our own soil may last, but are agreed that at the present rate of consumption the American fields will have been practically exhausted before the dawn of another century and that adequate foreign reserves to supplement them must be made available by American enterprise. Petroleum is therefore a problem about which the man on the street and not merely the oil merchant must perforce think internationally. The people of other countries are to-day wide awake to the necessity



Steam stills at a modern refinery



Storage tank at Cushing, Oklahoma, struck by lightning—not an infrequent occurrence. 55,000 barrels of crude oil being consumed of securing petroleum reserves for themselves in regions of potential oil-bearing character; and in some instances they have shown themselves very active.

In an exceedingly able paper presented by Mr. David White, Chief of the United States Geological Survey, to the Society of Automotive Engineers in February, 1919, that authority drew attention to "the widening angle between the flattening curve of production and the rising curve of consumption," and announced that after a most exhaustive survey of American oil potentialities, in which many experts coöperated, the conclusions had been reached that the available oil in the ground at the end of 1918 approximated 6,740,000,000 barrels. The total production of crude from the United States wells from 1858 to the end of 1918 was approximately 4,598,000,000 barrels, more than two-thirds as much as the total remaining in the ground according to the estimates of the Mineral Resources Division of the Geological Survey. To understand fully the significance of these figures it must be realized that the rate of production has enormously increased during the past decade. Mr. White's figures placed the oil produced from United States wells in 1918 at

345,500,000 barrels. Production, if continued on like scale annually, would exhaust the estimated supply in America in less than twenty years. Moreover, despite its vast extent, the curve of actual production in that year fell so far short of the requirements of domestic consumption that the amount of oil in storage was reduced to the extent of 27,000,000 barrels, and it was necessary to supplement the home supply with a net importation of 31,000,000 barrels, chiefly from Mexico. The year 1918 was a war year but in 1919, despite peace, production in the United States rose to 377,000,000 barrels. Thus an ever-increasing demand—especially for gasoline—is producing a pressure on crude supplies greater than in war time.

It does not follow that all the estimated available crude reserves in American territory can be reached in even the near future. American oil wells will undoubtedly be producing at least seventy-five years hence, for the very good reason that all the hidden pools cannot be discovered forthwith or immediately made productive, even when located. But the condition the American nation must face in connection with its own wells is the probability of a gradual decline after the peak of production has been reached, an event that may transpire this year or next, or may be delayed for a decade.

Mr. White's paper, which had the effect of enlightening many as to the changing phases of the oil industry, also emphasized the possibilities of the development of shale oil, a potential resource which might prove a suitable substitute. But since this product is still in the experimental stage, and since it has never been claimed for it that it could develop the manifold richness and varied utility of crude petroleum, it is not necessary to discuss its possibilities in a book devoted to the latter product. Whatever the future of shale oil, it cannot alter the plain circumstance that if it is to be maintained at its present level for any extended period, the American oil industry must look for reserves abroad.

A glance at the world's production for the year 1917 proves that the United States has more at stake in this matter than all the other nations combined. The production was distributed as follows:

United States . . .	66.2 per cent.
Russia	13.6 " "
Mexico	10.9 " "
Dutch East Indies. .	2.6 " "
Other countries . .	6.7 " "

Since then the proportion has been altered, Russia dropping to third place and Mexico rising to second, the relation of the United States to total production remaining probably unchanged.

The predominating importance of the petroleum industry to the American people was indicated in a speech delivered by Sir Auckland Geddes, British Ambassador to the United States, at New York in May of the present year (1920) when he said that this country controlled 82 per cent. of the present visible world supply.

This estimate of course embraces not only domestic fields but foreign fields developed by American private enterprise. It demonstrated completely the claim of the United States to leadership in dealing with so vital an international question as the world's petroleum supply—not only as the chief consumers but to all intents and purposes, the founders of the industry.

As has been set forth elsewhere in this book, the importance of petroleum to countries of maritime aspirations, either naval or commercial, is inestimable, and it is on that phase of the question that the minds of British statesmen have, within the past five years, become concentrated. So far as Great

Britain is concerned, this is a new development, born of the great war. Sir John Cowans, G. C. B., Quartermaster General of the British Army throughout the decisive period of the conflict, has said "Great Britain was, when the war broke out, between twenty and thirty years behind the American and Dutch nations in its knowledge of oil." He and other eminent Englishmen have emphasized the difficulty of making up that leeway, one obstacle being that at least eight or ten years was required for the education of an oil expert. In seeking a trained personnel to handle the problem, Great Britain, like most other countries, must for the time being at any rate look to the United States. But though the awakening of the British to the importance of petroleum was belated, it is real. Not only their Admiralty, but their Army authorities are insisting on the importance of adequate reserves. Controlling as they do the destinies of a vast maritime Empire, the growing dominance of oil-burning ships, and the necessity of providing for their fuelling, has become an ever-present thought in the minds of British public men at a time when the American Government, relying perhaps on a factitious belief in the inexhaustibility of our native oil resources, remained indifferent. There is no reason to doubt that the aim of Great Britain is her own national and Imperial security, rather than aggression. The British Ambassador, in the address referred to, gave the most absolute assurance on that point, but the fact is patent that, through governmental coöperation, British oil men have secured distinctive advantages in foreign fields, advantages which, with similar coöperation, might have been available to American oil interests—whose leaders may be accepted as equal to foreign business men in foresight, courage and enterprise.

