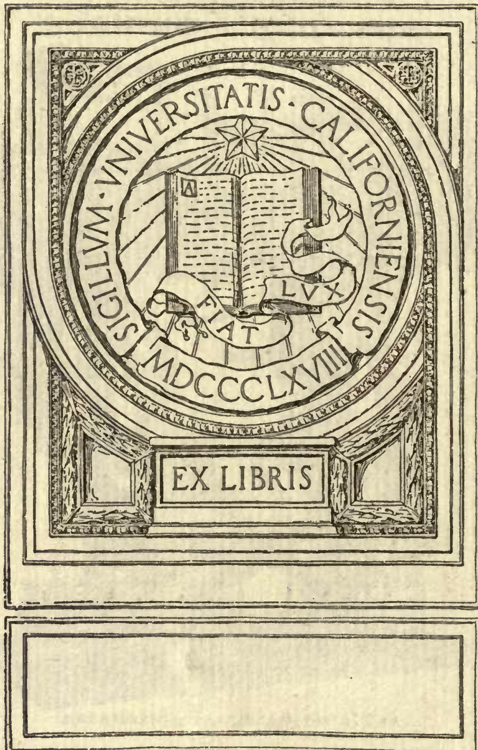
COMMON COMMODITIES AND INDUSTRIES

PETROLEUM

Albert Lidgett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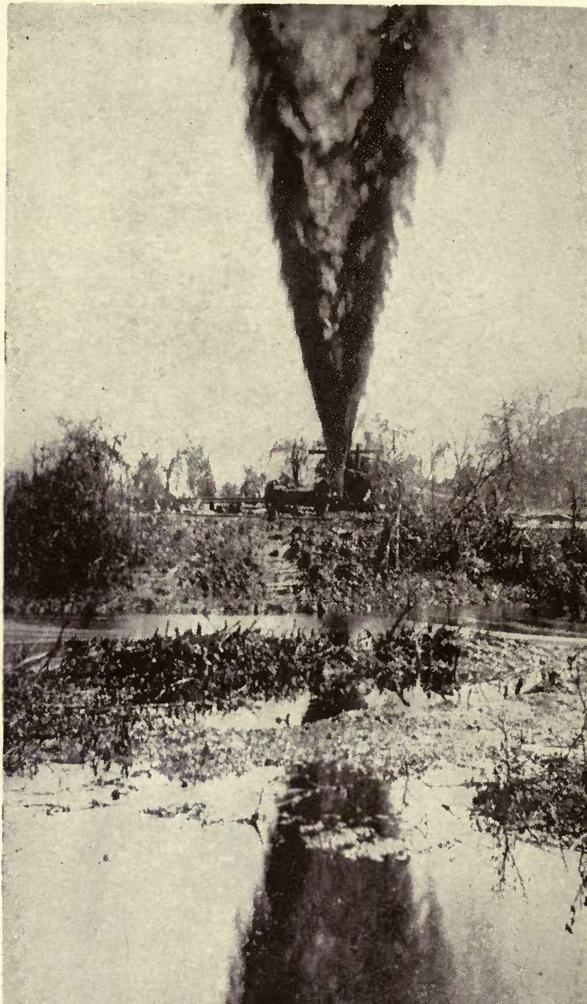

A TYPICAL MEXICAN OIL GUSHER

Potrero, No. 4—Mexican Eagle Oil Company

Frontispiece

PITMAN'S COMMON COMMODITIES
AND INDUSTRIES

PETROLEUM

BY

ALBERT LIDGETT

EDITOR OF THE "PETROLEUM TIMES"
LATE EDITOR OF THE "PETROLEUM REVIEW"

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PREFACE

ALTHOUGH numerous volumes have been written upon petroleum, and some very educational works on this important subject are to be found in technological literature, it is strange that prior to the appearance of this little book, it has been impossible to turn to any publication which deals with this Common Commodity of Commerce in a popular manner.

Of a truth, we to-day live in an age of Oil, for the products of petroleum are inseparable from our daily life. Refined petroleum breathes the breath of power to the internal combustion engine which claims a realm of its own on land and sea, in the air, and under ocean waters; it also gives artificial light to countless millions in all corners of the world under a variety of circumstances and dissimilar conditions, while the wheels of industry unceasingly revolve consequent upon oil lubrication.

And in no sphere of commercial and industrial activity has greater progress been made during the past few decades than in regard to the multiplication in the uses of the products of petroleum. The avenues for advantageous consumption are constantly increasing, and this to such an extent that the production of crude petroleum—enormous though this is—has been outstripped by the demands for the refined product.

In the following pages I have striven to deal with the chief phases of the petroleum industry in a manner which, I have reason to believe, will be acceptable to the general reader, and the fact that the volume is written in language free from technicalities, will, I trust, render it particularly interesting to those who would know something of that immense class of commercial products covered by the name "Petroleum."

ALBERT LIDGETT.

ROYAL AUTOMOBILE CLUB,
PALL MALL,
LONDON, S.W.1.

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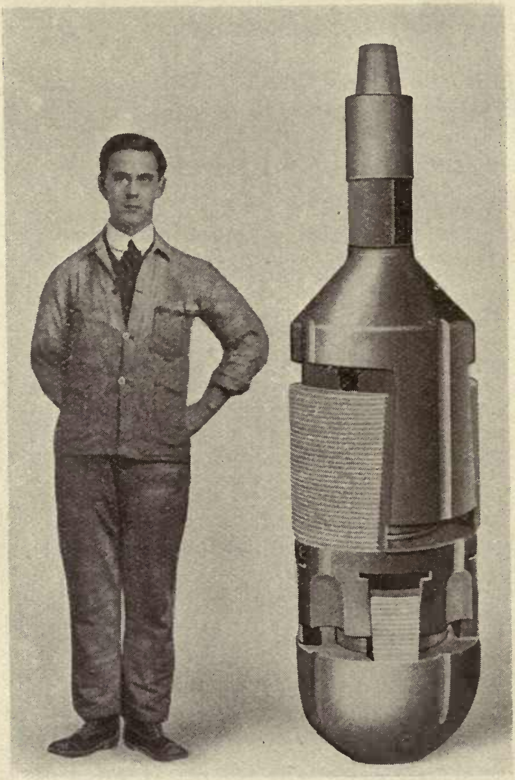


Taken from an actual photo of a trip spear with mechanic alongside for comparison of size. This is for 21 inch O.D. drive pipe. We have facilities for producing the heaviest tools required.

LIST OF ILLUSTRATIONS

PETROLEUM

CHAPTER I

PETROLEUM AND ITS ORIGIN

IN dealing with the question of petroleum and its origin, the subject can well be defined under two headings: one, the origin of the word "petroleum"; the other, the origin of the mineral itself. As to the former, this is a matter of historical interest; of the latter, the question is still in doubt—and the doubt becomes even the more doubtful, the more the question is debated.

Let us, therefore, take first the word "petroleum" as we know it to-day. It covers a multitude of products derived from the refining of crude oil, though the word does not suggest any of them. It is quite a generic term, and in a general way represents the whole of that ever-increasing family of hydrocarbons—the refined products of crude oil. There is no doubt that it derives its name from the Latin *petra oleum*, which, literally, is rock oil, and equivalents of the name are found in all languages. Even in modern practice we use the word, though not in a specific sense, while our own Government usually refers to "petroleum oil," which, of course, involves tautology. Crude petroleum is known throughout the oil-fields of the world as denoting the crude oil coming from the wells: then we have petroleum spirit, otherwise the lightest form of refined oil; we have petroleum distillate, designating an illuminating oil; but, "petroleum oil" is, it is to be regretted, generally used as suggesting some form of petroleum product.

Though the petroleum industry—in its commercial sense—only goes back some sixty years, the use of petroleum can be traced to Biblical times, for was it not the great Prophet Elisha who told the widow to "Go, sell the oil and pay thy debts and live"?

Job also speaks of the rock which poured him out rivers of oil; in Maccabees we find that the priests hid the fire which they took from the altar in a deep pit without water; while Nehemiah called the liquid which burst into flame and kindled a great fire by the name "Nephthar, which is as much as to say, a cleansing; but many call it Nephai." And so, in many parts of the Old as well as in the New Testament, oil is clearly referred to, and, in Biblical times, as much later, was looked upon as a sacred fire.

Many ancient authors make extensive reference to oil, prominent among them being Herodotus, who described the methods adopted at the pits of Kirab for the raising of the oil, which liquid "gives off a very strong odour."

Petroleum, as known in Biblical times, and as so widely known to-day, occurs in greater or less quantity throughout the world, and it is found in the whole range of strata of the earth's crust, from the Laurentian rocks to the most recent members of the Quaternary period, though it is found in commercial quantities almost wholly in the comparatively old Devonian and Carboniferous formations on the one hand or in the various divisions of the comparatively young Tertiary rocks on the other.

The problem of the origin of petroleum has been the subject of considerable scientific controversy for many years. Not a few of the leading scientists hold to the theory that petroleum is derived from metallic carbides lying far beneath the porous strata in which the oil is stored by Nature, and that even at the present time the process is in operation. This idea, which may be termed the inorganic theory of petroleum origin, was considered to have received substantial support when it was found that the action of water on the carbides of certain metals resulted in the liberation of hydrocarbons.

The view that petroleum is of organic origin is to-day almost universally accepted, although there is no general agreement either as to whether petroleum is derived from vegetable or animal matter, or as to the forms of life that provided for its genesis. In certain places in the world—notably on the eastern side of the Caspian Sea and also near the Mediterranean—there is some conversion of organic matter into petroleum actually to be seen to-day. It is not difficult, as Sir Boverton Redwood, Bart., pointed out in an address before the Royal Institution of Great Britain a few months ago (June, 1918), to account for the formation of adequate deposits of the necessary material. In the comparatively deep and quiescent water along the margin of the land in past ages, there would be abundant opportunity for the deposition not only of the remains of marine animals and plants, but also of vegetable matter brought down to the coast by the water courses, and the changes which the earth has undergone would result in the burial of these substances under sedimentary mineral matter, the deposits thus formed being ultimately, as the result of further alterations in the earth's surface, frequently found occupying positions far removed from the sea, and sometimes beneath immense thicknesses of subsequent deposits.

That vegetable matter may be the source of certain petroleums is an opinion that has found increasing evidence to support it. There are two kinds of vegetable matter which are possible, terrestrial and aquatic, and in the deltaic conditions that characterize so many oil-fields, either could be equally well appealed to as a source of accumulation. The extensive coal and lignite deposits in many geological periods bear eloquent testimony to the presence of carbonaceous matter far in excess of that required to provide proved supplies of petroleum. Every important coal-field demonstrates the fact that vegetable matter can be partially converted into bituminous compounds or hydrocarbons by natural processes. Marsh gases often occur in great quantities in faulted zones in the coal measures, though the bituminous substances found in coal are not true bitumens that dissolve in the usual solvents, while the tars derived from the destructive distillation of coal in no way resemble natural petroleums or the products of oil-shale distillation.

In spite, however, of the outstanding differences between petroleum, oil-shales and coal, I might here point out in favour of the vegetable theory of origin, that actual petroleum and true bitumens have been found in some coals, though in small quantities, while solid paraffins have been extracted by means of pyridine and chloroform. Again, low temperature distillations have yielded petroleum hydrocarbons, all of which appear to indicate that even when coal was the overwhelming product, at certain times and places the conditions were merging into those which could yield petroleum. There is no doubt that each of the various views expressed as to the organic origin of petroleum contains elements of truth, and it is reasonable to assume that a substance so varied in its physical and chemical properties as petroleum has not in all cases been created under precisely the same conditions, or from an exactly similar source.

Summing up the whole question of origin, however, the balance of opinion points to its being the result of organic action, and that the petroleum which we now find in the Palaeozoic and Tertiary rocks is substantially of the same geological age as the rocks themselves.

Volumes of technological literature have been written upon this complex question of petroleum origin, and though these may be of intense interest to the student of geology, the brief references which I have already given to the question are sufficient for the purpose of this little publication.

The geographical distribution of petroleum throughout the two hemispheres is no less wide than the geological. The deposits mainly occur along well-defined lines, often associated with the mountain ranges. This is chiefly due to the formation, in the elevatory process, of minor folds which have arrested and collected the oil in richly productive belts.

CHAPTER II

THE OIL-FIELDS OF THE WORLD

EVER since petroleum and its products entered the realm of commercial commodities, there has been a ceaseless search throughout the two hemispheres for crude oil, and to-day there are comparatively few countries in the world where the presence of petroleum has not been proved. The ever-expanding uses of petroleum, which in their train have called for a continually increasing demand for crude oil, have given an impetus to the search for commercially productive oil-fields, which, in mining history, has no parallel. On the one hand, we have those important oil-producing regions which embrace enormous regions of the United States, Russia, Roumania, the Dutch Indies, India, Galicia, and Germany; on the other, we find comparatively recent enterprise which is bringing into prominence the newer oil-producing regions of Mexico, Egypt, Trinidad, Canada, the Argentine, and various parts of Australia and Japan, though in several of these latter mentioned countries, the production of petroleum has been carried on by primitive means for not only many years, but even for centuries.

It naturally follows that, with the constant withdrawal of large supplies of crude oil from Mother Earth, Nature's stores must be growing less, and it is not surprising, therefore, to hear, with persistent regularity, alarming rumours of the coming dearth of crude oil. Experts have devoted considerable time and thought in an endeavour to arrive at a conclusion as to the length of time it will take for the withdrawal of practically the whole of the crude oil from the known deposits in the more developed fields: their conclusions, however, are widely different, for while some assert that in the United States, for instance, the known fields will cease to be commercially productive within forty years, others there are who declare that centuries must elapse before the question of a failing supply need call for serious consideration.

But there is one point which must not be overlooked in this connection, and that is the fact that, while thus far very few thoroughly developed oil-fields have shown signs of permanent decay, there are numerous others which, while having already furnished conclusive proof of their productivity, have, for the most part, been but slightly developed. Each passing year registers the incoming of fresh oil-producing areas, while numerous regions in practically every part of the world, giving much promise of the success of ultimate oil developments, are as yet virgin territory.

The cry of possible shortage of supply was, fortunately, made at the opportune moment: it was a word of warning, and was taken to heart especially by those associated with the development of the older producing oil-fields. In these fields—whether we look to America or Russia—there has always been considerable waste of crude oil, mostly in regard to furnishing power for oil-field operations, while the natural gases which exude from the wells themselves, and to which reference is made in another chapter, have, in times past, been allowed to pass uncontrolled into the atmosphere. To-day, however, we see conservation in every direction—thanks to the application of scientific and engineering knowledge, combined with the exercise of care—and there is no doubt that this new factor will tend in a greater degree than may at first be imagined toward the preservation of Nature's stores of crude oil for unlimited time.

With these few general remarks, let us proceed to briefly survey the principal oil-fields of the world, leaving those which are in the process of development or exploitation to later consideration.

The United States.—In no other country has such continuous progress been recorded in connection with the production of petroleum as in the case of the United States. Quite recently, the U.S. Geological Survey estimated that there are no less than 9,000 square miles of oil-bearing territory in the States, yet the petroleum industry was not commercially established until the early sixties of the last century. It was in Pennsylvania that the industry had its birth, and the troubles which beset Drake, the pioneer, have filled many pages of early oil literature. His first well, which produced quite a modest yield of crude oil, was at Titusville, Pa., which spot soon became a thriving town. And as Pennsylvania was the scene of the early successes, it also became the pivot round which the petroleum industry of the States prospered for many years. Until 1885, the Pennsylvanian fields furnished over 98 per cent. of the production of crude oil: then a gradual decline set in, until, at the present time, Pennsylvanian regions do not produce 10 per cent. of the oil output of the United States. No sooner had the petroleum industry been firmly established in Pennsylvania than an active search was made for the precious fluid in various parts of the States, and one by one new oil regions were opened up, but it is interesting to recall the fact that, even in the first developed oil-producing region, no district has been entirely abandoned as exhausted of oil, for to-day wells are being pumped quite close to Drake's first well and the scene of the birth of the American petroleum industry. In the zenith of its prosperity, the Pennsylvanian field produced nearly 5,000,000 tons of crude oil per annum, but to-day the output has fallen off nearly 40 per cent.

When it is mentioned that the output of crude petroleum from the various fields of the United States last year was over 40,000,000 tons, the magnitude of America's oil industry will at once be apparent. The regions known as the Mid-Continent fields—and which embrace the extensive oil-producing regions of Kansas and Oklahoma—are responsible for a very large portion of this output. Each field has its various "pools," the most famous of this part, perhaps, being the Cushing pool, which came into prominence but a few years ago. Toward the end of 1914, it was estimated that the daily output of Cushing was 35,000 tons of crude oil. Cushing, like all other prolific oil districts, has many interesting stories associated with its rapid rise as an oil-producing centre, and there are instances on record where, in the course of a few days, land values have increased tenfold.

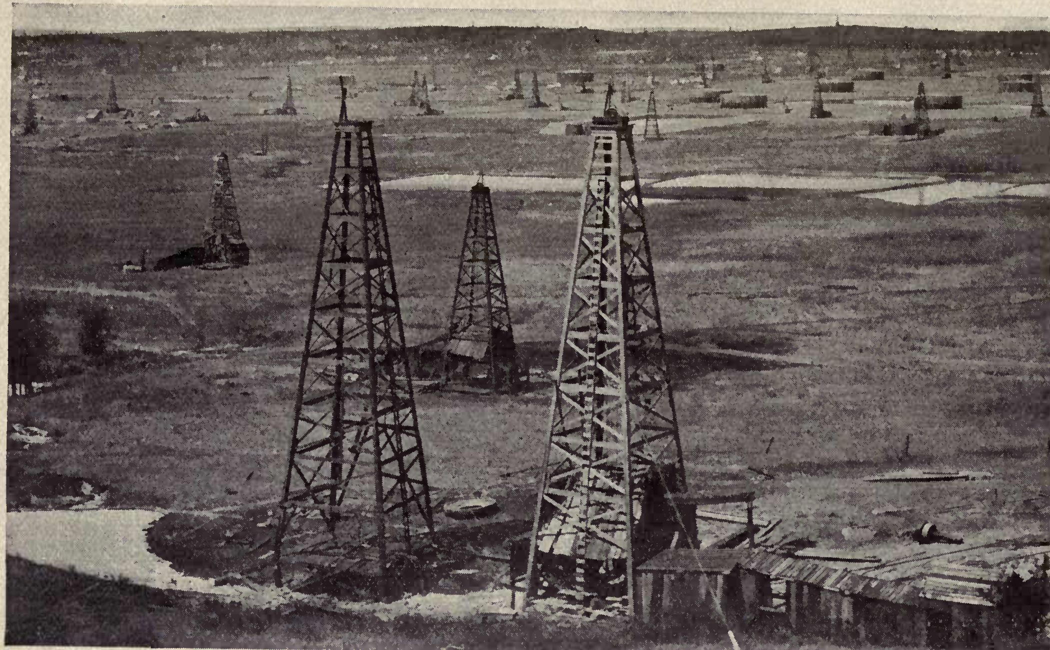
The rise of the Californian fields, too, is an example of the rapidity with which oil regions can be developed. California's output in 1917 was, roughly, 100,000,000 barrels of crude oil, or over 14,000,000 tons. It possesses nearly 900 square miles of oil-lands, and though at one time a great difficulty was experienced in disposing of the crude oil production, since it was of a somewhat low grade, the position has now been reversed, and the consumption of petroleum products is greater than the supply. With the improvement of the methods of drilling, and the debut of the rotary system, it has been possible not only to drill to much greater depths, but to considerably reduce the time requisite for drilling a well to the oil sands. Californian records for quick drilling with the rotary machine show that wells have been got down to the producing sands, in some fields nearly 4,000 feet below the surface, within one month.

This deep drilling policy, which is now much in vogue among Californian oil operators, has proved the existence at the greater depth of larger volume of oil of far better quality than that met with in the shallow strata, and it is to the discovery and consequent development of the deeper oil horizons that much of California's recent advance is due.

Though but of small significance, the oil-wells in Summerland, Cal., call for mention for the reason that these are drilled in the sea at quite a distance from the coast. The encroachment of sea-water to the wells themselves is prevented by the continuance of the tubes in the wells to a height above the level of high-water mark, the produced oil being piped to the mainland.