The relation of the foreign petroleum situation to the re-born American ambition to possess a merchant marine that shall carry American wares in American ships must be clear to every reader. Just as Great Britain owes her far-famed sea power to her policy of maintaining coaling stations at the best available locations on the seven seas, she now aims to preserve that prestige by oil bunkering stations advantageously placed. The situation might conceivably arise whereby (despite our vast home production), the American merchant marine when at sea would find itself dependent on the bunkering stations of foreign powers. No one will question the right of

Great Britain to protect and maintain her trade routes by reserves of the new maritime fuel, and her Government deserves praise rather than censure for backing British enterprise in measures directed to that end. The point to be borne in mind is that American oil men, the real creators of the industry, have accomplished what they have in the foreign field virtually *without* governmental support or co-operation. It is hardly overstating the facts to add that they have been harassed and interfered with in their efforts to maintain the future security of their industry and of their nation in this matter of petroleum reserves. Thus, there has lately arisen a demand for constructive legislation which will permit governmental coöperation and diplomatic action that will place American oil interests on something like an equal footing with those of Britain and other countries in securing a necessary augmentation of the home supply. Disinterested public men who have made a study of the problem are of the opinion that in the national interest, and entirely without reference to the advantages that might or might not accrue to this or that individual, American petroleum companies should be encouraged by all the power and influence their Government can exert to acquire foreign sources of supply wherever available.

A glimpse at the facts with regard to the oil bunkering situation shows how closely petroleum and national aspiration are allied. The estimated requirements for the U. S. Navy for the fiscal year of 1919-20 were about six million barrels. In the undesired event of war this estimate would be vastly increased. With regard to the American merchant marine, it is worth noting that about one half of the vessels constructed in 1919, representing approximately three million deadweight tons, were of oil-burning design. On the Pacific Ocean, where satisfactory grades of steam coal are not so generally available as on the Atlantic, oil has come into general use as fuel. American companies furnish most of the fuel oil which is supplied at ports outside the United States and the United Kingdom, the total number of such foreign bunker installations, owned by American companies, being 88 in a total of 114. But the possession of such foreign facilities for American shipping will prove of little value unless Americans have sufficient oil, from either home or foreign fields, to furnish adequate supplies at competitive prices. With an increasing shortage of oil for domestic consumption, bunker fuel oil supplies can only be maintained through the control of production in advantageously located foreign fields.

Among the rivals to American enterprise which have arisen, the most important is the Royal Dutch Shell combination, which, though of Holland registration, has been a partner with the British Government in petroleum enterprises, and is to-day the leading factor in the Far East and in Australia in this vital matter of bunker supply. It is acquiring potential petroleum fields in Mexico, South America and the United States itself. The British Ambassador's statements tend to allay fears that there is any deliberate attempt to discriminate against the United States in any part of the world; yet it is a fact that this country is likely to be seriously handicapped in its efforts to obtain its share of the world's carrying trade if its ships abroad are eventually compelled to rely on foreign companies for fuel.

In order that the reader may clearly visualize the situation with regard to the prospects of augmenting home supplies, it is necessary to speak once more of certain foreign fields mentioned in the geographical survey that constituted an earlier chapter. The nearest field and the one to which Americans must naturally look, because for an indefinite period it will continue to produce oil far in excess of the needs of its own people, is Mexico. Unbacked by governmental coöperation in any form, American private enterprise has done much in an endeavour to develop permanent supplies in that country, and has paid its way generously. Fortunately, the internecine warfare which has paralyzed the maintenance of law and order in many parts of that country has been less serious in the oil regions than in some other provinces, but precious lives have been lost, and considerable property destroyed without redress. Still more serious is the fact that in the face of the activities of foreign powers anxious to secure American holdings of great potential value the American Government has been inert in a field where, for geographical reasons alone, it has a claim to first consideration. The patriotism of an American citizen, Mr. E. L. Doheny, controlling owner of the Mexican Petroleum Company, has been more potent than that of the public authorities in safeguarding the future of our interests in that country. Mr. Doheny received a handsome offer from the Royal Dutch Shell Company for his interests; but he refused it on the ground that for the future welfare of the United States, his properties should remain under an American control. Undeniably the lot of the American capitalist in the Mexican oil fields has been rendered so difficult that any man might be tempted to sell to the first bidder. While a recent Mexican administration proposed to "nationalize" petroleum there have been many attacks in other forms upon the rights of American oil companies, but so far these companies have escaped absolute confiscation of their properties. Here is obviously a field in which American interests must have the same sort of diplomatic assistance which Great Britain extends to its nationals if the future is to be secure.