There is no doubt that a wonderful future awaits California in regard to its oil export trade. The Far East is largely drawing upon the State for crude oil for treatment in the Far Eastern refineries: the oil-burning vessels of the Pacific rely upon Californian fuel oil for their supplies, while the opening of the Panama Canal, and the establishment of oil storage depots there, has brought California within easy transport distance of the European markets. During the past few years several cargoes of Californian refined oil have, in fact, come upon the English market.

The oil-fields of Texas have, perhaps, witnessed more "boom" periods than any other oil regions of the States. The Gulf coastal fields which embrace Texas and Louisiana, came into prominence some seventeen years ago, and they were not long in recording an output of over 5,000,000 tons in a single twelve months. The prolific districts of Spindle Top, Sour Lake, Humble, etc., attracted rapid attention, and the speculator in oil lands became immensely rich. But these boom periods cannot be said to be of much real value to the oil

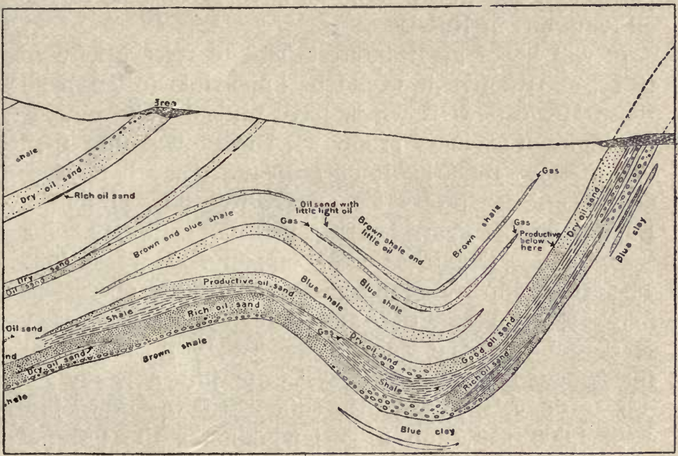


THE GLEN POOL—ONE OF AMERICA'S OIL PRODUCING CENTRES industry, for they are always followed by times of depression, when fortunes are lost almost as quickly as they have been made. To-day, the Gulf coast fields have settled down to a period of steady expansion; systematic development is taking place in every field, and, as in California, the policy of deep drilling has been eminently successful.

Space forbids my entering into details respecting the more recently developed or partially exploited fields of America, but it is safe to say that there is scarcely a single State that does not hold out hope for profitable oil development: this is evidenced by the large amounts of new capital which are to-day finding employment in regions which are only commencing their oil-field history.

There is no other oil-producing country in the world where the petroleum industry has reached such a highly organized state as in the United States. Each producing field is connected by means of underground pipe-lines with the trunk pipe-line system, by which it is possible to pump oil from the most distant fields direct to the Atlantic seaboard. Some of the principal lines are hundreds of miles in length. In another chapter I deal with this wonderful system of oil transportation: it is, therefore, unnecessary here to more than mention it *en passant*. The oil-refining branch of the American petroleum industry is also particularly well organized and up to date, but with this subject, too, I deal at length elsewhere.

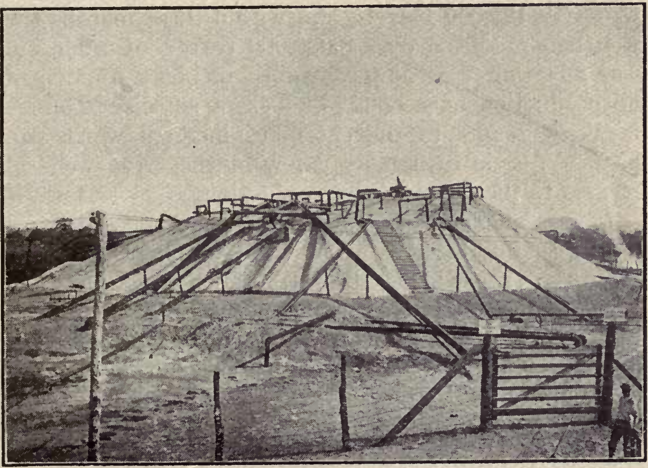
MEXICO.—The oil-fields of Mexico can claim to have leapt into prominence at a far more rapid rate than any other oil-field of importance in the world. Their development has been phenomenal, and from being practically unknown sixteen years ago, they now rank as the third largest producing regions, coming but next to the United States and Russia. My object in dealing with the Mexican fields prior to referring to the Russian petroleum industry is that they may be said to form an integral part of the fields of the New Continent, and, from many points of view, are linked up with the petroleum industry of the United States. Indeed, there are several authorities who are now urging that it is to Mexico that the United States Government must



A TYPICAL GEOLOGICAL SECTION SHOWING THE OIL SANDS

look if it is to be in a position to furnish the major portion of the petroleum products required for the markets of the world.. Another reason for my dealing with Mexico at the moment is that, when development operations are carried a little further, and when ocean transport facilities are available for adequately dealing with the flood of Mexican petroleum, there is not the slightest doubt that Mexico will rank as the second largest country of petroleum production. Its annual output of crude oil is, approximately, 6,000,000 tons, but even this figure in no way represents the productivity of its prolific oil-producing regions, for practically all the large wells are either shut down or controlled in such a manner as to limit their production to but the smallest proportions. The Mexican oil-wells have no parallel in the world, large as have been some of the oil-fountains in Russia.

It will be of great interest here to refer briefly to these, and though it would be impossible to detail all those Mexican wells which have ranked quite outside the limits of ordinary producers, I will touch only upon two of these remarkable oil gushers. They both were drilled on the properties owned by the well-known English firm of Pearsons, the operating company being the "Aguila" (Mexican Eagle) Company. It was in 1906 when the Company commenced active drilling operations in Northern Vera Cruz, and though these were very successful from the start, it was two years later that the famous "Dos Bocas" well came in. A heavy gas pressure developed when the rotary drill was down just over 1,800 feet, and in a few minutes the internal pressure manifested itself by bursting the wire-wrapped hose connected with the drilling apparatus. The oil then commenced to come to the surface in an immense stream, and in twenty minutes the well was beyond control. Fissures began to appear in the ground at considerable distance from the well, and through these came oil and gas. One of these fissures opened directly under the boilers, and though the fires had been drawn, the gas ignited. The position was well-nigh hopeless from the start, the well itself was throwing out an 8-inch column of oil hundreds of feet in the air. The force of the volume of oil below ground flung the heavy English drill pipe out of the well, and soon it became impossible to approach within 300 feet of the "mad gusher." The flames of fire are said to have reached 1,000 feet in height, and inasmuch as all ground round the well had fallen into the cavity caused, they were



A GUSHER OF THE MEXICAN EAGLE CO. UNDER CONTROL—A DOME BUILT OVER THE MOUTH

over 50 feet in diameter. And for 58 days did this gusher burn with all the fury imaginable, its glare being seen far out at sea. Anything approaching an approximate production of oil from this well will never be made: it can safely be recorded, however, that its mad flow of oil ran into many millions of barrels, and it is placed on record that nearly 2,000,000 tons of solid earth were carried away by the force of the oil from the well's mouth, for a crater of nearly 120,000 square metres was formed round the well.

Toward the end of 1910 another surprise was in store for those in charge of drilling operations for the Company, for it was then that the world famous "Protero del Llano" gusher came in. This well ranks as one of the largest, if not the largest, ever associated with the petroleum industry. Its estimated daily flow was over 125,000 barrels, and within three months the well had produced over 8,000,000 barrels of crude oil. The fact that it is now controlled to but a fraction of its production on account of lack of sufficient storage facilities, points to the enormous increase which can be made at any time by a few of the great wells in Mexico to the country's oil production.

It says much for the enterprise of the Pearson (Lord Cowdray) interests that they have been able to build up such a remarkable business in Mexico's oil industry in so comparatively a short space of time. The production of crude oil, as everyone knows, is but the first link in a long chain of commercial oil operations. To-day, the Mexican Eagle Oil Company owns considerably over 250 miles of pipe-line (mostly of 8-inch capacity), possess several miniature railways, and on the fields of production has bulk oil storage accommodation for several million barrels of crude oil. It has also two large refineries—one at Minatitlan and another at Tampico, which together are capable of handling over 5,000 tons (about 35,000 barrels) of crude oil daily, and turning the same into a complete range of high-grade products—motor spirit, illuminating oils, lubricants, fuel oil, paraffin wax, and an asphalt for road-making.

An interesting equipment of this Company in Mexico is that of its sea-loading pipe-lines at Tuxpam. Here, the water inside the bar is too shallow to allow the gigantic bulk oil-carriers of the Company's associated concern—the Eagle Oil Transport Company, Ltd.—to come alongside and load. Pipe-lines have accordingly been laid on the bed of the sea reaching out to a loading terminal a mile and a half out at sea. Here, the pipe-lines are connected with the steamers by means of

INSIDE THE DERRICK OF AN AMERICAN OIL WELL

flexible hose, and three or four tank vessels can be loaded simultaneously from the storage tanks on shore. In one recent twelve months alone over 200 oil tankers were so loaded in this way, and on the average, each was loaded and dispatched within 2½ days, for the pipe-line facilities permit of 10,000 tons of oil being pumped into the vessel's tanks every 24 hours.

There are several large amalgamations of capital interested in the development of the Mexican fields—American and English, while, prior to the war, the Germans had anxious eyes upon this growing industry, and even formulated plans whereby German interests would be largely represented in its future.

While on the subject of the Mexican fields, might I say that no other oil-producing regions have, in the short space of time during which developments have taken place, exercised such an influence upon the international oil situation as has Mexico. This may be traced to the fact that Mexican oil is an admirable liquid fuel, and as such is now in regular use the world over. The vast consuming centres in the South American Continent have seen that, whereas coal is very dear, it is possible to secure almost unlimited supplies of Mexican fuel oil almost at their own doors, while overseas, consequent upon the advent of the fuel oil age, Mexican fuel oil is playing a most important part, and to-day is in general use upon numerous units of the British Navy.

Russia.—Long before the commercial value of petroleum and its products was established, Baku—the present centre of the Russian petroleum industry—had become famous for its "Eternal Fires," and it was to that place the Parsees made pilgrimages for over 1,000 years; in fact, centuries before the Russians occupied the Caucasus, the tribes of Persia eagerly sought the oils of Baku for their curative qualities.

The Russian oil-fields have an output of, approximately, 10,000,000 tons annually, or, roughly, 15 per cent. of the world's total production of crude oil. Since the time when the petroleum industry was placed upon a commercial footing, the Russian fields have produced 230,000,000 tons of petroleum. Enormous though this quantity is, it has been more than doubled by the United States.

The oil-fields of Baku have gained a distinction for the reason that numerous individual wells have given forth a flood of crude oil which has, with very few exceptions, been unknown in other petroliferous regions. The Baku fields proper embrace the districts of Balakhany, Saboontchi, Romany, and Bibi Eibat: the first three districts stand on a plateau but a few miles from Baku, while Bibi Eibat is located quite near the Caspian Sea, on a bay from which the field takes its name. One remarkable feature of these fields—as showing their prolific oil content—is that the four main oil-producing districts in Baku have an area of less than 4,000 acres. It is in this locality that the Russian petroleum industry, having had its birth, became centred, and though it is known that there are several really promising oil areas in this south-western part of the Caucasus, the fact that the lands belong to the State has been a sufficient stumbling-block to development in the past.

Apart from the Baku fields, the most highly developed oil-field of importance in Russia is that of Grosny, which is situated on the northern slopes of the Caucasian range and connected with the Vladicaucas railway by a branch line. The Grosny field, however, has only been developed during the past fifteen years in what may be called a commercial sense, but its operated area is almost double that of Baku.

There are also several other regions in Russia where not only is the presence of petroleum known, but where developments have taken place of recent years. It is not an essential feature of this little publication that minor regions shall be all enumerated, and thus I may be forgiven if I refer but to one of the several new districts which have recently attracted the attention of both oil operators and speculators. I refer to the Maikop fields, which prominently came before the British investing public in 1910, and which were directly responsible for the oil boom of that year. A few months before, a very prolific spouter of oil had been struck in Maikop, which was then quite an agricultural centre, and enormous excitement followed. Land was quickly taken over at ever-increasing prices, and the boom, for which English capital was largely responsible, lasted for several months. There have been many opinions put forward by supposed experts in oil geology for and against the Maikop oil region, but the kindest thing of all that can be said for the district is that, while there was really no justification for the remarkable Maikop oil boom of 1910, there was certainly no reason why public opinion should so rapidly change in regard to its potentialities. I have every reason to believe that some day Maikop will justify the optimistic opinions held for it during the boom, but in the eyes of the English investor the region bears the stamp of fraud, for the simple reason that so many have invested their savings in it, and have been doomed to acute disappointment.

Some millions of English money went into Maikop oil enterprises during that ill-fated oil boom, but a very small percentage of this went to really prove the contents of the lower strata. The fact that the ground was simply "scratched" and condemned because it did not respond with oil fountains, cannot in the slightest affect the ultimate career of the Maikop oil region, the presence of oil in which has been known even from ancient times. Looking back upon that Maikop oil boom, one cannot but express surprise at our gullibility generally: we stake our faith and our capital upon what at the best is a sheer gamble, and we seem content if we find that anything approaching 20 per cent. of the money subscribed actually goes into the serious development of the scheme which we fancied. There are a few who grow suddenly rich upon the spoils of such oil booms—I know some of these personally, and to me it has always been a source of keen regret that the State does not exercise something of a rigid control over these publicly invested funds. I cannot here refrain, while on the subject of the Maikop oil boom, just making a remark as to the overrated value which the public generally attach to the reports of many gentlemen looked upon as oil experts. Some remarkable stories are associated with the locking up (and loss) of English moneys in the Maikop boom, but the strangest I know is of a Russian who came to England when the boom was at its height, for the purpose of selling a number of Maikop oil claims. There were many prospective buyers, but it was necessary to possess a report from some supposed "oil expert." To save time, the seller of the claims drafted what he considered quite an alluring statement, and the next day the report, couched in the same language, bore the "expert's" signature. And the "wheeze" worked.

But to return to the main subject. Prior to 1870, the crude petroleum in the Baku district, as well as in the minor fields of Russia, was obtained from surface pits, dug by hand, and rarely more than 50 feet deep, and the production was carried away from the mouth of the shaft in leathern bottles. The general arrangements were on the most primitive lines, but, nevertheless, the industry—such as it was then—thrived. Even to-day in several fields in Russia we see the survival of the hand-dug wells, but they are steadily becoming a feature of a page of oil-field history which is almost filled.

It was in 1873 that Robert Nobel went to Baku, and to his enterprise and technical genius a great deal of the subsequent rapid development of the Russian industry is due. Boring by steam power was introduced, and the deeper oil horizons were reached, but, owing to the depth at which the strata became commercially productive, it was necessary to commence the well with a starting diameter of 36–40 inches, so as to ensure the requisite depth being obtained with a workable size of baler—for the Baku crude oils are "baled" from the wells. Upon the question of baling wells, I shall have something to say in another chapter.

Under the improved conditions which were introduced in methods of boring and operating the oil-wells, the industry steadily expanded, the general awakening of boring enterprise being best reflected in the number of oil-wells in operation in subsequent years. For instance, in 1893, the Baku fields could boast of but 458 bore-holes; in 1898, the number had increased to 1,107; in 1903, it was about 2,000; while in 1911, there were over 3,000 bore-holes in the Baku fields. There has been a steady decline in the number of these bore-holes since 1914 due in some part, I assume, to the difficulties of securing the requisite materials for new boring, combined with the enormous increase in the cost of the same. The drilling of the wells in Russia is a very expensive item, for they cost from anything over £10,000 up to £15,000, and usually take a couple of years to drill. But when they are down to the producing strata and commence production, it can be taken for granted that they will continue, providing ordinary care is taken of the well itself, for many years to profitably produce.

The Russian petroleum industry is in the hands of a large number of operating firms, the majority of which work quite independently of each other, and these independent firms are responsible for more than one-half of the total output. The other production of the crude oil, representing certainly over 40 per cent., is in the hands of combines representing the large and middle-class firms, prominent among which we get the firm of Messrs. Nobel Brothers, the "Shell" group, and the General Russian Corporation.

The refining of the crude oil is carried out in Baku, the portion of the town in which this operation takes place being known as Blacktown. It does not belie its name either. At one time these refineries, or at least many of them, were erected in the centre of the town of Baku, or near it, and made it almost uninhabitable by their smoke, smell, and refuse, the latter flowing into the streets and the harbour. A special district was therefore selected, to which all had to remove, and it is this portion of the town which forms "Blacktown" to-day.

One of the great difficulties of the Russian refining industry in its commencement was due to the fact that sulphuric acid, so absolute a necessity in petroleum refining, had to be brought from Europe at great expense, but in 1883, Messrs. Nobel built a factory for its production on the spot from Caucasian pyrites, mined in the neighbourhood of Alexandropol. Other factories for the same purpose and for the regeneration of the acids have since that time been established.

As in other great industries, so in regard to the methods by which the Russian crude oil is transported and to-day handled, great strides forward have been made since the early days. Then the whole of the prevailing conditions were primitive: crude oil, for instance, was carried from the Baku wells to the refineries in skins and barrels loaded on carts or camels. Messrs. Nobel Brothers were the first to lay a pipe-line to their factory, but later on pipes were laid between the refineries and the harbour, these obvious improvements meeting with fierce resistance on the part of the work-people. The transport of the refined products from Baku to the consumers was equally difficult. There was then no railway from Baku to Tiflis, and the only way to the Black Sea was thus effectively shut off. On the other hand, the navigation of the Volga was only possible during six months of the year, while the monopoly of water transport on the Caspian Sea imposed high rates on all Baku petroleum products.

Improvements were again due to the enterprise of Messrs. Nobel Brothers, who built the first cistern waggons for transporting oil on the railways, instead of using the old wooden barrels, which were far from satisfactory. In order, too, to open an outlet on the Black Sea, the same firm, in 1889, constructed a pipe-line from Mikhailovo to Kvirili, over the Suram mountains. Now, of course, we have the great pipe-line running from Baku to Batoum, a distance of nearly 560 miles, and which is responsible for the transport of the quantities of Russian oil exported.

But the Russian petroleum industry has always existed more or less under a cloud. The old regime of Government did not attempt to foster and encourage the industry from which it received so much yearly in royalties, for it must be recollected that the Russian State was the chief gainer by the exploitation of the Baku oil lands, owing to the prevalence of the system of royalties. It seemed to be content to leave the industry to its fate, so long as it received therefrom so substantial a sum in royalties, etc. Instances are on record where operating firms pay the Government 40 per cent., or even more, of their crude oil production as royalties—payment for the privilege of taking the oil from the ground. Such conditions have been relentlessly imposed, and it is not surprising to find that, operating under this burden of expense, numerous firms find it quite out of the question to earn profits for their shareholders. Several English enterprises come into this category, but the fault is not of their seeking; it is, however, to be regretted, for once an equitable system of payments is arranged, the Russian petroleum industry will expand in a healthy manner, and become a much greater source of revenue to the State than it is at present.

But, apart from the troubles which have to be faced by the Baku oil producers, and which we may call Governmental, the relation between the employers and workpeople is far from being friendly. To-day, of course, it is worse than it was under the old regime of the Tzar, and then it was bad enough. The oil-field workman in Russia is the incarnation of all that is unsatisfactory. He works when he thinks he will, he labours under grievances, many of which are purely imaginary, and then he ventilates his spite upon his masters. The pages of history tell of many a conflict between capital and labour in the Baku oil-fields, with the consequent burning of all that would take fire on the fields, and the damaging of the producing wells by the workpeople. Instances are placed on record where, in a single night, dozens of productive oil-wells, which have taken years to bring into production, have been irreparably damaged by these oil-field workers. Their life, admitted, is nothing to write books upon, and their environments are in some cases of the worst description, rendered no better by the natural aptitude of the people themselves. But their views upon labour are of the most Utopian imaginable. During recent years, there has been a sort of combination between these operatives, whose socialistic tendencies run high, and less than two years ago they collectively put before the managers of the oil-fields the conditions under which they would in future work. There were nearly 100 different claims detailed, and a few of these are worthy of mention, as showing the appreciation of fairness which is instilled in the mind of the Russian oil-field worker. In the first place, a 50 per cent. increase in wages was desired, this to be retrospective. Holidays had to be paid for by the masters, and when the worker went on strike he had to receive his full pay from the master until such strike was settled. Then the workmen had to be represented on the board of management of the companies, their houses had to be improved by the masters, free railway and tramway accommodation had to be provided, etc. Generally, the demands put forward were distinctly arbitrary, though in many cases very humorous.