The next closest field to which Americans must naturally look is the Caribbean Region—the Central American and West Indian Republics, Colombia and Venezuela. Their importance lies almost wholly in their future possibilities, but they undoubtedly have oil potentialities of considerable value. Therefore, the control of concessions is of very grave importance in view of the need for acquiring extra territorial oil reserves. Fortunately, Americans are here first in the field, though enterprise has not gone very far beyond the securing of concessions. Such privileges obtained in Colombia, Panama, Nicaragua, Honduras, and Costa Rica are held by various American syndicates. A Venezuelan concession originally American-owned is at this writing in British hands, and British capital is also interested in Honduras oil development. It is obvious that the sympathetic coöperation of the authorities at Washington, is necessary in the Caribbean area if the United States is to render secure an ascendancy there.

In South America the rivals of the United States interests are also active but have not outstripped them, and with a progressive policy on the part of their government Americans may hopefully look for reserve supplies from that vast continent, though their development, owing to the mechanical and speculative conditions of modern oil production, cannot be rapid. Argentina, which already has two producing fields, operates them as state enterprises and has as yet granted no foreign concessions. Peru is already a large producer of crude petroleum and has opened her gates to American oil interests, but here, as elsewhere, the need of diplomatic backing is present. Generally speaking, though the real potentialities of South America are unknown, it is a territory in which the United States, if it is to safeguard its future interests, cannot afford to remain indifferent.

The world-wide British Empire includes many countries containing oil potentialities, though the total production is inconsiderable in comparison with that of a single American state like California or Texas. According to the statistics put forth by Sir Auckland Geddes, production under the British flag in 1919 represented but five per cent. of the world's petroleum output. But there is no certainty as to what the future may bring forth and the general policy in all parts of the Empire seems to be to keep oil development in the hands of British nationals and to restrict operations by foreign capital. In the important oil territory at Burma these restrictions are absolute; though in self-governing Dominions, like Canada, they do not obtain. In all Crown colonies the British Government retains the right of pre-emption at need. Quite as severe are the laws covering oil deposits or potential oil deposits in French colonial possessions. The Dutch East Indies, a comparatively promising field, are closed to all but subjects of Holland, or to companies which have a majority of Dutch subjects on their directorate; under the latter provision British capital dominates the oil production of Borneo.

Outside the Western hemisphere the only fields where the United States may look for reserves, (which, as has been explained, are of especial importance in connection with bunkering stations,) lie in what are respectively known as the Near East and the Far East. China has undoubtedly oil potentialities, though data on the subject is vague, and it is presumed that the Chinese government, which holds a monopoly of them, will one day admit foreigners into partnership in the working of them under some sort of special contract. Japan already has a somewhat similar arrangement. In demonstrated possibilities the Near East is of much more promise. The importance of the Roumanian field has been spoken of elsewhere and prior to the war American interests were established there. Later in its reconstruction policies Roumania is contemplating changes in its petroleum program not formulated at this writing. It is reported that French and British interests, supported by their respective governments, are making every effort to secure important holdings in the Galician oil fields, formerly situated in Austria, but now coming within the boundaries of the new Republic of Poland. The future administration of the Russian fields is still problematical. At the moment they are occupied by the Bolsheviki. The Persian field, by an arrangement dating back to 1901, is operated by British interests. The potential fields of Mesopotamia and Palestine are under control of Britain by mandate of the League of Nations; but that country expressly disclaims any special authority to exclude other nations from participation in petroleum development in these territories. It must be plain to the most inexperienced reader that in the case of Asiatic and East-European fields, however, American oil interests are powerless to achieve influence and obtain due recognition without the diplomatic assistance and coöperation of their home government. It is necessary, if they are to secure equal rights under international law that will serve not merely as a check upon any possible unfair discrimination, but enable them to secure workable international arrangements. These should redound to the interest of all countries for the United States is the motherland of the science of oil production. The prestige of this country is such that in many cases a mere diplomatic protest would be sufficient to rectify many disabilities under which the American oil company seeking foreign reserves at present labours, without creating serious disputes or international entanglements. In the words of Thomas A. O'Donnell, President of the American Petroleum Institute, with which most of the leading petroleum producing and manufacturing companies of the country are associated:

> The American oil industry asks only the support of the nation in giving it an equal status, putting it upon an equal footing with the nationals of other countries in the development of the world's petroleum resources—and it asks this in the interest of the nation.

With the Government at their back to secure for them fair play, American oil interests could face the future with confidence, if not with certainty; lacking such coöperation, the future is fraught with hazard to an industry that stands as a monument to American organizing genius.

THE END

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