Recent events in the conduct of affairs in Russia do not suggest that great improvements may be expected in the near future, either in regard to the attitude of the Government toward the Russian petroleum industry, or to the attitude of the workers to those responsible for oil-field operations. Even before the European War, the Russian petroleum industry was rather on the decline. The only hope that can be expressed at this juncture is that when Russia possesses a stable government, and the country enters upon a period of peaceful progress, the Mining Department will take care that Russia takes its proper position as one of the most important oil-producing countries in the world. But before this comes about, there will have to be a complete

ROUMANIA: A FEW OF THE HAND-DUG WELLS IN BUSTENARI revision of the Government's policy respecting oil royalties. The destruction, however, wrought in Baku towards the end of 1918 will take several years to make good.

ROUMANIA.—During comparatively recent time, Roumania has come prominently forward as one of the large petroleum-producing countries of the world, and its yearly output of crude oil, according to latest returns, is about 11,000,000 barrels, or, say, 1,600,000 tons. The production of petroleum in the country, however, has been proceeding for centuries, for, in the seventeenth century, the peasants were in the habit of digging wells by hand and selling the crude oil for medicinal purposes, the greasing of cart-wheels, as well as for lighting. There are many places in Roumania which are named from petroleum, a fact which points to the existence of the industry long before the present-day methods of extraction were thought of. Several hundreds of these hand-dug wells still exist round the fringe of the Transylvanian and Carpathian Alps, and though many of them have now fallen into decay, there are numerous others from which a payable quantity of petroleum is extracted by primitive methods.

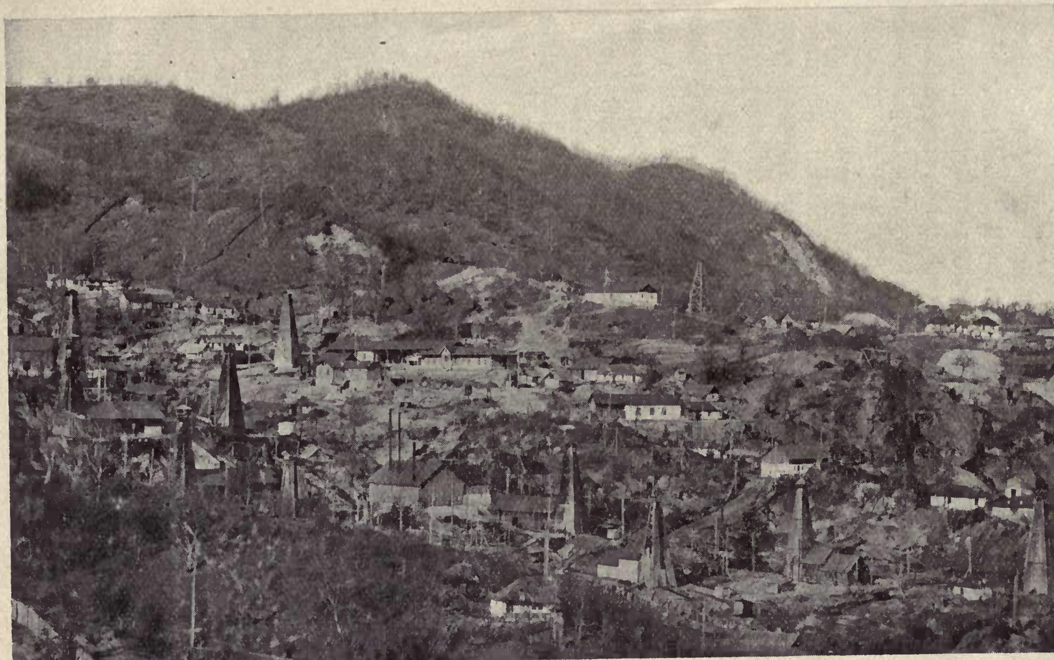
The hand-dug wells in Roumania are highly interesting relics of a period which is now relegated to the past, though so long as the Roumanian petroleum industry exists, so long will the old hand-dug wells be associated with it. These wells are about 5 feet in diameter, and are sunk through alternate layers of clay, schisty clay, sandy clay, sandstone, and petroliferous sand to the more shallow oil horizons. They are dug by workmen who descend dressed with the minimum of clothing, usually saturated with oil, and wearing a tin hat to protect the head from falling stones, etc. The sides of the wells are lined with impermeable clay, which is protected by wicker-work. The man is lowered by a rope, air being supplied to him by means of bellows. At some places the rotary fan was employed more recently, but somehow it frequently happened that it was operated in the wrong direction, and the unfortunate digger was asphyxiated. These old wells have a depth of about 450 feet, and though their yield of oil is not considerable, it has for many years been a paying proposition to those engaged in this primitive method of petroleum production. The excavated earth, when digging these wells, was brought to the surface in buckets, lowered and raised by means of either manual labour or horse traction. When the first oil source was reached and the extraction of the crude oil commenced, this was accomplished by means of the use of wooden buckets or leather skins, one being lowered empty while the other was raised full. By this means it was possible to raise as much as 20 tons of the oil per day—quite a considerable amount, considering the primitive means adopted.

Mechanical developments throughout the Roumanian oil-fields on a more or less serious scale began about 1898, as the result of the introduction of foreign capital, and, from that time to the present, the history of the Roumanian petroleum industry has been one steady period of continued expansion. Various systems of drilling have been introduced into the work of developing old fields or opening up new centres, but in regard to these I shall deal at length in another chapter. The advent of the rotary method of drilling, however, opened up a new era for expansion in 1912, and since that time Roumania has made more marked progress than at any time previously.

The Roumanian oil-fields, as at present defined, cover a region roughly 20 miles in width, and extend to a length of between 300 and 400 miles, with, of course, numerous breaks. Of the numerous petroliferous regions in Roumania, those of Campina-Bustenari, Gura-Ocnitza, Moreni, and Baicoi-Tzintea among them provide about 95 per cent. of the total production, and, with the one exception of the Moreni field, all have been previously exploited by hand-dug wells.

The prosperity of the Roumanian industry has been directly the result of the influx of foreign capital, and the majority of the 550,000,000 francs employed in it, is mostly made up of British, American, and German capital. The principal English Company in the fields is the Roumanian Consolidated Oil-fields, Ltd., which concern, with its capital of one and three-quarter millions sterling, represents an amalgamation of many small companies.

Space forbids my referring at length to the momentous happenings in the Roumanian fields towards the end of 1916, but they will ever form one of the most interesting—and at the same time the most tragic—incidents associated with Roumania's petroleum industry. At that time, the German armies were pushing their way toward Roumania, and, in fact, having crossed the border, were marching on for possession not merely of territorial gains, but in order to secure themselves of large quantities of petroleum products by capturing the prolific oil-fields of the country. It was at that critical time that the British Government sent out its Military Mission, headed by Colonel (now Sir) John Norton Griffiths, completely to destroy all that was valuable in connection with the oil-fields, the refineries, and the installations. One night the Mission arrived at the offices of the Roumanian Consolidated Oil-fields, Ltd., and made its plan of campaign clear. There was nothing to be done but to fall in with it, and the following



BUSTENARI—ROUMANIA'S FAMOUS OIL REGION

morning practically everything was destroyed, or rather, a start was made to destroy it. And the destruction was carried out in a complete manner, for not only one, but several concerns which had been steadily built up to perfection as the result of many years of careful and systematic expansion, were all wiped out, excepting in name. The oil-wells were plugged beyond all hope of repair, the refineries were dismantled, machinery broken, pipe-line connections damaged, and both crude and refined oil stocks burned. It was the most tragic proceeding ever recorded in oil-field history, but it was necessary, and not carried out one day too soon, for the incoming armies were dangerously near. A day of reckoning must, of course, come, when those patriotic companies who gave all their assistance to this only course of frustrating the aims of the Germans will be fully compensated, but, so far, the attitude of those Government Departments responsible for making good the claims connected with this incident, has been anything but satisfactory. Once on the oil-fields the Germans soon commenced to try to make good the damage, and after many months of toil, I learn from unquestionable sources that the crude oil production in Roumania was 80 per cent. up to its quantity of pre-war times.

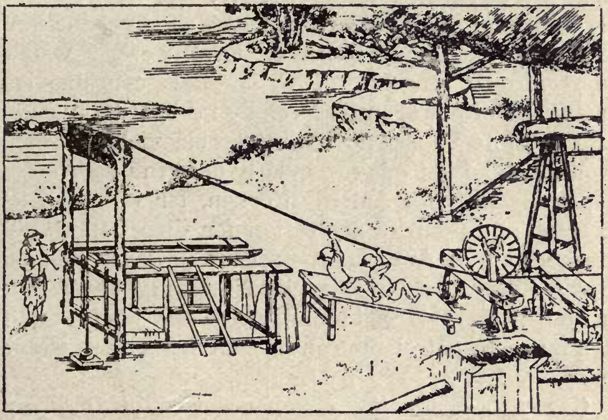
During the past decade Roumania has necessarily catered for the export trade, for the volume of crude oil produced has been far beyond its requirements. The great petroleum storage port of Constantza has been made the centre for this export business, and the completion of a trunk pipe-line from the Roumanian refineries to the port was one of the most recent enterprises undertaken by the Roumanian Government prior to the war. During the period when Roumania was under German control its terminal point was so changed that the line ran to a spot which rendered the transport of petroleum to Germany a matter of ease. Now, however, Germany's plans have been frustrated, and Roumania's great pipe-line well have its terminal point at Constantza, where all kinds of petroleum products can be pumped direct to the oil tankers.

THE DUTCH INDIES.—The growth of the petroleum industry in the Dutch Indies has been surprisingly rapid, and this growth synchronizes with the advent of the "Shell" Company into the Far Eastern fields. It is stated that there are many hundreds of square miles of territory in the East Indian Islands which can be remuneratively developed; at the moment, however, though but the fringe of exploitation has been touched, the production has been amazing. Eighteen years ago, it was placed at 300,000 tons of crude oil; last year it nearly reached 2,000,000 tons. In Sumatra several companies successfully operated for many years, but most of them eventually became merged with the Royal Dutch Company, whose interests now are also those of the "Shell" Company. As to Borneo, the "Shell" Company commenced active developments in 1900, or thereabouts, for it had acquired an area of approximately 460 square miles. The fields rapidly responded to the drill, and the crude oil production rose by leaps and bounds. The crude was of a high-grade character, and for a long time it taxed the energies of those responsible for the good conduct of the concern, as to exactly what should be done with some of the refined products. As a matter of fact, some thousands of tons were burned, for at that time there was little or no demand for motor spirit. I well remember when the Company's Chairman—Sir Marcus Samuel—faced the shareholders in 1900 and explained that if only the Company could realize 6d. per gallon for its motor spirit, what handsome profits would accrue. But events have marched quickly since those days. The motor-car has come to stay, and what seemed a useless product of the Far Eastern oils in the early days of development, is now one of the chief sources of revenue. The advent

OIL PRODUCTION IN THE EARLY DAYS OF THE INDUSTRY IN BURMAH

of the heavier motor spirits has also been of great benefit to the Borneo petroleum industry, for the public has grown accustomed to recognize that it is not specific gravity which counts in the quality of motor spirit, but the closeness of the boiling points of its constituent fractions. To-day, the Far Eastern fields supply enormous quantities of refined products to the consuming markets of the Eastern hemisphere, and so long as the supplying centres continue their present productivity, there need be no talk of approaching famine, for, if necessary—providing facilities permitted—these regions could supply the entire world with all the petroleum products it requires.

INDIA also ranks to-day as a very important petroleum producing region, the fields of Upper Burmah—in which



AN OLD JAPANESE WAY OF OPERATING THE WELLS

the Burmah Oil Company operates—being responsible for practically the whole production. In another part of this little publication, I deal briefly with this Company's operations, so, for the moment, it is sufficient to mention that, though to-day they produce large quantities of petroleum, there are several new districts which show much promise of new production. For many years the Upper Burmah fields were exploited by means of very shallow wells: it was only when the deeper strata were reached that the potentialities of the region became fully manifest.

JAPAN, as an oil-producing country, affords food for an interesting story, for it was here that very early attempts were made to develop production. Even in the seventh century, the Emperor was presented with "burning water" with which the Palace was lighted. The crude oil was collected from pools, or, alternately, wells were dug by hand, the process of extraction being very picturesque, if very primitive. To-day, Echigo is the centre of the industry, for which the introduction of European methods of drilling have worked wonders in regard to progress. The Celestials consume large quantities of petroleum, especially for lighting purposes, and in spite of the now considerable yields from the wells, a gigantic trade is regularly done in imported oils, especially those of American origin, for which there is a most up-to-date organization for distribution. The statement that American petroleum products find their way to every quarter of the globe is strangely exemplified in Japan (as also in China), where the ubiquitous tin container for petroleum can be seen in the most isolated parts.

GALICIA.—Since the commencement of the period when petroleum and its products assumed a degree of industrial importance, the Galician oil regions have attracted considerable attention. The area of the oil-fields extends over a length of 200 miles, and in width varies from 40 to 60 miles, and though in this territory several fields of considerable note have for many years been systematically developed, there is enormous scope for future operations. Its annual output of crude oil, which nearly reached 1,900,000 tons in 1909, is in itself suggestive of the extensive manner in which the oil-producing fields have been developed during late years.

THE GALICIAN FIELDS, SHOWING DAMAGE DONE BY THE RUSSIAN ARMIES WHEN RETREATING IN 1916

The oil-field history of Galicia is particularly interesting, for the oil seepages round Boryslaw have been exploited for very many years. Long before the introduction of the drilling methods of modern times, the shallow oil sources in the Galician fields were tapped by means of the hand-dug wells, but it was only when the first drilled well was sunk in 1862 that the real value of the Galician ozokerite, which abounds in many places in the oil-fields, was appreciated by the operators. This ozokerite is one of the most valuable of bitumens, and though found in several countries, is nowhere met with in such large quantities as in Galicia. The ozokerite there fills the fissures in the much disturbed *cpaly*, and evidently originates from a natural process of concentration. The mines are operated by modern machinery, and the industry in Galicia has reached a stage of great importance, some thousands of tons of the mineral being yearly raised. The material is refined, and the resulting wax serves numerous commercial purposes, the refining taking place in the Austro-Hungarian refineries. Considerable quantities of the raw material are exported to Germany and Russia, while the refined products are well known on the export markets. About seven years ago, serious water trouble materially reduced the production of the Galician oil-wells (for when the water courses are not properly shut off, water may encroach and cause the loss of the producing well), but the trouble was to some extent surmounted by the taking of greater care in cementing the wells. The introduction and consequent popularity of the modern drilling methods which were introduced by Mr. W. H. Margarvey in 1882 permitted the testing of the deeper horizons of the Galician fields, and to-day wells are by no means uncommon with depths up to and sometimes exceeding 4,000 feet. The Boryslaw-Tustanowice district still continues to be the centre of the crude oil production, but several new oil areas with great promise have been opened up during the past six years. Naturally, the European War has retarded development work considerably, and the Galician fields have on more than one occasion been the scene of battle. At one time in 1915 they passed over to the Russians, but when the Russian retreat occurred later from Lemberg, considerable damage was done to the fields in order to prevent their being of immediate use to the enemy. The wells were seriously damaged, and the State refinery at Drohobitz was partially dismantled, while immense reserves of refined oil stocks were burned.

The Galician oil industry has for years attracted the attention of foreign capitalists, for the highly remunerative nature of petroleum exploitation is generally appreciated. English as well as German capital is invested in the industry in large amounts. Germany depends very largely upon the Galician petroleum industry for its requirements, but at no time was its dependence so great as during the war, when the whole of the facilities for import from the United States were effectively shut off.

GERMANY has made great endeavours in the past to institute a petroleum industry of its own, but no great success has been recorded, for while it does possess several oil-producing areas, these are only small fields, with a very limited yield of heavy petroleums. The wells, though producing for many years steadily, do not give forth those large quantities of petroleum so characteristic of the best wells in other petroleum-producing fields, and flowing wells are indeed very rare. Germany, therefore, has to look to imported petroleum for its large demands.

In a succeeding chapter I refer at length to those oil regions which come within the limits of a chapter, "Petroleum in the British Empire": there is no need at the moment to make reference to them here.

Space does not permit my even briefly touching upon the many other oil regions of the world which are now being successfully operated; it is certain, however, as time goes on that their number will be materially increased.

CHAPTER III

HOW PETROLEUM IS PRODUCED

TIME was when the engineering aspect of the production of petroleum was practically non-existent. The ancients, and even those of the last century, were content to resort to the most primitive means for winning petroleum from the earth. Shallow wells were sunk or dug by hand, the eventual securing of the oil being carried out by lowering primitive receptacles (generally leather bottles) into the hole. It was a period long before the advent of the Oil Age, and the methods employed were clearly in keeping with the mode of life of that day. In practically every oil-producing field of the world—though in this respect the United States is almost an exception—the history records the fact that for many years the extraction of oil from the ground was confined to the use of the primitive methods which held sway in those days—those associated with the operations of the hand-dug wells. In the Far East, notably in Japan, we find the first serious attempts to obtain and utilize petroleum, for as far back as A.D. 615, there were shallow wells in existence, from which the "burning water," as it was called, was collected. In Roumania and Russia, too, the earlier attempts to create a petroleum industry were confined to these methods.

It was only when the demand for petroleum became large and consistently increased with the opening up of new fields, that we find other and more practical methods were introduced for winning larger quantities of the oil from the earth. To-day, in every branch of the industry associated with petroleum—whether it be in producing the crude oil, in transporting it, or in refining Nature's product into those numerous commodities which are part and parcel of everyday life—the engineering aspect is one of very great importance. In fact, throughout the petroleum industry, engineering science is the Alpha and Omega. By its means we are now able to carefully study the nature of the ground at depths of 6,000 feet, and to extract from the deep lying strata a wealth of minerals; we are able, too, to transport thousands of tons of crude oil daily across thousands of miles of continent, while is it not the direct result of engineering science which allows over 15,000 tons of petroleum products to be carried across the oceans of the world in one vessel with the same ease that one would take a rowing boat from one side of a lake to another ?

Great, however, as have been the degrees of progress recorded in connection with drilling for petroleum, the old methods, generally speaking, and which date back to the days of early China, are still largely copied in all pole and percussion systems of drilling, and though steam has replaced manual labour (and electricity now bids fair to replace steam), the operating principles to-day are the same as then. The only exception, of course, is the advent and growing popularity of the rotary method of drilling, to which interesting phase of the subject I will briefly refer later.

The old Eastern method of drilling has obviously been the forerunner of the Canadian, standard, and other systems of to-day, the wire rope replacing the use of poles. In oil-field work, the principal types of percussion drills used are known (1) as the Pennsylvanian cable, (2) the Canadian pole, and (3) the Russian free-fall system, and though from time to time many attempts have been made to introduce modifications of these, the vast majority have been unsuccessful in their operation.

The Pennsylvanian cable system was used for drilling the earliest oil-wells in the United States, and doubtless took its name from the fact that it was so largely used in that oil region. As may also be gathered from the name, the principal feature in this system is the cable by which the tools are suspended and connected to the walking beam. There is no doubt that this system of drilling, which has been so universally used in the oil-fields, gives most satisfactory results. When first introduced in Pennsylvania, the cable system of drilling was particularly simple, and did remarkably good work, for the reason that the strata usually encountered was of such a nature that it did not cave, and, as a result, the well-pipe was only lowered when the full depth of that string had been drilled. The drilling bits were seldom more than 4 inches thick. In order to give a rotary motion to the bit, the continuous twisting of the cable to and fro was necessary; but when in other fields, where deeper strata had to be explored, the cable system was introduced, the semi-sandy nature of the strata called for wells of larger diameter with correspondingly larger drilling bits. As a consequence of the additional weight of the drilling bit, it was found that the swing of the tools was sufficient to give them a rotating movement for the drilling of a circular hole. In regions where caving-in of the walls of the wells was liable to occur, the string of pipe had to closely follow the tools, which, with the old Pennsylvanian type of rig, meant frequent winding of the cable from the bull wheel, so as to allow of the well pipes being handled.

In order to prevent the waste of time which these operations occasioned, the calf wheel was added, by means of which the pipe could be lowered into the hole without the removal of the drilling cable. This cable almost invariably was of the Manila character, and in many instances this rope is retained to-day, though wire ropes have been introduced frequently.

The Canadian pole system, which is largely in use in oil-field operations, is, like the first-mentioned method of drilling, of the percussion type, the chief essential difference being that, instead of a cable connecting the tools to the surface, poles are used. In former times, these poles were of ash-wood, but with the extended use of the system, iron rods took their place. The introduction of these iron rods was a distinct advantage, for they could be welded to whatever lengths are required, whereas the wooden poles, which were seldom more than 20 feet long, had to be spliced for practical work. The rig used with the Canadian system is not so powerful as that for the Pennsylvanian method, but the one great advantage of the Canadian system is that, for the drilling of shallow oil-wells, it could be operated by men of less experience. The success which has attended the operation of the pole system lies in the fact that although drilling by its means is very slow—for seldom is 250 feet per month exceeded—it is one of the best methods of drilling through complicated strata, and, in the hands of conscientious men, does highly satisfactory work. It might be of interest to very briefly refer to the operations of the system when a well is being drilled. The rig (that is, the superstructure above ground) is quite a simple framing, 70 or more feet high, with a base of about 20 feet. The power is usually derived from a steam engine, with the usual means for operating the gear from the derrick; fuel found locally, natural gas, or other form of heating agent used. One shaft and two spools running in bearings transmit the various motions desired, the drive being taken up by a pulley attached to the main shaft. On this shaft are keyed two band pulleys, which communicate by belting with two spools running immediately overhead in the upper part of the framework. Fastened to one extremity of the main shaft is a disc crank, which, through the medium of a connecting rod, transmits an oscillating movement to an overhead pivoted walking beam. In all systems of percussion drilling, the drilling bit is raised and then dropped a distance of several feet, the result being that the strata to be drilled are steadily pounded away. As the ground is pulverized by the percussion tools, the debris has to be cleared away so as to enable the drill to fall freely and to deliver clean blows to the unbroken strata, and this work is performed by appliances known as bailers and sand pumps. There is no need for me to go into the numerous technical details regarding this or any other system of drilling, for my only desire is to give a general impression as to the usual methods adopted for the winning of petroleum.

I will therefore pass on to deal briefly with the Russian free-fall system so much in vogue in the Russian fields. Incidentally, I may here say that when drilling for oil in Russia, one has to recollect several features which are not common to the development of other oil-fields. Bearing in mind the great depth to which wells have to be sunk to reach the prolific oil horizons in the majority of the fields in Russia, which necessitates starting the well with a very large diameter—frequently 30 inches—it will be easily appreciated that the loss of a hole in the course of drilling is a very expensive affair. The Russian free-fall system of boring necessitates patient and hard manual labour. It is, as its name implies, of the percussion type, and is, in fact, a modified pole-tool system which well suits the local conditions.

The clumsy drilling tools have a practically free drop, being picked up when the walking beam is at its lowest point, and released at the top of the stroke. When released, the tools naturally force their way downwards in the strata, and are released only with difficulty, although in a measure this difficulty is minimized on account of the fact that the under-reaming (slightly enlarging the diameter of the hole) is done simultaneously with the drilling.

After a Russian well has been started by means of a slip-hook suspended from a haulage rope, and a depth of some 30 feet obtained, the free-fall is added to the string of tools. This free-fall is composed of two separate parts—the rod and the body—and these are held together by means of a wedge working in vertical slots cut in the sides of the body. In operating the free-fall, the handles, fixed to the temper screw, are held by the driller. On the downward stroke these are pushed forward from right to left, but as soon as the downward stroke is completed, they are quickly pulled backwards. The steel wedge enters the recess and the tools are carried to the top of the stroke, where, by a quick forward jerk, the wedge is thrown clear of the recess, and the tools drop freely, the momentum of the string of tools driving the drilling bit deeper into the hole. After several feet of the hole are drilled, the tools have to be withdrawn in order to allow the pulverized mass of debris to be cleared away, while, owing to the caving nature of the strata, it is necessary to case the well as drilling proceeds.

As I have said, the system is very cumbersome, but, in the hands of experienced men, it does its work well, if but slowly. There are many cases on record where, when the well has assumed a considerable depth, it has been completely spoiled by the carelessness of the

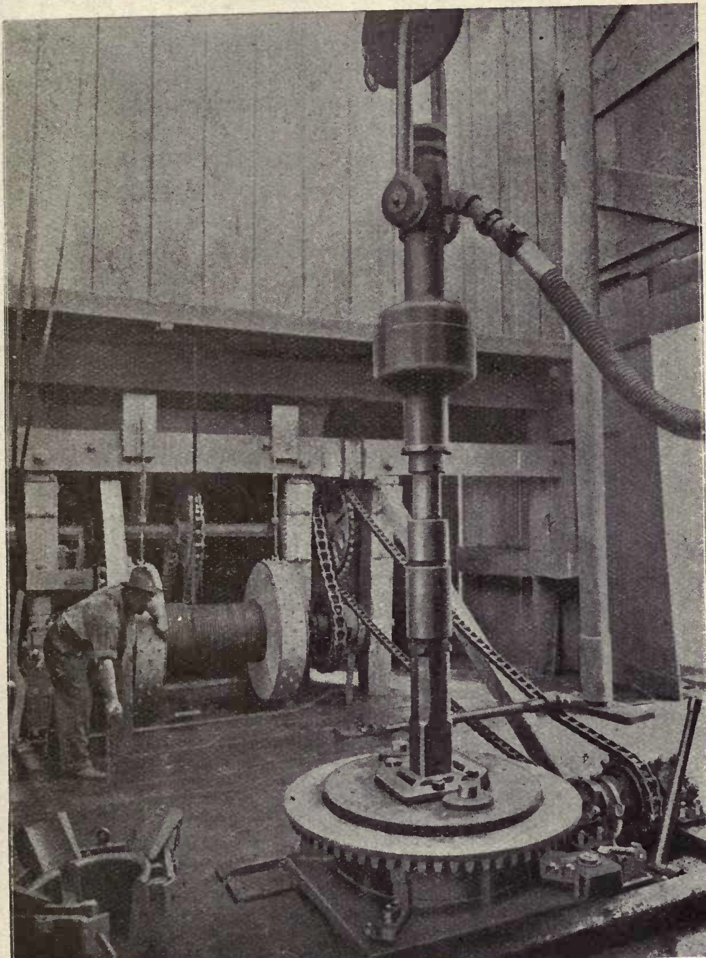


ILLUSTRATION OF THE "OILWELL" HEAVY ROTARY OUTFIT, SHOWING RING AND WEDGE (ON LEFT-HAND SIDE OF FOREGROUND) TO GRIP THE CASING operators, but, more often than not, this has been deliberate, for the Caucasian oil-field worker has many grievances, admittedly more or less imaginary.

During recent years, the rotary method of drilling has been successfully adopted, and it is in regard to this revolutionary method of speedy drilling that I will now touch upon. The rotary method of drilling made its début in Texas some fourteen years ago, and since then it is not any exaggeration to say that nearly 20,000 wells for oil have been drilled with the system, which has found popularity in all the oil-fields of the world. Its main operation is simplicity itself: a rigid stem of heavy pipe rotates a fish-tail drilling bit at the bottom of the hole, cutting and stirring up the formation to be drilled. It cuts its way through the underground formations, much in the same way as a screw when rotated forces its way through wood. It is the essence of speed in drilling, for, unlike the necessary principles to be adopted in the percussion methods of drilling, the rotary drill does not have to be lifted from the hole for the purposes of clearing. The pulverized strata are continuously washed from the hole by a stream of water reaching the bottom of the drill. Very frequently, a pressure-fed mud is used, and this serves a double purpose, for in its return to the surface it tends to plaster the walls of the well. The mud emerges in streams of high velocity from the two apertures in the drilling bit (for in its downward course it is carried through the drilling pipe or stem), but naturally loses this velocity considerably in its return to the surface. It is, however, very easy to detect the kind of stratum being drilled through from the returned cuttings, these reaching the surface but a few minutes after the drilling bit has entered the formation.

From time to time various grievances have been ventilated against this improved system of boring for petroleum, but to-day its adoption is world-wide, and by its use wells which, with the old-fashioned method of drilling would take many months if not two or three years, are now got down to the producing horizons in but a few weeks. It is, in fact, solely due to the ever-increasing use of the rotary drill that the universally increased demands for petroleum products have been met by an ever-increasing production of the crude oil.

Leaving the question of drilling methods, I cannot fail to mention the interesting fact that in oil-field operations progress is now being recorded in another direction, and that is by the increasing utilization of electrical power in the place of steam. At the time of writing, it is safe to say that fully 60 per cent. of the power requirements on the oil-fields is provided for by steam plants, with their attendant waste. Oil and gas engines, with their greater efficiency, may claim to be operated to an extent of 35 per cent., while not more than 5 per cent. of the requirements are satisfied by the use of electric motors. There is no doubt that prejudice has had a deal to do with the very minimized use of electrical power on the oil-fields in the past, but this is being gradually swept aside, and, in the next few years, I have no doubt that both electrical manufacturers and the petroleum industry generally will materially benefit from the use of this cheap and very economical form of power. In the past, many disastrous oil-field conflagrations have been due solely to the use of open-fired engines in close proximity to the wells, but with the use of electrical energy this fire danger will be rapidly removed.

Before closing this chapter, I would say a word or two with respect to the bringing into the producing stage of the oil-wells when once they have been drilled.

In the early history of oil-field developments, it was not infrequent to find the crude oil ejected from the well by natural pressure, but to-day it is the exception to find those oil-fountains which have made the early history of the Russian oil-fields so famous. In many of the fields, explosives are used to promote the flow of oil, and when the well "comes in" to production, the ordinary methods of bailing or pumping are resorted to. Compressed air is also used for bringing about and sustaining production. The quantity of air and the periods of admission naturally vary with the diameters of the wells, the amount of gas present, the level of the liquid, etc., which latter also determines the pressure of air necessary.

The natural exhaustion of oil-wells can obviously have no remedy, but areas conveying that impression can often be revived by methods, the study of which is being carefully continued. As I write, I find that the officials of the United States Bureau of Mines, who have been studying this question of exhaustion, have arrived at the conclusion that from 20 to as much as 90 per cent. of the crude oil remains in the strata tapped by the well, even when it is abandoned as no longer capable of profitable production. This conclusion opens up what may prove some day to be a most interesting chapter in oil-field history.

CHAPTER IV

THE REFINING OF PETROLEUM

INASMUCH as the aim of this little volume is to interest other than those who are directly associated with the petroleum industry, I shall endeavour in this chapter to refer to the refining of petroleum in a manner which shall be readily understood by the reader, and shall, wherever possible, refrain from entering into those highly technical matters which do not lend themselves to popular expression.

The refining of crude oil as it is produced from the earth, consists in the classification of its various hydrocarbons by means of fractional distillation, into the various products which so largely enter into our commercial and domestic life of to-day. The refined products, in the order in which they are received by distillation, are: motor spirit, illuminating oils, solar oils, lubricating oils, fuel oils, residuum, etc.—the first mentioned being the lightest and the last the heaviest in specific gravity.

Almost simultaneously with the discovery of petroleum, there sprung up the first attempts to refine Nature's product, and though these early experiments were of a most primitive character, they doubtless served their purpose admirably. In this respect, probably the most primitive oil refinery in the world was built near the Tigris, in Mesopotamia.

Crude petroleum varies in its character, for while certain crudes are pale in colour and almost transparent, others are almost black and viscid. Some, indeed, would appear to have undergone a course of refining by Nature itself, for in some fields the crude oil will freely burn in lamps without any refining treatment: in the vast majority of cases, however, the crude oil, as withdrawn from the producing wells, represents a liquid somewhat like molten tar.

The chemical composition of petroleum consists essentially of carbon and hydrogen, together with oxygen and varying amounts of nitrogen and sulphur. The crude from Pennsylvania—and this is the finest crude in the United States—consists chiefly of a large number of hydrocarbons of the paraffin series, whilst in the Russian petroleums, the predominant constituents are naphthenes or polymethylenes. Then the crude petroleum of the Dutch Indies and Burmah is of a different character from that found elsewhere, for in it aromatic hydrocarbons are largely present. The various series of hydrocarbons found in crude oils—the paraffins and naphthenes—readily lend themselves to conversion into other compounds of carbon and hydrogen by dissociation, and this conversion produces compounds of higher volatility, such as motor spirits, etc. When the compounds of hydrogen and carbon are submitted to distillation, certain chemical changes occur, as the result of which other series of hydrocarbons are formed, and, though it is not my intention here to dive into this comparatively new realm of chemical investigation, it is interesting to mention that, by carrying the treatment of the compounds still further, it is possible to obtain aromatic hydrocarbons, including trinitrotoluene (generally known as the explosive T.N.T.), in addition to various dye products.

In the earlier methods of refining, the stills usually consisted of a vertical cylinder in which the charge of crude oil was distilled almost to dryness, but this method was completely revolutionized many years ago,

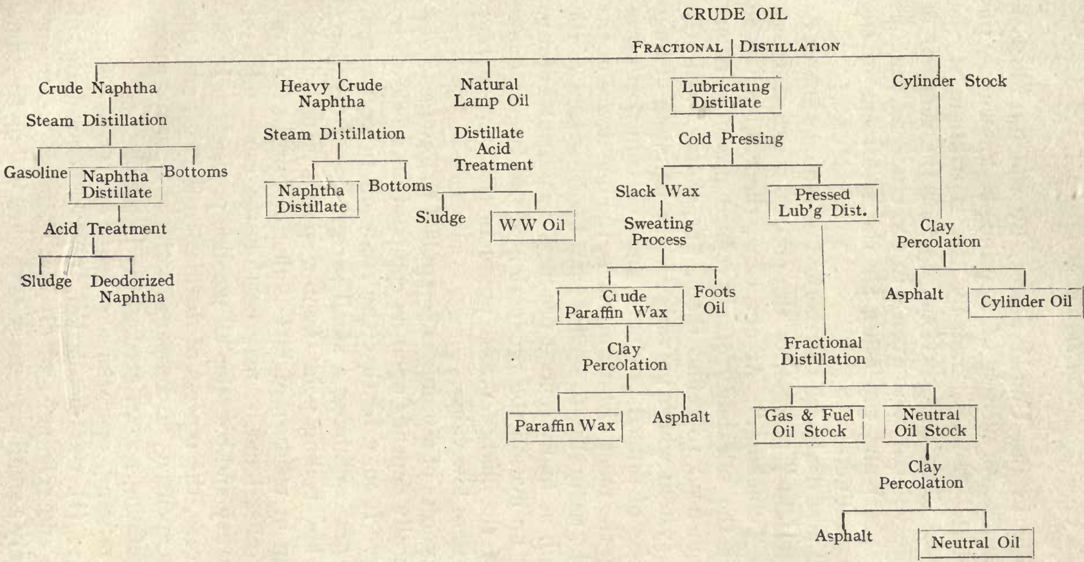


DIAGRAM SHOWING THE PRODUCTS OF PETROLEUM BY FRACTIONAL DISTILLATION especially in the United States, by the introduction and immediate success of a principle known as the "cracking" process, and by the separation of the distillation into two portions, one for the removal of the more volatile constituents in the crude oil (such as motor spirit) and the other for the treatment of the heavier products.

I will first deal with the method of refining known as the "straight" process, or the process which does not involve "cracking." At one time, the refiner had to consider the saleability of his refined products before he commenced to refine them, but to-day, with the perfect system which prevails for the handling of huge quantities of refined products, and the transporting of them to the most distant markets, the one desire of the refiner is, naturally, to secure from his treatment of the crude oil, as many refined products as possible, always keeping an eye on the production of the largest quantities of the higher priced products than upon those which are of low value.

The process of refining to be applied to any particular oil naturally depends upon its composition as shown by analysis. It may be that the crude oil to be treated, apart from containing a small percentage of distillates with a low boiling point (motor spirit), is principally made up of residues of little value except as fuel, or, on the other hand, it may be that the crude oil is of high quality and contains all possible products. In the former case, the process of distillation is brief, and the plant inexpensive, as compared with the lengthy process of full refining necessitated in the latter case.

The refining operations consist of three distinct branches: (1) the distillation, (2) the extracting of paraffin and refining, and (3) the chemical treatment. When only a small percentage of the low boiling fractions

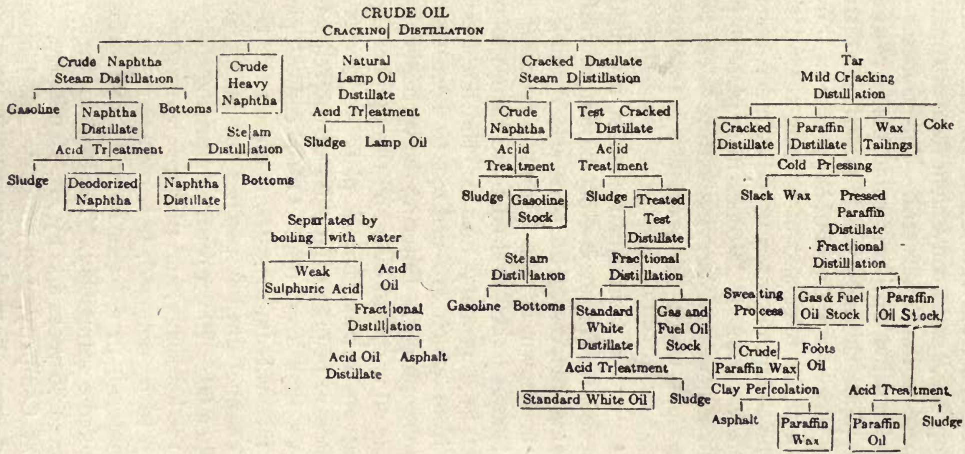


DIAGRAM SHOWING THE PRODUCTS OF PETROLEUM OBTAINED BY THE "CRACKING" PROCESS

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has to be removed from the crude oil, the process is known as "topping," and a convenient form of apparatus for the purpose is the tower still. This consists of a vertical cylinder fitted with perforated plates resting at intervals on pipes through which superheated steam travels. The pipes serve the double purpose of conveying the steam to its inlet and of heating the oil to be distilled. The steam, on entering the cylinder, ascends, meeting the crude oil, as it descends from plate to plate in a regulated stream, and carrying with it to the outlet the light fractions which the operation is intended to remove.

A few years ago, a Californian chemist invented an improvement of the principles of maximum heating and evaporating surfaces. His name was Trumble, and the process is known as the Trumble process. The crude oil is heated to the desired temperature in pipes or retorts set in a primary furnace, the hot gases of combustion from which are utilized to heat the distillation chamber proper. Entering the vertical cylinder at the top, the oil is spread over and through perforated plates falling on a cone-shaped plate to divert the continuous stream of oil to the sides of the still, down which it flows in a thin film. Other conical plates, arranged at intervals underneath, maintain the flow in the desired channel until it reaches the outlet at the bottom. When 60 or 70 per cent. (comprising the motor spirit series, the kerosenes, and perhaps the intermediate fractions) are to be removed, it is common practice to distil the crude oil in a series of stills, cylindrical in shape, connected continuously. The best-known system is that patented 35 years ago by Mr. Henderson, of the Broxburn Oil Company, Ltd., for the distillation of shale oil, and since adopted by many refiners of petroleum. In this system, the crude oil flows from a charging tank by gravity through a pre-heater, heated by the passage, from the second or other still, of distillates of suitable temperature, and thence into the first still. Here it is raised to distillation temperature, and the specific gravity of the distillate therefrom fixed. The feed of the crude oil is constant, the residue formed in the still passing through a connection at the bottom into the second still in the series, at the top, and led from back to front so that the inlet and outlet shall be as far apart as possible. It is here raised to a higher temperature, yielding a distillate of higher specific gravity, the residue passing on to the next still, and so on through the series of stills until it reaches the point where all the motor spirit (or benzine, as it is called), kerosine, and the intermediate distillates are removed.

The distillates obtained from the refining of the crude are usually purified by treatment successively with sulphuric acid and solution of caustic soda, this process of chemical treatment being necessary before the products are fit for the market.

The " cracking " process of distillation briefly consists in distilling the oils at a temperature higher than the normal boiling points of the constituents it is desired to decompose, and, in practice, the result is that the heavier oils are turned into lighter hydrocarbons of lower boiling points: thus the yield of the more valuable of the refined products is materially increased. The " cracking " process, which very largely obtains to-day, was quite accidentally discovered by a small refiner in America many years ago. The man in charge of the still left it with the intention of returning very shortly. He was, however, absent for several hours, and to his dismay found that, as the result of his neglect in attending to the still, a very light coloured distillate of much lower density than that which it was usual to obtain, was issuing from the condenser.

Upon investigation, it was found that a portion of the distillate had condensed upon the upper part of the still, which was cooler, and had dropped back into the still, where the temperature was sufficient to produce products of a lower boiling point—certainly a distinct improvement. As may be imagined, this "cracking" process does not commence until the lighter products of distillation have been removed, and is now so popular because by its use a greater yield can be obtained of those more valuable products for which there is an ever-increasing demand.

It is unnecessary here to enter into those various improvements which have been introduced from time to time, all of which have as their aim the production of larger quantities of refined oils, and it would likewise be invidious to enumerate even the more popular scientists to whose energies much of the resulting progress has been due, for the simple reason that it has ever been the aim of the petroleum chemist to turn his abilities in the direction indicated.

As may be imagined, the industry of petroleum refining has had to adapt itself to the altered conditions of to-day. For instance, prior to the advent of the internal combustion engine, which now is responsible for such a wide application of motor spirit, the demand for this, the lightest product of petroleum distillation, was non-existent. Consequently, when such spirit was produced, there was no market for it, and its production represented sheer loss to the refiners. Both in the Far East and in Russia, we have examples of the enormous loss which accrued to the refiners by reason of there being no market for this highly inflammable product. In the Far Eastern fields, in particular, this loss was very heavy, for in the earlier days of its operations, the "Shell" Company had to remove thousands of tons of this now valuable motor spirit from its refineries and burn it in the open fields. The successful introduction of the internal combustion engine, however, completely changed the aspect of petroleum refining, and the desire became general, not to see how little motor spirit could be produced, but to perfect methods by which the yield of the benzene series of hydrocarbons should be as large as possible. Even to-day progress is still being recorded in this direction, and each American refiner is vying with his neighbour as to how far that output of gasoline, as it is there called, can be increased.

Many and varied are the means which have been resorted to for this purpose, but most of them have reference to improvements in the processes for refining the crude oil. One, however, is worthy of being mentioned in this little treatise, inasmuch as it deals with quite another aspect of the problem of increased motor spirit supply.

As I have mentioned in another chapter, enormous quantities of natural gas exude from the oil-wells, and this in the past has been for the most part allowed to go to waste in the air, causing an ever-present danger to oil-field operations on account of its liability to ignite. Being heavier than the air itself, for it is impregnated with oil gases, it remains for long periods in the lower air strata, and, consequently, not infrequently, has been the direct cause of great oil-field fires. This gas—casing-head gas, as it is termed—comes from the oil-wells between the casing and the tubing, and, in the case of numerous wells, the flow is remarkable, some wells giving forth 300,000 cubic feet of gas every 24 hours, and the only useful purpose that this vapour has served until recent years has been to light several towns situated comparatively near to the oil-producing fields. The great volume of the gas, however, has been allowed to go to waste.

But experiments have proved that the gas is capable of condensation into motor spirit, and the general yield of such spirit may be taken as fully 2 gallons per 1,000 cubic feet of natural gas treated. What wonderful possibilities lie in the direction of the conversion of this vapour into motor spirit! The oil-producers in the United States have not been slow to appreciate this, and to-day there are hundreds of plants in the United States which have been erected solely to condense these oil-well gas vapours. Some of these plants are dealing with as much as 3,000,000 cubic feet of gas a day. The most recent official returns available from the United States show that the production of gasoline (motor spirit) from this process of oil gas condensation is, approximately, 100,000,000 gallons per annum, and even this substantial figure is being steadily increased.

There is also another phase of the oil-refining industry which, during recent years, has materially altered. I refer to the production of solar oil during distillation. It is an apt saying that we can scarcely look to any section of our commercial or domestic life without being confronted with the fact that oil products play some part therein: there are few, however, who, without reflection, would agree that when they light their gas they are dependent upon petroleum for much of the light the gas gives. It is, nevertheless, a fact, as I will proceed to show.

Many years ago, the oil refiners in Baku were confronted with a problem which appeared for some time to be insurmountable. After the distillation of their kerosene, or illuminating oil, and before they could commence to take off the lubricating oil fractions, there was an intermediary product which, while being of no use for lamp oil, did not possess the necessary constituents of viscosity to make it acceptable as a lubricant. It was a fairly decent volume of something for which there was no market at the time.

Experiments were made, and with these the name of Dr. Paul Dvorkovitz will ever be associated, and it was found that by the passage of a current of gas over the surface of this intermediate product, the gas caught up as it were a richness which materially increased the lighting power of the gas. To cut a long, but highly interesting, story short, this solar or gas oil was subsequently introduced by Dr. Dvorkovitz to England for gas enrichment purposes, and the extent of its employment to-day may be judged from the fact that the United Kingdom regularly imports between 60,000,000 and 70,000,000 gallons per annum for the enrichment of the coal gas which finds useful employment in practically every home throughout the land. As is known, the gas companies have to produce gas of a certain lighting quality, and it is in the upholding of the lighting strength of the gas that solar oil to-day plays so important a part. At first, the oil came almost exclusively from Russia, but now the competition from the United States has secured for our American friends the vast bulk of the trade, which, as I have shown, has reached enormous proportions.

Solar oil is also largely utilized for the production of refined perfumery oils, which are quite colourless and inodorous, while the finest quality is used in pharmacy and known as *paraffinum liquidum,* and is in much demand, but in this connection it is the Russian petroleums that have gained distinction. It was held for many years that such tasteless and colourless oils could not be produced from the United States petroleums, but from the commencement of the European War, and the consequent closure of Russia's export port, whereby all overseas trade in Russian petroleums was held up, much progress was made in the manufacture of tasteless medicinal petroleums in the United States, such articles having now become popular throughout the world.

One of the most important discoveries made during recent years has been the finding of large quantities of toluol in petroleum. This article is necessary for the manufacture of high explosives. In Borneo heavy petroleum, toluol exists to a very large extent, and it was its discovery and consequent use by the allies—thanks to the offer made to the Governments by Sir Marcus Samuel, Bart.—that almost unlimited quantities of high explosives were manufactured.

Vaseline is another useful commodity which is derived from the refining of crude petroleum, and this article is turned out of the American refineries as well as those of Russia and Galicia, in large quantities, but, beyond mentioning this fact, no useful purpose would here be served by relating the various processes employed.

With reference to the methods generally adopted in the refining of the products from the distillation of the Scottish oil shales, these are briefly dealt with in the chapter devoted to the Scottish oil industry.

It is safe to say that the past two or three decades have witnessed marked progress in perfecting the methods by which crude petroleums are refined into the innumerable common commodities of commerce, and it is doubtful whether in any branch of chemical research there has been such concerted energy shown as in regard to the refining of mineral oils. Signs, however, are not wanting to show that the zenith of this progress has by no means been reached.

CHAPTER V

TRANSPORT BY LAND AND SEA

THE remarkably perfect methods by which petroleum and its products are transported by land and sea before they reach the consumer may not at first sight appear to be anything but commonplace, but a moment's reflection will be sufficient to suggest that a vast and complete organization must be required in order that petroleum may be brought from practically the ends of the earth to the consumer in the most remote village in the British Isles. But it is the demands of necessity that have been responsible for the building up of this vast organization of transportation which represents, in the United States alone, the investment of many millions of pounds sterling.

Taking first the methods of oil transportation by land, in no other oil-producing country do we find such an elaborate system for dealing with enormous quantities of petroleum as in America, for it is safe to say that at least 500,000 barrels of crude oil have to be dealt with daily at the present time.

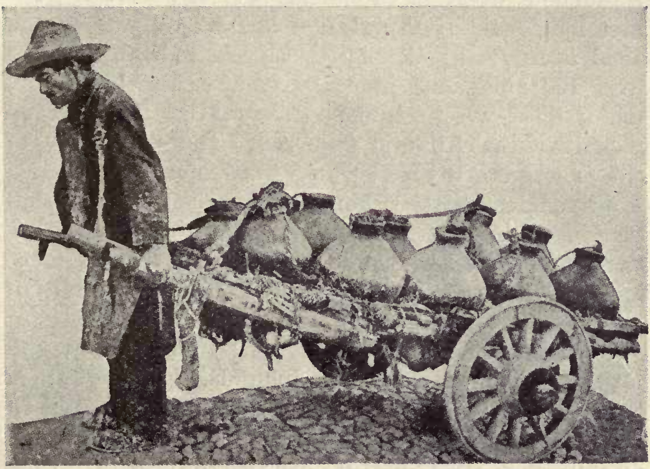
Going back to the time when petroleum first became a commercial commodity—when the first wells in Oil Creek commenced to open up a period of new prosperity for the United States—these wells were situated so close to the water that their product could easily be loaded into canoes and barges, and floated down the Alleghany river. In the dry season, the flow was insufficient to float the craft, and then some hundreds of the boats, carrying each from 50 to 1,000 barrels, would be assembled in a mill-pond near the wells, and the water impounded while the loading was in progress. Then the gates would be opened, and the fleet, carried on the flood of rushing water, would be hurried down the river in charge of pilots. The fleet of creek and river boats engaged in this novel work at one time numbered 2,000.

But, as the production of oil increased, and new districts were successfully tapped, it became obvious that some different method of handling the crude oil would have to be adopted. The inland wells could not get rid of their production, and it is not surprising to find that at one time—about 1862—crude oil prices at the well fell to 10 cents per barrel. A system of horse haulage was initiated, and in time thousands of animals were required to haul the oil from the inland wells to shipping points. The waggon train of the oil country in the pre-pipe-line days at its maximum consisted of 6,000 two-horse teams and waggons, and a traveller in the oil region in those early sixties could not lose sight of an endless train of waggons each laden with from five to seven barrels. The roads were almost bottomless, and the teamsters tore down fences and drove where they liked. These men, always of the roving, picturesque type, would earn anything from 10 to 25 dollars per day, spending the most part in revelry on the Saturday night.

It was at this time that a Bill was introduced into the States legislature authorizing the construction of a pipe-line from Oil Creek to a spot known as Kittanning, but the opposition of 4,000 teamsters defeated the Bill and the first effort to organize an oil pipe-line company. The modest beginning of the present-day system of oil transportation on land by pipe-line was due to the enterprise of a Jerseyman named Hutchings, who laid a 2-inch pipe from some wells to the Humbolt refinery.

The teamsters, foreseeing the possibilities of this innovation, proceeded to tear up the line, and warned the oil-producers not to adopt these new methods of oil transportation.

But Hutchings was undismayed, for he laid a second line, this being composed of cast-iron joints caulked



A PRIMITIVE METHOD OF TRANSPORTING OIL

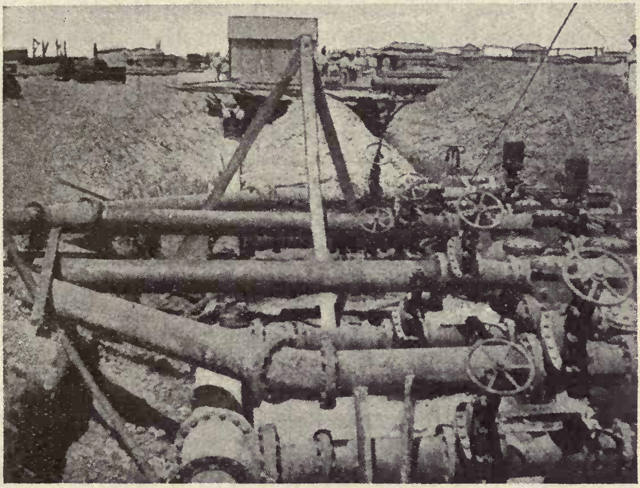
with lead. Although this was impracticable, the teamsters again wrought vengeance on the proposition, and completely destroyed it. Hutchings still persisted in his efforts, but died—disappointed and penniless—a genius living a little before his time.

At the end of 1865, a Henry Harley commenced the laying of a pipe-line to the terminus of the Oil Creek railroad, but teamsters cut the pipes, burned the collecting tanks, and retarded the work in every possible way. Armed guards eventually came on the scene, the mob was quelled and dispersed, and the line completed. It was of 2-inch diameter, and laid to handle 800 barrels of oil daily: this was the first successful and profitable pipe-line on record for the handling of oil.

From this time, the number of pipe-lines have multiplied, until to-day there are thousands of them scattered throughout every oil-producing field of America. The first long main transportation line for oil was laid in 1880 from Butler County to Cleveland, a distance of over 100 miles, and immediately after its completion, trunk lines were commenced from the Bradford oil region to the Atlantic seaboard. The popularity of this new method of oil transportation may be judged from the fact that within three years from the completion of these first propositions, the National Transit Company possessed over 3,000 miles of oil pipe-lines, and had iron tank storage for 35,000,000 barrels of crude oil.

Then a few master minds came to the front, and loyally supported by Mr. John D. Rockefeller, of Standard Oil fame, they undertook the herculean task of practically girdling the 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 practices of handling petroleum, and substituted therefor the stem pump, the iron conduit, the steel tank storage, and systematic and businesslike methods which soon commanded the confidence and respect of all oil-producers. They extended their pipe-lines to practically 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.

A pipe-line connection to a producer's tank ensures prompt service and a cash market for his product at all times. The small line connected with his tank conveys the crude oil therefrom, either by gravity or by means of a pump, into a receiving tank of the



OIL PIPE-LINE CONNECTIONS IN THE AMERICAN FIELDS

gathering or field lines of the pipe-line system, from which it is pumped into the main trunk pipe-lines to the refineries.

The system by which the producer can have payment for his oil at any time, for he is credited with its value when it once enters the pipe-line, is the perfection of simplicity, accuracy, and efficiency. The pipe-line of which the gathering or field lines are composed varies in diameter from 2 to 8 inches, the joints of which are screw threaded. The main trunk lines are from 6 to

10 inches in diameter, and pumping stations, supplied with powerful plant driven by steam or internal combustion engines of the Diesel type, are located at suitable points of the line. According to the nature of the crude oils to be passed through the pipe-line must the erection of pumping houses be governed: for instance, in handling the heavy Californian or Mexican crudes, the pumping stations have to be much nearer each other than when a lighter crude oil is transported. Some of the heavier oils have, in fact, to be heated before they enter the pipes at all.

As already mentioned, the total oil transported to-day by the American pipe-line system exceeds half a million barrels daily. The lines themselves—all laid, of course, below ground—are so unobtrusive and do their work so quietly and unseen, that they attract no attention, and yet they are vastly important to not only the business of the States, but to those myriads of consumers abroad.

It is, in fact, impossible to over-estimate the importance of this up-to-date system of oil transportation in the United States as it exists to-day. To show the impossibility of conducting the present-day American petroleum industry without the use of pipe-lines, let me give a few facts. The large oil-tank cars, which are not unusual sights on our railways, hold, at the maximum, about 25 tons of oil. Excluding California altogether from these illustrations, the half-a-million barrels of oil which are transported daily in the States by pipe-lines would fill over 2,500 tank cars. Taking 25 cars to make up a freight train, it would require fully 100 trains daily to transport the oil that now goes by pipe-line, and inasmuch as it is estimated that the oil on the average is transported overland (or, rather, under-land) 1,000 miles, it would require, approximately, 200,000 railroad tank cars to do the daily work in connection with the transport of oil in the United States east of the Rocky Mountains, for the average movement of tank cars is 30 miles daily, and all empty cars must be returned. No less than 8,000 railroad engines would be required to do this work, which, on the face of it, is a railway impossibility.

I am afraid I have devoted more space to the question of pipe-line transport in the States than the confines of this little work warrants, but the subject is one of great interest to all who would know the magnitude of the organization which is comprised in the limits of the petroleum industry.

The United States, however, is but one of the large oil-producing countries where the pipe-line system for the land transport of oil has become the backbone of transport. In Russia, for instance, the fields of production are situated hundreds of miles from the exporting ports, and, following upon the principles which obtain in the United States, the pipe-line system had, perforce, to be adopted. In this respect, however, Russia has still a great deal to learn from our Western friends, and the conservative policy which permeated the Russian Empire as a whole has precluded the making of much headway.

The Russian oil-fields—those of Baku and Grosny—are situated at great distance from the coast, and the necessity of connecting both fields with the export port of Batoum, on the Black Sea, has frequently been put forward as a project offering the one solution of the difficulties attending the retention of a large export oil trade. The Grosny pipe-line is still a scheme for future solution, but that affecting Baku has been solved by the laying of a pipe-line from Baku to Batoum. This line, which is approximately 650 miles long, runs direct between the two oil centres and, assuming it operates 24 hours in the day, has a capacity of transporting over 3,000 tons of oil daily. Inasmuch as the Russian oil refineries are at Baku, the line is used solely for the transportation of the refined products. The line itself is laid alongside the railway line of the Transcaucasian Railway, at a depth of 4 feet, but many strange stories are related as to the tapping of it at various points, and a lucrative trade being done in the oil so caught. When, after the war, the Russian petroleum industry rights itself, and an export trade is reinstated, there is not the slightest doubt that another line will be laid—this from the Grosny fields direct to seaboard—for the engineering difficulties to be encountered *en route* can, with comparative ease, be solved.

Roumania can also boast of a main trunk pipe-line for refined products from the inland refineries direct to the port of Constantza. This important project, which has been carried out practically by the Government itself, was just about ready for service when the European War broke out: it has, therefore, had little time in which to display its practical use to the petroleum industry at large. When one recollects that Roumania's future, so far as the petroleum industry is concerned, lies in the direction of the building up of its already established export trade in petroleum products, the necessity for such a trunk pipe-line to the seaboard has been obvious for many years. Unlike the case of the United States, there are no interesting events to recall which delayed the advent of this new form of land oil transportation. There is only one oil pipe-line of any considerable length in the United Kingdom and this runs across Scotland from Old Kilpatrick (on the west) to Grangemouth (on the east coast), its terminal being in close proximity to the naval base at

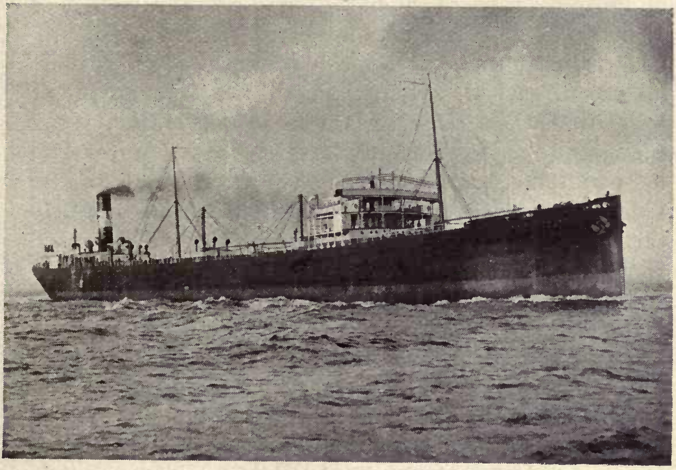
Rosyth. The line, which is 36 miles long, was laid to circumvent the activity of enemy submarines, but was only completed in November, 1918, after the conclusion of the European hostilities.

The one other important oil-pipe-line which calls for mention is that connecting the oil-fields of Persia with the coast. In this scheme, the British Government is heavily interested, and, though there has been much criticism of its action, there is no doubt that, in due time, the Persian fields will play an important part in the supply of petroleum products to England, and, in that connection, the Persian pipe-line must naturally prominently figure, since, without it, there would be numerous difficulties to be contended with in getting the oil to the coast.

The carrying of large quantities of petroleum products over the seas of the world is a subject which has taxed the minds of experts quite as much as that of land transport. For many years it was the rule to ship petroleum products overseas in the ordinary barrels (approximately, 42 gallons each) to the consuming countries. It was a costly business, for, apart from the initial cost of the barrels themselves, they took up a very considerable space on the vessels, which was not proportionate with the quantity of oils carried. Leakage also played a very important rôle in this ocean transport, and, generally, the principle left much to be desired. The *Atlantic* was doubtless the first vessel designed to carry petroleum in bulk from America, but records show that some years previously—in 1863—a Mr. Henry Duncan, of Kent, sent the first oil-carrying vessel to Europe. The vessel, however, never completed her voyage, for she was lost in the Gulf of St. Lawrence, just as she was starting on her trip across the Atlantic. The *Charles*—quite a small vessel—also played a part in the early days of bulk oil transport across the Atlantic, for this steamer was, I believe, the first to employ iron tanks for the bulk transport of petroleum. After these first few attempts to convey petroleum in bulk from continent to continent, tank vessels steadily wiped the barrel-carrying boats off the seas. It was found that not only did oils carried in bulk take up but one-half the space of those in barrels, but the cost of the oak-staved barrels themselves (usually 5s. each) was obviated. At first, sailing ships were adopted to meet the newer requirements, but later, vessels propelled by steam were introduced.

At first the shipbuilders had nothing to guide them in the shape of practical experience of bulk oil carriers, but, from small things, a great ocean trade in bulk petroleum products soon grew. It is interesting to note the enterprise which English shipbuilders displayed in this new method of handling petroleum for ocean transport, for during at least two decades the vast bulk of construction of oil carriers took place in English shipbuilding yards. The opening of the Far Eastern fields of production led to the construction of a large number of oil tankers—each of increasing size—for Messrs. M. Samuel and Company, and these were named after various shells. The fleet of "Shell" tankers to-day ranks as one of the finest in the world, and forms the connecting link between the prolific oil-producing properties of the "Shell" Transport and Trading Company, Ltd., in the Far East, and the demand for petroleum products in this and other countries, the vessels themselves being owned by the Anglo-Saxon Petroleum Company, Ltd., one of the influential owning interests in the wide ramifications of the "Shell" Company.

For several years the oil tanker *Narragansett*, owned by the Anglo-American Oil Company, Ltd. (London), held claim to being the largest bulk oil carrier in the world, for the good ship had a capacity of nearly 11,000 tons of products. The size of this vessel may be judged from the fact that she has a length between perpendiculars of over 510 feet, with a 63 feet beam, while her moulded depth is 42 feet. This vessel, which marked a distinct step forward in oil tanker construction,



ONE OF THE MAMMOTH TANKERS OF THE EAGLE OIL COMPANY'S FLEET

belongs to Lloyd's A1 three-deck class, and its cargo of oil is carried in sixteen huge tanks, eight of which are forward and the other half aft, the engines being amidships, as against those placed aft in many other oil tankers.

It was left to the enterprise of the Eagle Oil Transport Company—that important concern associated with Lord

Cowdray's immense oil organization for handling Mexican petroleum products—to make what will ever go down as the most bold policy of increasing the size of oil tankers by 50 per cent. upon all predecessors. Some six years ago, just when the Mexican fields were commencing to pour forth their flood of oil for the world's requirements, the Eagle Oil Transport Company included in its programme of activities the building of an immense fleet of oil tankers, and it was decided that a number of these should each have a capacity of 15,000 tons of petroleum products. There were many who asserted that the limit to the size of oil tankers had been reached, but, undaunted, the Company went forth with their policy. It was a bold stroke, yet a successful one, for not only have the vessels proved to be very practical, but they have taught a lesson in economy of ocean transport which has been seriously taken to heart by practically all engaged in ocean oil transport.

I had the honour of being one of the invited guests at the launch of the first of these gigantic oil carriers, and of subsequently experiencing a trip in the mammoth floating "tank." The vessel behaved admirably at sea, and in a chat with the designer, I recollect asking if there were any reason to believe that the limit in size had been reached. The reply was pointed: "So long as we can have loading and discharging berths large enough to enable such large vessels to be manipulated, we can easily go beyond the present size." Events have proved that the policy adopted by the Eagle Oil Transport Company was justifiable, for already a new oil tanker, the *San Florentino,* has been launched, having a capacity of over 18,000 tons.

Before leaving this interesting subject of ocean oil transportation, I should like to emphasize the distinct step forward which is marked by these latest oil tankers. To-day, we have entered the era when oil fuel has passed its experimental stages and become one of the greatest boons to those associated with the navigation of the seas. The ease with which oil fuel is handled is remarkable, for vessels of the largest size—that is, those using oil instead of coal for power purposes—could replenish their stores within a few hours at any oil port. In the transport of petroleum by the modern tankers, the taking on board of a full cargo is accomplished in about a single day, thanks to the most improved means of pumping oil from the shore tanks through flexible pipes. The great oil tankers trading between this and other countries and Mexico, load up off the Mexican coast by means of a submarine pipe-line, and, reckoning but fourteen return trips per annum, it will easily be apparent what immense stores of petroleum can with ease be brought to the centres of consumption. Compare this with the primitive methods of transport in barrels, and it will be readily seen with what rapidity the hands of progress have moved during comparatively recent years.

The vast majority of oil tankers to-day, true to their calling, derive their power from oil, for they burn it under their furnaces, and, therefore, are not liable to those tedious delays so inseparable from the use of coal, and should severe storms beset their passage in Mid-Atlantic, then a little oil pumped overboard will quell the most turbulent sea and permit a safe passage onward.

CHAPTER VI

PETROLEUM AS FUEL

So much has been written of late as to the use of petroleum as fuel for the purposes of steam-raising, that the reader is bound to be more or less *au fait* with the subject. It is, of course, one of vast importance, and during the next decade is certain to receive far more consideration than it has hitherto done, owing to the general desire that our coal wealth shall be conserved as much as possible. Given the one allowance that oil fuel can be procured at anything approaching a reasonable figure—and there is no reason why, in normal times, this reasonable price should not be prevalent all over the world—then petroleum offers many advantages over its older competitor, coal. The ease with which large quantities can be handled, the simple method of operating anything which is fired by petroleum as fuel, and the fact that its heat-giving units are far higher than those of coal, will ever be the chief factors governing its popularity.

Many years ago, fuel oil made its serious début, but at that time the supply of the product was very uncertain, and, consequently, progress in passing from the old to the new form of power-raising was slow. To-day, however, matters have materially changed. The crude oil output has been immeasurably increased, and many fields whose production of crude oil is essentially suited for fuel purposes have been opened up. In this respect, the oil-fields of Mexico have no parallel, and it is recorded that, once these fields are provided with adequate storage and transport facilities, they can easily supply the whole of the fuel oil necessary for the world, and at the same time have immense quantities to spare.

But, though the subject of petroleum as fuel has aroused much attention for some years, there is still an erroneous idea prevailing as to what really is fuel oil. A word or two on this question will, therefore, not be without interest. Fuel oil is that portion of crude oil which is incapable of giving off by the process of ordinary distillation those lighter products of petroleum known as motor spirit, illuminating oils, or lubricants. It is, in a word, the residue of distillation which is unsuitable for refining purposes. It represents a black, tarry liquid, and is, of course, minus those fractions that go to produce the refined products. Many there are who refer to crude oil as fuel oil, but this is a misnomer, though crude oil, in many instances, is utilized for the purposes of fuel. In this chapter, however, when I speak of fuel oil, I am referring not to the crude oil as it comes from the ground (and which has a comparatively low flash) but to the article of commerce, the residue of distillation, which is the real article—fuel oil.

The headway which fuel oil has made during the past few years has been remarkable, though it is safe to say that its general use is still in its infancy. In no matter what capacity it has been tried as a heating or steam-raising agent, it has proved itself capable of withstanding most successfully the most stringent tests, and has convinced all who have given the question serious consideration that it holds numerous advantages over coal, yet has no drawbacks. Perhaps the most recent impetus which has been given to the use of fuel oil is that following the introduction of it, and now its general adoption, throughout the units composing the British Navy. On land, however, it has for some years achieved marked distinction. Especially is this the case in regard to its use on locomotives, the United States railways alone consuming last year over 6,000,000 tons of fuel oil. In the realms of industry, fuel oil, too, is claiming the attention of those large industrial establishments, and to-day is largely used for creating intense heats, such as are necessary in hardening, annealing, melting and smelting, rivet heating, glass-melting, etc.

Let me first of all refer to the use of fuel oil for marine purposes. Following the decision of the United States Navy, which some time ago definitely abandoned the use of coal in all its new fighting ships, the British Admiralty, too, has cast its voice in favour of fuel oil. To-day, a very large number of battleships, cruisers, and torpedo boats of the Navy are fitted to burn liquid fuel, the first battleship exclusively to burn oil being the *Queen Elizabeth*, and, with the increase in our naval strength, so will fuel oil be adopted. The Continental Powers have also gone, more or less, over to oil, and the fact that all new sea fighters are designed to run exclusively on fuel oil is itself suggestive that the new fuel has already outclassed coal for naval purposes.

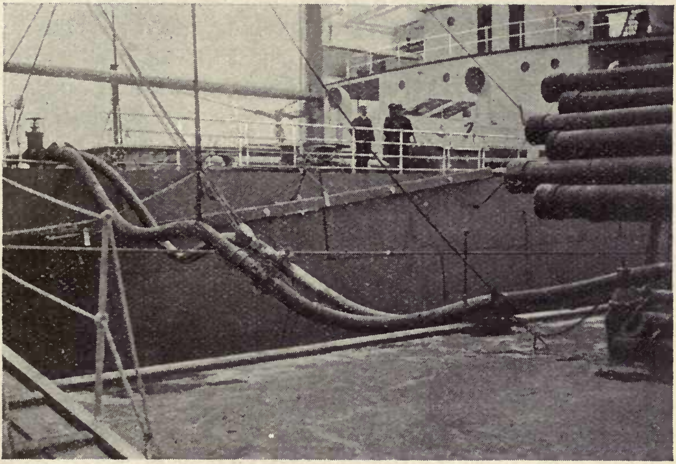
There are, of course, many reasons which have commended fuel oil to the naval experts as a substitute for coal. In the first place, inasmuch as one ton of fuel oil is equal to more than one-and-a-half tons of coal, the radius of action of units fitted for utilizing fuel oil is increased over 50 per cent.—I speak from the point of view of bunker weight. Again, one ton of oil occupies considerably less space than an equivalent weight of coal, while this advantage can be materially increased—as is now the usual practice—by carrying the fuel oil in double-bottom tanks. Then the bunkering question is one of vital moment. Fuel oil can be taken on board under far cleaner conditions, and at a greatly accelerated rate, than would be possible with coal. There is no arduous manual labour required. Once the hose connections have been made, the fuel oil is pumped on board at the rate of hundreds of tons an hour, and a few hours suffice to re-fuel our largest battleship. But it is when bunkering at sea is required that fuel oil further emphasizes its immense advantages. This question was some years ago one of the problems of naval strategy: to-day it is regularly carried out in the simplest possible fashion, hose connections to a standing-by oil tanker being all that is required.

Another advantage of fuel oil is that materially increased speed can rapidly be attained, for, with fuel oil fired furnaces, the ship's boilers can be forced to nearly 50 per cent. above normal rating without that great strain on the personnel which would be essential in burning coal under forced draught. Then there is the great saving of labour effected when burning fuel oil, the stokehold staffs being reduced by quite 80 per cent. The fuel oil is automatically fed to the furnaces and mechanically fired, the maximum heat of the oil burners being attained within a few minutes of starting. But the absence of smoke when the battleship is proceeding at full speed is, perhaps, one of the most important advantages which the use of fuel oil gives to the units of the fleets employing it. The emission of dense volumes of smoke, which are ever present on a coal-fired vessel, is quite absent when fuel oil is used, and this advantage is twofold, for not only does it prevent the giving away of the location of the battleship, but it also renders its own gun-fire more efficient.

The advantages attendant upon the use of fuel oil for naval vessels are, in the main, also strikingly apparent when oil is adopted for the mercantile marine.

It is many years ago since the oil tankers of the "Shell" Transport and Trading Company, Ltd., commenced to do the voyage regularly from the Far East to this country and back without an intermediate port of call. To-day, practically every oil tanker afloat burns fuel oil. But, of recent date, fuel oil has reached wider application by reason of its being adopted on many cargo and passenger vessels, and, had the European War not considerably hampered ordinary shipbuilding construction, we should have seen ere this a number of the largest vessels crossing the Atlantic exclusively running on oil. In fact, arrangements have been made whereby many of our Transatlantic lines will operate exclusively on fuel oil, which will be taken on board in the United States.

My friend, Mr. J. J. Kermode, of Liverpool—the well-known fuel oil expert—has taken the most prominent part in calling general attention to the immense superiority of fuel oil over coal, and it is due to this gentleman's untiring energies that not only does our Navy to-day use fuel oil to such an extent, but that those responsible for ocean passenger transport have taken the matter up so seriously. There are three general headings under which fuel oil use will affect transport costs. They are as follow: (*a*) by increased passenger or cargo capacity, (*b*) by increased speed, and (*c*) by a great reduction in running costs. As to the increased capacity, I have already shown that fuel oil can be stored in considerably less space than coal, and the simplicity of both bunkering fuel oil, and using it on vessels, has also been touched upon. With reference to the increased speed which vessels utilizing fuel oil can attain over those running on coal, I have a concrete example in front of me. Two sister ships of the Eagle Oil Transport Company—the *San Dunstano* and the *San Eduardo*—each of 9,000 tons deadweight capacity, are fitted to burn coal and fuel oil respectively. Upon a trip carried out under careful observation, the weight of fuel consumed worked out as two to three in favour of fuel oil, while the indicated horse-power developed showed an 18 per cent. improvement in the case of the oil-fired vessel. But the striking fact of the comparison is that the *San Eduardo* made the round



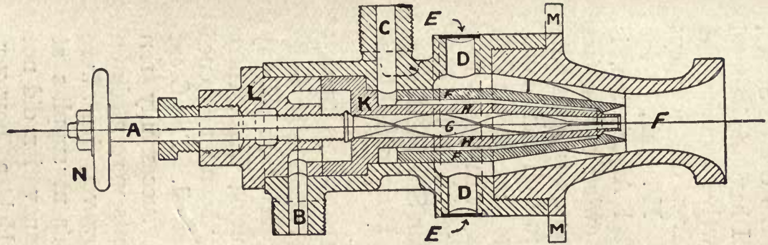
TAKING OIL FUEL SUPPLIES ON BOARD

voyage to Mexico—out and home—eight days quicker than the other, this additional speed being solely due to the fact that with fuel oil it was possible to maintain consistent speed throughout the voyage—an impossible matter when coal is consumed. If space permitted, I could enumerate many cases where the results in favour of fuel oil are even more strikingly apparent, but

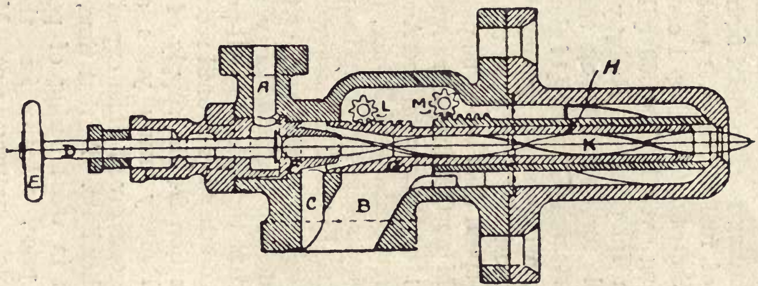
I will content myself by briefly referring to calculations made by Mr. Kermode, based upon voyages of our largest liners: they are sufficiently interesting and suggestive to record here. On an average, says Mr. Kermode, to maintain a speed of 25 knots, 5,500 tons of coal are consumed upon the voyage between Liverpool and New York by one of the mammoth liners; or 11,000 tons for the round trip. Some 3,300 tons of fuel oil—which could be stored if necessary (and as will frequently be done in the future) in the double bottom of the vessel—would, by automatic stoking, do even more work than 5,500 tons of coal. Calculating the daily consumption of 600 tons of coal now used for 24 hours, this represents about 2,000 tons less fuel on a five days' trip, land to land run, or 4,000 tons less, out and home. The utilizing of the vacant space thus saved for merchandise would bring in a very handsome income. Of the 312 firemen and trimmers now employed for a coal-fired liner, 285 might be dispensed with, and occupation found for them under healthier conditions ashore, say in handling the additional cargo which would be carried. The saved accommodation in this respect could be allotted to third-class passengers, of whom at least another 250 could be carried. Our mammoth liners are fitted with 192 furnaces in order to produce 68,000 horse-power (as was the case of the *Mauretania* and the *Lusitania*), and, on the assumption that thirty-two fires are cleaned every watch, 10,000 indicated horse-power is lost every four hours through burning down and cleaning, a quite unnecessary operation with fuel oil. Figures such as these show the startling possibilities of fuel oil for marine purposes.

But it is on land, as well as on sea, that we find fuel oil rapidly making headway, for, as far back as 1889, hundreds of the Russian locomotives went over to the

TYPICAL LIQUID FUEL BURNERS



THE KERMODE STEAM BURNER



KERMODE'S AIR JET BURNER

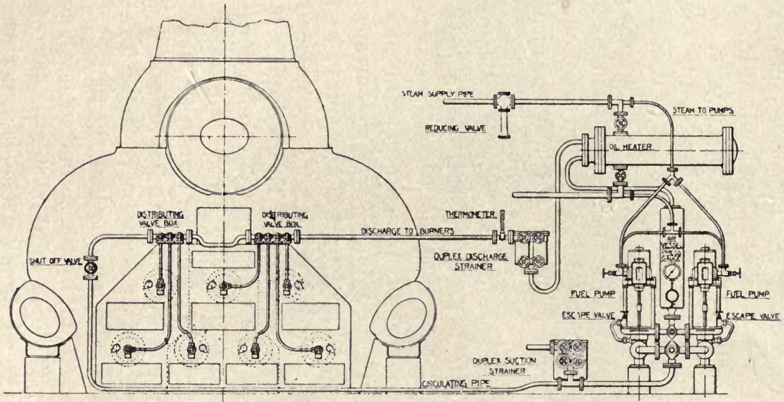
In the steam burner, the oil enters through B, the valve G giving it a whirling motion. The steam goes round the cone A. *F* is the air cone, the amount of air being adjusted by the openings D by means of a perforated strap E. In the air jet burner the oil enters at A. The previously heated air enters at the branches B and C, and as the air passes C it meets the oil as it passes the control valve operated by E.

burning of a petroleum residue. This was the first practical application of fuel oil for railway haulage. To-day, nearly 50,000,000 barrels of fuel oil are consumed annually by the various railroads in the United States, and, according to the official figures I have of the total mileage of fuel oil for the past twelve months, the United States oil-burning locomotives did journeys aggregating over 145,000,000 miles. Mr. Hall, of the American International Railway Fuel Association, is responsible for the statement that, owing to the fact that the steaming capacity of the engines is materially increased, a locomotive running on fuel oil can haul a load of considerably greater tonnage and at a much increased speed than would be possible with a coal-fired engine. Many Continental railways use fuel oil rather than coal; the Roumanian and Austrian State Railways, the Western Railway of France, the Paris and Orleans Railway, being a few of the principal.

So far as England is concerned, the use of fuel oil has not made great headway, for the reason that, while on the one hand, the majority of our great railway systems pass through the coal-producing fields, there has, on the other hand, until recently been an absence of organization for the supply of fuel oil. The Great Eastern Railway many years ago successfully ran oil-fired locomotives, while experiments were made on several other lines. At that time, however, there were difficulties in the securing of permanent supplies at moderate price, and therefore the innovation did not receive much encouragement. Mr. Holden, however, successfully demonstrated that fuel oil is a very practical proposition for the British railways.

In our industrial life of to-day there are a vast number of instances where fuel oil is rapidly displacing coal: the oil-fired furnace has been brought to a stage of

OIL FUEL FOR MARINE PURPOSES



Arrangement of heaters, filters and pumps for burning oil fuel for marine purposes. The installation is that of the Wallsend-Howden pressure system.

perfection, and is being extensively and increasingly employed both in this country and abroad in regard to metallurgical and industrial processes. Without going into detail respecting the numerous spheres in which the new fuel finds profitable employment it is safe to say that these are being extended every year.

A wealth of inventive effort has been bestowed in the perfection of the burners employed to consume fuel oil. Leaving aside for the moment the principles governing the use of oil in the internal combustion engines of the Diesel or semi-Diesel type, fuel oil used for the production of power is introduced into the furnace in the form of a spray, this being accomplished by atomizing the oil in its passage through a specially designed burner. Of these burners, there are numerous makes upon the market, each of which possesses its own characteristics and advantages. The one feature common to all fuel oil burners is the arrangement for atomizing the oil fuel into a fine spray, so that each particle of fuel shall receive sufficient oxygen to ensure its complete combustion. Theoretically, it requires about 14 lb. of air to effect the combustion of 1 lb. of oil, and on the thorough combustion of the fuel oil depends the efficiency of the furnace. There are three distinct methods by which the atomization is brought about, and each of these means possesses its advantages and limitations. By one method, the fuel oil is atomized by the use of steam; by the second method, compressed air is used; while a third system—that of applying pressure to the oil supply itself—is sometimes adopted. Steam is the method usually employed for stationary boilers and locomotives, for it is the simplest to manipulate, and does not call for the employment of auxiliary apparatus in the shape of air compressors or oil pumps, but most industrial oil furnaces work on compressed

ALLDAY'S PORTABLE OIL BURNER: DRYING A MOULD air, which gives exceptionally good results. There is no doubt that, with the use of compressed air, say admitted at a pressure of 80 lb., a saving in fuel oil is shown over using steam at similar pressure, but the cost of the compressing plant, which must be taken into consideration, is sufficient to wipe out the greater part of this advantage.

With respect to the use of the fuel oil direct under pressure, this system generally involves the heating of the fuel oil, as well as its filtration, the fuel being supplied under pressure by means of pumps. The system is extensively employed at the present time on marine boilers operating with forced or induced draught, and, in this connection, the Wallsend system stands pre-eminent.

CHAPTER VII

PETROLEUM AS A LIGHTING AGENT

FROM times immemorial, petroleum has been utilized as a lighting agent. Fifteen hundred years ago we have records of its use in the Far Eastern countries, and in the seventh century one of the Emperors of Japan ordered that his temples should be illuminated by the sacred oil light. And from that long distant date to the present times, petroleum has played a not insignificant part in the provision of artificial light throughout the world. For centuries, petroleum, as a means of artificial light, had the field to itself, and, though the Ancients consumed large quantities for lighting purposes, the apparatus used for burning the oil were of a most primitive type, giving results which to-day would be considered far from satisfactory.

About the middle of the last century, when the petroleum industry was making steady advance in several European countries, and a little later, when the United States entered upon its era of oil progress, there was marked development in the use of oil for lighting purposes. The more modern oil lamp was introduced, and it is worthy of record that in one year alone over fifty patents were taken out in the United States for oil lamp improvements. The Germans, too, were not behind in this respect; in fact, it is very largely due to the numerous German improvements that the general governing principles of present-day oil lamps became so popular.

There is no doubt that the ordinary oil lamp has often been, and still is, unjustifiably condemned for certain defects which are not inherent in it. It necessarily demands attention if it is to give a satisfactory light, but, unfortunately, this attention is not adequately bestowed upon it, and complaints are the result. I have frequently argued that, just as it is possible with inattention to make the most improved pattern of oil lamp operate unsatisfactorily, so is it possible, with a little care and common sense, to get a really good and satisfactory light from the cheapest oil lamp obtainable.

In days gone by, the quality of the oil was, in many cases, unsuitable for burning in the ordinary lamps; its lighting power was very inferior, and it gave off a distinctly unpleasant smell. To-day, however, the illuminating oil sold throughout the world is a first-class article, and its flash-point has been so raised that it can be used freely without there being any suggestion of its lack of safety. One still hears of the "dangerous" paraffin lamp, but, to all intents and purposes, whatever danger was attendant upon the use of oil lamps has long ago departed, though, of course, care must always be exercised, a remark which naturally applies to every illuminant. It is not within my province to give a series of hints to the ordinary user of illuminating oil, but it is well to draw attention to a point which is frequently overlooked: that is, to see that lamps should be kept well filled. It has been established that the light from an oil lamp is greatly affected by the quantity of oil in the reservoir. An increase of 20 per cent. can be secured in the illuminating power of the lamp if only the oil is kept to a good level in the container. This is due to the assistance given to the capillary action of the wick by the higher level.

The advent of gas, and, at a later period, electric current, for illuminating purposes has, to an extent, restricted the use of oil as an illuminant, yet the reader will be surprised to learn that at least 2,000,000 oil lamps are nightly lighted throughout Great Britain. The inhabitants of the majority of our villages have to fall back upon oil lamps after nightfall, and even in remote spots where enterprising gas companies have laid gas mains large numbers still keep faith with oil, no doubt by reason of its cheapness in normal times.

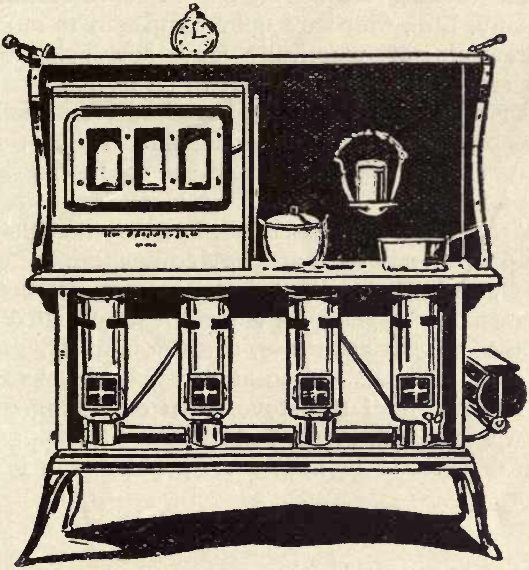
The greatest improvement made in regard to oil lighting has been in connection with the introduction of the incandescent mantle. As a result of this innovation, several elaborate designs of lamps have been placed on the market, and to-day oil is frequently used in large residences in preference to the more modern illuminants. This is due, without doubt, to the fact that oil light is particularly soft, and, while giving a great illuminating power when consumed under the best conditions, lacks that dazzling brilliancy which causes injury to the eyes.

One of the earliest methods of utilizing petroleum under an incandescent mantle was the Kitson system, according to which illuminating oil is compressed to about 50 lb. per square inch in a suitable vessel, forced through a soft brass tube of very small bore into a heating chamber, and, subsequently, through a needle orifice to a Bunsen burner. The Kitson system, which has found many adherents in the United Kingdom and abroad, is particularly adapted for lighthouse illumination, and in such cases where large units are essential. It is interesting to record the fact that for some time one of London's main West-end thoroughfares was illuminated by incandescent oil lamps, and, though they are now superseded, no tangible reason was given as to why these highly economical means of illumination were ever removed.

Space forbids my referring to the various designs of oil lamps on the English market to-day: they may be counted by their hundreds, while still a larger number of those which have either been unsuccessful or have found no sale may be found in the records of the Patent Office.

During comparatively recent times, devices have been brought forward whereby remarkably good results have been achieved by the use of gaseous vapour for portable lamps. In these cases, motor spirit is vapourized and used under an incandescent mantle. The best known of these lamps is the "Petrolite." In this lamp, a porous stone is impregnated with suitable hydrocarbons—motor spirit—and a current of air is introduced, the necessary draught being provided by the use of a fairly long chimney. The great advantage of the "Petrolite" lamp is that of its perfect safety, for if by any chance the lamp becomes overturned and the chimney displaced or broken, the draught ceases, and with it, the generation of the inflammable vapour; the lamp, therefore, immediately going out.

But while this method of utilizing motor spirit for illuminating purposes has been adopted to a very large extent by means of portable lamps, a greater field has been developed both in this and other countries in connection with the domestic and industrial use of petrol air-gas for lighting purposes. These apparatus in the main possess but slight differences. The essential principle of each is that motor spirit is carburetted and then, in the form of an oil gas, conducted through pipes in the same manner as coal gas is burned, to the rooms in which it is required. The carburetted air-gas is automatically produced, and the small cost at which these automatic plants can be supplied has rendered this system of lighting deservedly popular. Its great economy also is an important point, for 1 gallon of motor spirit will yield almost 30 cubic feet of vapour, This vapour, in order to form a lighting agent, is mixed to the extent of over 98 per cent. air and less than 2 per cent. petrol vapour, so that 1 gallon of motor spirit will produce, approximately, 1,500 cubic feet of air-gas. The plants, which are usually worked by a



THE ANGLO-AMERICAN OIL COMPANY'S OIL COOKER

small hot-air engine (or, alternately, by the use of weights), supply only the demand created, and their control is automatic perfection.

To-day, petroleum plays quite an important part in heating arrangements, and several stoves are upon the market which burn the ordinary illuminating oil. The prettily designed heating stoves of the "Perfection" or " Reform " make are largely in use, the efficacy and economy of these being responsible for their popularity. Various makes of oil cookers are also in large demand. These range from the small variety like the " Primus " stove, which burns illuminating oil under pressure, to the oil cooking stoves of the Anglo-American Oil Company, Ltd., which are quite competent to meet the requirements of practically any household. These latter stoves consume illuminating oil by means of the circular wick arrangement, and are in several sizes, one of the best being that containing three lighters. Two of these are under the oven, and one at the end can be used for boiling purposes. Speaking from several years' experience of these stoves, I can say that they are truly perfection. They are very economical, are easily cleaned, and when in full operation give off not the slightest odour. The oven is more readily heated than with the coal gas apparatus, and the properly diffused heat cooks all kinds of food most readily and perfectly. The illustration of the stove given on the preceding page will afford the reader a good idea of the apparatus, which deserves to be even more popular than it is at present.

CHAPTER VIII

INTERNAL COMBUSTION ENGINES

In no other sphere of employment has petroleum made such rapid strides during the past two or three decades as those recorded in connection with its use in internal combustion engines, and one of the most interesting features of modern mechanical engineering is their development. The advent and immediate popularity of this kind of engine has been responsible for some of the most remarkable conquests of mankind over the forces of Nature, for it has brought into being the automobile, the aeroplane, the dirigible airship, and that multiplicity of craft—submarines—which are to-day playing such a vital part in moulding the destinies of nations. It has also been responsible for quite a new departure in ocean power production, and has opened up an era, the immense possibilities of which cannot readily be appreciated.

It might, by way of introduction, be well to explain for the benefit of the uninitiated, the meaning of the term " Internal combustion engine." As most of my readers are well aware, the steam, or, rather, to be exact, the highly heated water vapour which drives the steam engine, is supplied from boilers which are heated by the burning of coal, oil fuel, or, sometimes, gas, and such engines might, therefore, be called " external combustion engines," since the fuel is consumed in apparatus external to the engine proper. Such a term, however, is not in use amongst engineers, and might raise a superior sort of smile if used in their presence. It will be readily seen from the foregoing that a great deal of weight and apparatus of some complication is required before the water vapour which drives the steam engine can even be provided.

In the case of the internal combustion engine, the fuel (motor spirit or the heavier oils) is introduced directly into the engine and there vapourized and mixed with air so as to form an explosive mixture, so that all boilers, with the necessarily complicated systems of piping, etc., are done away with. It needs no imagination to understand the enormous saving of weight and space resulting from this elimination of the boiler, and of the room which it would occupy.

The latter-day demands for the provision of lighter and yet lighter, as well as space-saving propelling machinery for submarines, airships, aeroplanes, motor-cars, etc., especially during the war, have enormously stimulated the development of the engine which consumes its own fuel, and which is known as the internal combustion engine. A very wide field has thus been opened out for the exercise of the engineer's ingenuity, and he has availed himself to the full of the opportunities thus created, never failing to rise to the occasion when fresh demands have been made upon him.

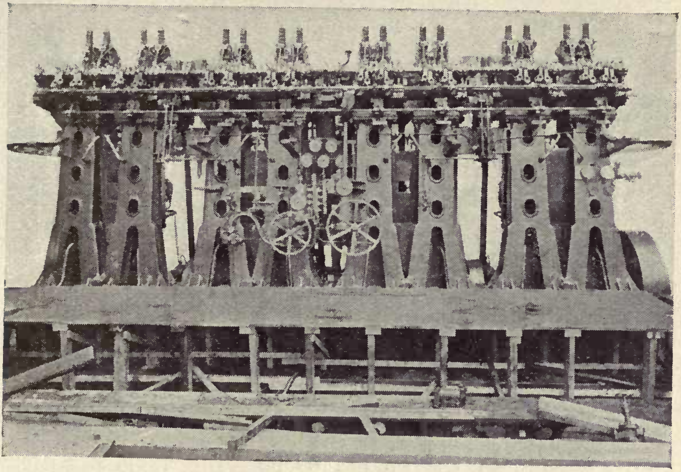
In these circumstances, it is not at all surprising to find that numerous firms have given considerable attention to the manufacture of the internal combustion class of engine, and many varieties, for a multiplicity of purposes, are upon the market. The limits of space effectively prevent my detailing the list of even the largest manufacturers; I will therefore content myself by referring to but one firm—Messrs. Vickers, Ltd.—who are now the largest manufacturers in the Kingdom. This progressive firm has grappled with the internal combustion engine problem from the earliest stages of the petrol engine to the latest forms of the heavy oil engine and its remarkable developments, and a large section of their establishment at Barrow-in-Furness is, and has long been, set aside exclusively for the design and manufacture of the heavy oil internal combustion engine. A very large staff of expert engineers has been selected for the work, while experiments with a view to improvements being effected in details are continually being conducted in the establishment. The result is that the development of this engine at the Barrow works has been attended with the highest success, a fact which is not widely known to the general public.

I take it as a great compliment that permission has been given me in this book to refer somewhat in detail to the achievements of Messrs. Vickers, Ltd., in this respect, for, hitherto, publicity in connection with this section of the firm's operations has been strictly withheld. One of the latest and, it might well be said, the most important developments in connection with Messrs. Vickers' activities, is the Vickers patent system of fuel injection, which enables an engine of the Diesel type (that is, using heavy oil) to be successfully run without the use of an air compressor for injecting the fuel into the engine. Before the introduction of this system, an air compressor, with its attendant complication and weight, had to be used for the introduction of the fuel into the engine. The elimination of this compressor has resulted in considerable economy in weight, space, and attendance, which, it will readily be seen, is a step in the right direction, whilst the efficiency of the engine has also been improved. The disadvantages attendant upon the use of the air compressor were early comprehended by Messrs. Vickers, and they have spared no efforts (nor expense) in developing the system which has led to its elimination.

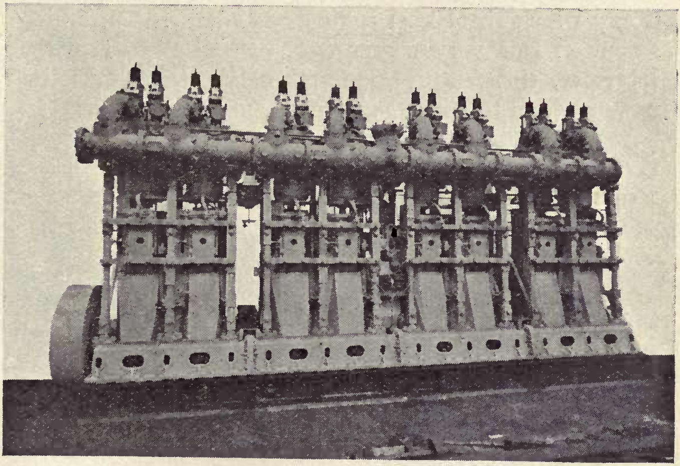
The reader will require no knowledge of the subject to understand that the question of fuel consumption is one of the highest importance in any engine system, and, in regard to this point, Messrs. Vickers have made a special study, with the result that whilst the ordinary consumption in a Diesel engine with air compressor is ·41 lb. brake horse-power an hour (or 184 grammes *par force de cheval*), that firm have been able to reach the low figure of ·376 lbs. B.H.P. an hour (or ·170 grammes *par force de cheval*).

As one might expect, Messrs. Vickers, in bringing their engine to its present state of perfection, have, perforce, had a varied experience with fuel oils—and a considerable one, too,—for they have experimented with oils from all the well-known producing fields, and find that, under their system, practically any fuel oil which can be made to flow may be utilized in their engines—a fact which, in its importance, speaks for itself. The physical properties of the oils used by them have, naturally, differed very considerably. For instance, specific gravities have varied from ·810 to ·950 flash points from 100° Fahr., to upwards of 250° Fahr., whilst the viscosities, which the lay mind might well be excused for thinking of as "degrees of stickiness," have varied from that of the ordinary kerosene (illuminating oil) to the thick asphaltic fuel oil which comes from Mexico. Readers may judge from this of the painstaking and difficult experiments that have been carried out in the Barrow works.

The advantages derivable from the use of the Vickers system could not, obviously, be withheld from general use, and the firm have upwards of twenty licensees now manufacturing internal combustion engines under their designs. This fact, though not familiar to "the man in the street," is known in the manufacturing world.



900 B.H.P. LOW DUTY VICKERS ENGINE FOR OIL TANK VESSELS



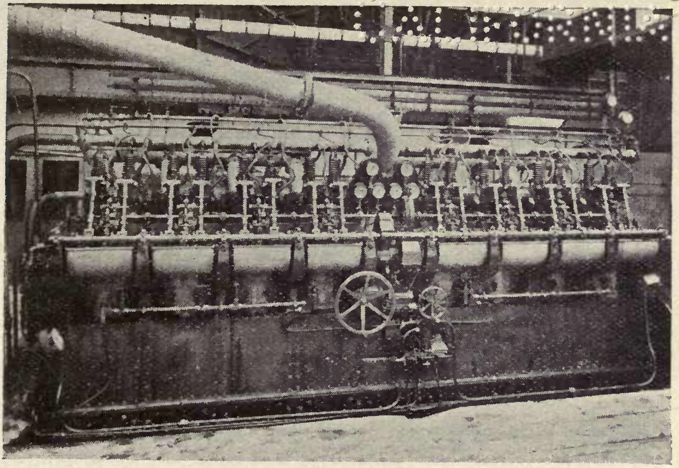
BACK VIEW OF ENGINE

Already a very large number of their engines have been constructed, the approximate brake horse-power produced by same being upwards of 337,600. These engines are of various sizes, ranging from 200 to 2,000 horse-power. The cylinders vary in diameter from 10 to 29 inches, and are arranged to work in groups to suit the power required, and may be either two-stroke or four-stroke cycle. The high temperatures set up in starting the engine are sufficient to ignite the fuel, the introduction of which in a finely-divided condition has been the object of so many experiments at Barrow; and so successful in this direction have Messrs. Vickers been that they are now able to deal satisfactorily, by careful adjustments of the engine to suit the various fuels, with the most troublesome oils.

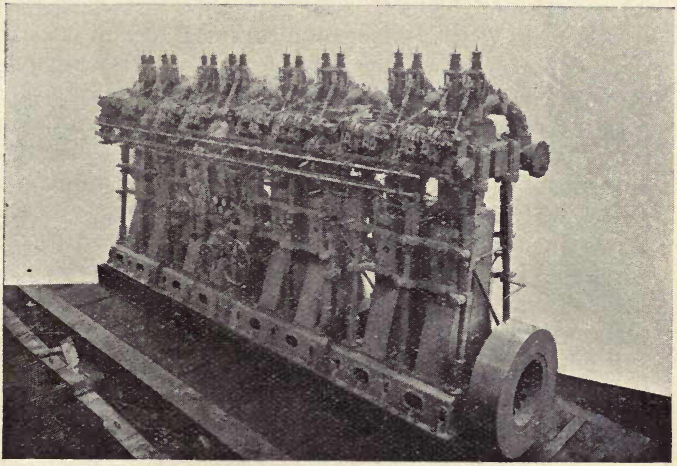
As already referred to, the elimination of the air compressor constitutes the chief improvement embodied in the Vickers type of engine, seeing that the greatest worry which the Diesel engineer has had to encounter has been this very compressor. Needless to remark, therefore, this feature alone strongly recommends the new system to the experienced man. Further, the power required to drive the compressor above-mentioned is considerable, so that economy is not one of the least results due to its absence.

The principal advantages that can be claimed for the Vickers engine may be summarized as under—

1. Safety in working. (Many accidents have been due to the use of the air compressor.)
2. Weight is saved.
3. Space is saved.
4. Lower air compression in the cylinders for ignition, and economy in air for starting the engine.
5. Reduction in first costs; and
6. Reduction in upkeep expenses.



900 B.H.P. HIGH DUTY REVERSING ENGINE FOR LIGHT CRAFT



1,250 B.H.P. LOW DUTY VICKERS MARINE ENGINE FOR OIL TANK VESSEL

With regard to (4), the low compression claimed is rather interesting, as Messrs. Vickers have successfully demonstrated that, although a high compression temperature is necessary in the ordinary Diesel engine with the usual air spraying compressor, a much lower degree suffices for their mechanical injection system, whilst there is a greater certainty of ignition of the fuel on its first introduction, even with the existence of lower compression in the cylinder. The reason of this is that the spraying air used in the ordinary Diesel is usually compressed to about 60 atmospheres (900 lb. per square inch). What happens when air spraying is practised is this. When the cold air carrying the very high pressure above mentioned enters the cylinder, it necessarily expands, owing to the lower temperature already existent there, and such expansion chills the whole mixture, frequently preventing ignition on the first introduction of the fuel.

Under the Vickers system of mechanical fuel injection, there is, of course, no introduction of very highly compressed air, and, consequently, first ignition is rendered easier. From this, it will at once be seen that an oil possessing a high flash point can be more easily burned in the Vickers engine than in the ordinary Diesel, with the necessary adjunct of an air compressor. Provision is also made (should the type of fuel used require it) for a higher temperature of compression, and such oils are, therefore, much more easily dealt with than in the ordinary Diesel engine.

From what I have already said, it will be evident to the reader that it is only a question of time for air spraying, with its attendant use of the compressor, to become a thing of the past.

The mechanism involved by the adoption of the new system of fuel injection developed by Messrs. Vickers is exceptionally simple. It consists of a small fuel pump, such as is ordinarily used for pumping fuel, a reservoir or accumulator of novel form to retain the charge, and a valve with a special nozzle to admit the fuel in the form of a fine spray into the cylinder. The accumulator, I may here mention, is merely a tube, flattened slightly on the sides, and of sufficient length, when the oil is forced into it, to enable it to yield and store up a charge of fuel at the required high pressure, as explained in the next paragraph.

The principal feature of the system (and the secret of its great success) is the very high pressure at which the oil is injected into the cylinder. This pressure is kept up at about 4,000 lb. the square inch, so that the oil fuel, when it enters the cylinder and encounters the hot compressed air therein, is in the form of a very finely atomized mist, a conjunction of circumstances most favourable for ignition. As in all great inventions, the simplicity of the arrangement is not the least of its merits.

This somewhat rough, yet brief, outline will suffice to explain the astonishing success of the Vickers heavy oil engine, but, if the whole history of these (and other) noteworthy experiments could be written, a highly interesting story would be produced, showing indomitable perseverance in the face of discouragement, difficulty, and very heavy expense.

I have avoided touching upon the ordinary kerosene engines, for I imagine they are too well known to need more than passing reference here; nor have I gone into the details concerning the advent of the ordinary Diesel engine, which was a German invention.

I have preferred rather to deal with a British invention which is already revolutionizing oil engine construction generally, and which, obviously, has limitless fields open to it.

CHAPTER IX

PETROLEUM IN ENGLAND

THERE will be no chapter in this little treatise which will be more carefully perused than the present one, for the subject is of direct interest to every reader, whether actually associated with the search for oil or not. To-day, as I have already mentioned in another chapter, this country is dependent for practically the whole of its petroleum requirements upon foreign oil-producing countries, and though ample evidence is forthcoming to suggest that there are possibilities of obtaining liquid oil in England—in fact, many years ago this was actually obtained in not inconsiderable quantities—it is very strange that only recently have serious efforts been made in the direction of systematic search for the valuable liquid.

That large quantities of petroleum can be produced in this country is agreed by all who have given the subject more than passing thought; the question is, by what means shall this production be brought about. While it is somewhat problematical as to the amount of success which will attend the present search for liquid petroleum, though those who are most competent to judge believe that large stores of liquid oil will be found, it is already certain that there are vast possibilities in England for the production of petroleum from the treatment of the bituminous shales which freely abound in many parts.

It will be seen, therefore, that the subject really divides itself under two heads, and it is with the first of these—that of the possibilities of finding liquid oil reserves in commercial quantity in this country—that

I will now proceed to deal. For this purpose, it is better that we divide the country into three zones—western, middle, and eastern. The western zone will include the whole of England between the third meridian of West Longitude and the Irish Sea, the Bristol Channel, and the North Atlantic. It will be bounded on the north by a line running near Whitehaven to the mouth of the River Tees, and having the English Channel as its southern boundary. In this zone, the most northern occurrence of petroleum is found at Whitehaven, Cumberland, and the next is found on the Lancashire coast. Other indications are to be found in Denbighshire and in the northern part of the South Wales coalfield.

The occurrences of petroleum in what may be described as the middle zone are far more important and numerous than those of the western zone. They are important in the physical conditions to which they are subordinate, and in their greater productiveness. They are more numerous, and their geological position is more in direct relationship with later dynamical alterations in the rock structures. In this zone occurs the most important occurrence which has so far been recorded—I refer to that at Alfreton, in Derbyshire—for it was from this natural flow of petroleum over 70 years ago that Dr. Young, the founder of the Scottish shale oil industry, manufactured paraffin wax. Near Chesterfield is also unmistakable evidence of the presence of liquid oil at depth, for considerable quantities have flowed from the workings at the Southgate Colliery. In this middle zone, too, are the occurrences of petroleum found near Wigan and West Leigh, while flows of oil are recorded from several spots round Barnsley and Ilkeston. The petroleum find at Kelham, near Newark, some few years ago, is important for the reason that the drill in this case, at a depth of somewhere about 2,400 feet, struck true petroliferous sands, underlain by dark, waxy shales. The oil rock has been proved to consist of loose, coarsely grained sand, having all the features of strata in which petroleum is ordinarily met with. The great value of this boring is that it has demonstrated the fact, so long doubted by many of the best geological authorities in Great Britain, that all the geological conditions, dynamical as well as historical, are present in this locality for the formation and subsequent retention of liquid petroleum, and that, as Mr. William Forbes-Leslie puts it, despite all contention to the contrary, a true oil-field exists in England.

So far as I am aware, however, North Staffordshire alone, among all the places in England, has the distinction of so far having produced liquid petroleum in sufficient quantity for refining purposes. It was in 1874 that oil was discovered in a seam of coal in one of the pits of the Mear Hay Collieries, Longton, and a contract was ultimately made with a Mr. William Walker, Senr., of Hanley, who erected plant at Cobridge for the purpose of refining the oil. I am indebted to Mr. Walker for the following facts, though in a general way I have full corroboration for them, for it was within a couple of miles from the collieries that I was born and spent my earlier days. The seam of coal wherein the oil was discovered was one of the deeper seams, and by no means one of the best in the district. At that time, the flow produced more than 5 tons of crude oil per week, and inasmuch as England then was not inundated with American petroleums, great possibilities were seen in the discovery. But almost before the refining of the crude had settled down to be a commercial undertaking, the plans of operation were upset, for a serious explosion occurred at the colliery, which rendered necessary the closing of the pit. Twelve months later, however, they were re-opened, and after the re-sinking had proceeded awhile, the oil was found far up the shaft, and in due course the shaft was cleared and the mines re-opened. Refining operations were resumed and continued for a year or two, when the pits had to be closed on account of the shafts shrinking.

However, in the course of a number of years, petroleum appeared in another colliery less than a mile from the Mear Hay Colliery, and again Mr. Walker secured the contract for the whole of the output. The quantity of crude oil found was several tons weekly, and a large stock had accumulated when Mr. Walker's attention was drawn to this new find. This time, the supply continued for a longer period, and then again the seam of coal in which the deposit occurred had to be abandoned. Thus, while the resources of this part of the Charnian axis have not been properly tested—for, in the opinion of the colliery owners, it is not possible profitably to work coal and oil at the same time—there is ample evidence to suggest that, in the not distant future, there may be most interesting oil developments in this part of North Staffordshire.

The eastern zone of the country doubtless furnishes the most interesting petroleum occurrences in England. Here, the interest does not so much depend upon the number of escapes, as upon the promising geological conditions subserving the production and possible retention of petroleum. According to the investigations of Mr. William Forbes-Leslie, whose valuable contribution on the subject of the occurrence of petroleum in England forms one of the most important papers ever read before the Institution of Petroleum Technologists, the northern line of oil occurrences runs from Filey, north-westerly, the principal finds being located at Filey, Pickering, and Kirby Moorside. Oil, too, has been found at Brigg, in Lincolnshire, at Market-Rasen, Haugmont, and Donnington-on-Bain. The line of oil occurrences starts at King's Lynn, on the Wash, and runs south-westwards as far as Cottenham, in Cambridgeshire, the principal occurrences being at King's Lynn, Downham, Littleport, and Ely. The information obtained by the bore-hole at Kelham, to which I have already referred, is a factor of great value when taken into consideration and applied to an analytical review of the petroleum seepages in England. It is a positive proof that a true oil-bearing stratum underlies the surface rocks, at any rate, in one part of the British Isles, and, when it is considered in relation with the surface position of the oil escapes on the eastern flank of the Pennine Chain, it suggests a possible connection between those underground sources of oil and those surface escapes which are scattered, seemingly at such random, along the Pennines.

The attempts which were made but a few years ago to develop the possibilities of the Heathfield district of Sussex, with a view to obtaining commercial quantities of natural gas, were also prompted with the idea of maybe striking deposits of liquid petroleum, though it is doubtful, both from a geological point of view, and from the nature of the natural gas which is there in abundance, whether liquid oil will be met with in that part of the country. What has been established, however, is the fact that large quantities of natural gas are to be found in this delightful part of rural Sussex, and it is a great pity that the necessary enterprise has not been forthcoming to permit of a really serious development. Some years ago, I motored an American oil-man over the gas-fields of Heathfield, and he assured me that, if such evidences were found in the States, there would immediately be a great boom, and finance would freely flow in to stimulate development. But not so with Heathfield, for the opinion is freely held that this field is too near our midst for real speculative enterprise. Remove it to the wilds of Russia, and British finance would appreciate the immense potentialities which to-day lie dormant. For those readers who are, perhaps, not conversant with the history of the Heathfield gas developments it is well to .record the fact that attention to these deposits was drawn years ago, when a well was being drilled for water on the property of the Brighton and South Coast Railway, near the present station. Strong smells of gas prevented working for some time, and as these increased it was decided that the better course would be to suspend drilling operations. The tubes of the well were partially drawn out, and the well sides caved in, yet the gas pressure increased. The well was abandoned as a water well, but pipes were attached to the cap at the mouth, and a steady pressure of gas was emitted. It was decided that, inasmuch as the gas burned with a pure flame, the station should be lighted with it. That was over twenty years ago, and to-day the well is still producing, and the station is still lighted with the natural gas, which needs no refining. Not only so, but a well-appointed hotel close by utilizes the gas for lighting and cooking.

A project was set on foot for sinking further wells and piping the gas to the southern coast resorts for general use, but lack of capital prevented progress being made, and so, to-day, Heathfield, like many other centres in the country, awaits the attention of the carefully-directed drill to open up its underground wealth.

In August, 1917, the feeling in many parts of the country that the Government should take some action in order to develop these latent resources became so strong that a Bill was introduced into Parliament with this object in view. No attempt was made to progress with it until the following October, when a financial resolution was rejected by the House of Commons on the question of royalties. An amendment was adopted against the payment of royalties to the owners of surface lands who had made no attempt to obtain liquid oil, and who, as a matter of fact, did not know that it was there. Two months later the Petroleum (Production) Bill was dropped.

In March, 1918, however, a most encouraging turn of events occurred, for Lord Cowdray, head of the great firm of Messrs. S. Pearson & Son, and associated with those influential interests in oil represented by the Mexican Eagle Oil Company, the Eagle Oil Transport Company, and the Anglo-Mexican Petroleum Company, made offers to the Government which were couched in the following terms—

(*a*) For the period of the war to place at the disposal of the Government, free of all cost, the services of his firm and geological staff for the purpose of exploration and development.

(*b*) If the Government did not wish to risk public money on what had to be deemed a speculative enterprise, Messrs. S. Pearson & Son were prepared to drill, at their own risk and expense as licensees, subject to certain areas being reserved to them. The offer committed the firm to an expenditure of, possibly, £500,000.

The personal opinion of Lord Cowdray upon the question of the existence of liquid petroleum in England may be gathered from this remarkable offer which he made to the Government on behalf of his firm: it is, that, notwithstanding the oft-expressed opinion to the contrary, the possibilities of securing a commercial production of petroleum in Great Britain are of a distinctly promising nature. It may be added that this is the opinion which Messrs. Pearson & Son have frequently put forward to the Admiralty.

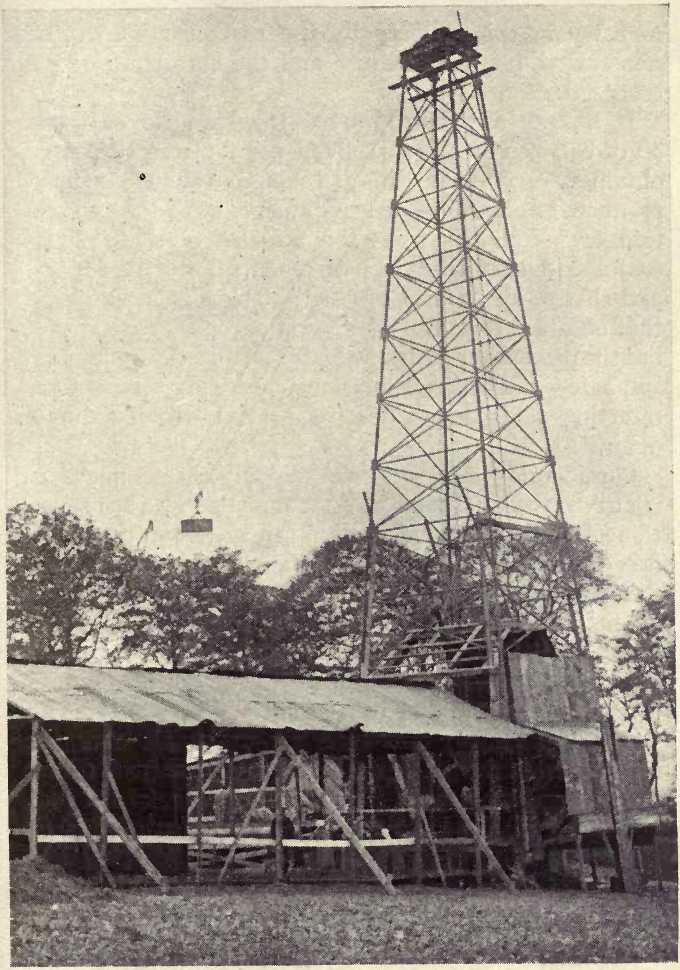
The public spirited offer of Lord Cowdray was most thankfully accepted by the Government and, with a minimum of delay, drilling sites were marked out for the commencement of active operations.

Lord Cowdray's geological staff particularly favoured the neighbourhood in Derbyshire, near to which Young made his first discoveries of oil, and Chesterfield was selected as headquarters for the new oil developments. The first oil well to be drilled in this country was commenced in September, 1918, at Hardstoft, near Pilsley, on the Great Central main line between Sheffield and Nottingham, and on Tuesday, 18th October, the inauguration of England's oil industry took place there in the presence of many oil notabilities. American drilling machinery of the percussion type was installed and, in view of the great depth to which it was expected the drill would have to proceed before encountering commercial quantities of oil, the well was commenced with a diameter of 18 inches.

Several wells are to be (or are already being) drilled in the same locality, it being the desire of Lord Cowdray that the whole of the possibilities of the district shall be fully tested.

Let us now briefly turn to the other aspect of the question of the production of petroleum in England—that is, of producing oils from the treatment of the bituminous shales. There are several sources from which petroleum can be obtained in this country by distillation, and these are: (1) oil-shales, (2) coal, (3) cannel coals and torbanites, (4) blackband ironstones, (5) lignite, and (6) peat.

The only source at present being utilized is oil-shale, and with this I deal at length in another chapter. The other shales—such as the Kimmeridge shales of Dorset, Norfolk, and Sussex—are not being worked commercially in spite of strenuous efforts, and there remains much to be done before a steady supply of petroleum can be counted upon from these sources. Of the other possible sources of supply, coal yields too little, and at the same time is considered too valuable to be utilized on a general scale; lignites are not yet opened for development on a sufficient scale; and peat has proved troublesome and expensive to treat owing to the difficulty of eliminating the water. This, therefore, leaves cannel coals, torbanites, and blackband ironstones, which are closely associated and, in numerous cases, easily obtainable. Cannel coal, I should explain, differs from the ordinarily known coal on account of its being less carbonized; it contains many fragments and particles of vegetable matter still showing their natural forms, though flattened by pressure. The percentage of hydrogen to carbon is higher in a cannel coal than in the bituminous coal, the percentage of inorganic matter is usually higher also, and the fracture and general appearance serve to distinguish this variety of carbonaceous deposit. Torbanites, though very similar in outward appearance, are essentially different from true cannels, and these consist essentially of a coal matrix in which are embedded certain spherical or irregular yellow or brown bodies, known as kerogen. These torbanites are known in many of our coal-fields; they are found in North Staffordshire, Cumberland, Northumberland, Derbyshire, and other fields, though none have been discovered of the richness of the famous Torbanehill mineral found at Bathgate, Scotland. And it is from these that it is proposed to founad new



ENGLAND'S FIRST OIL WELL

industry in this country by the carbonization of the minerals at low temperature and the extraction of the crude oil.

It has already been proved that a yield of crude oil of between 30 and 40 gallons per ton treated can be obtained, and from this all those valuable refined products of oil will result. Compared with the production of petroleums from the Scottish oil-shales, it is established that the yield of crude oil will be higher, and that of the refined products somewhat in excess of that obtained from the distillation of the Scottish shales, but the percentage of that valuable fertilizer—ammonium sulphate—will be lower, inasmuch as by low temperature retorting it is impossible to recover the maximum quantities.

Considerable progress has already been made in regard to the treatment of these minerals for the extraction of petroleum, and quite recently (May, 1918), the first interim report upon the experiments carried out at several gas-works has been issued. At the instigation of the Controller of the Mineral Oil Production Department of the Ministry, various practical experiments have been successfully made with cannel coals, and, as a result, a principle of distillation has been arrived at which will enable numerous gas-works all over the country to carbonize cannel coal in the normal course of their working, with a good production of oil fuel, and, as a matter of fact, large quantities of this oil fuel are now being produced.

This, of course, is primarily a war measure: it is now certain that in due time we shall see the various petroleum-bearing shales of this country treated in enormous quantities, so that England may be far less dependent upon foreign sources for its petroleum supplies than in the past.

CHAPTER X

PETROLEUM IN THE BRITISH EMPIRE

THE desire that the British Empire should be self-supporting in every possible way has been the predominating idea of our statesmen for many years: it is to be regretted, however, that such little progress has been recorded in the direction of the achievement of a practical result. This remark applies to many commodities, yet to none more so than to petroleum and its products. To-day, as much as at any preceding time, the Empire is dependent upon foreign sources of supply for the vast bulk of its petroleum products. It is true that in the United Kingdom there is a growing production of oil from the shale-fields of Scotland, but this total represents but a fraction of the large quantities of products which are annually required to meet the ever-increasing demands in commercial and domestic circles.

At the outbreak of the European War, it was forcibly brought home to us as a nation that we were in a position regarding our petroleum supplies of absolute dependence upon other countries. The refined products were an essential part of the war, for without them it would have been impossible to have continued for almost a single day, and yet, practically every gallon used had to be transported thousands of miles, and from a country which at that time was neutral. To make matters even worse, the Continental sources of supply from which we had been previously drawing large quantities of petroleum were closed to export, for, through the Dardanelles, the Roumanian and

Russian export ports were effectively shut off from the outside world.

Fortunately for Great Britain, the United States came forward with the offer of all the petroleum products required for the successful prosecution of the war, and we owe to the United States alone all success which has been the natural result of possessing ample requirements of petroleum products both on sea and land.

The fact, nevertheless, stands out tragically prominent that we as a nation have not developed our own oil resources in a manner we ought to have done, although everyone conversant with the oil business has been for years advocating the giving of serious attention to this important subject. To-day, speculative drilling for petroleum is proceeding in England, and it is to be hoped that some success will be ultimately recorded, but, inasmuch as I dealt with the question of Petroleum in England in the previous chapter, I will at the moment pass over this very interesting phase of the problem, and briefly look at the subject from an Empire point of view. Under the British Flag, we already have, or control, some excellent oil-fields in Burmah, Persia, Egypt, Trinidad, and Assam, and each producing steadily increasing quantities of crude oil. The Burmah fields have achieved fame mainly owing to the very large profits made by the chief operating company—the Burmah Oil Company, Ltd., whose head offices are at Glasgow. These have of recent years been developed upon most up-to-date lines, and the producing limits of the territory greatly extended, until now the annual crude oil production is upwards of 1,000,000 tons. The fields of Persia are very prolific, and their control to-day is in the hands of the Anglo-Persian Oil Company, Ltd., an influential concern largely controlled by the British Government, by reason of the investment of large sums of public moneys a few years ago. The development of the Persian fields is more or less in its initial stages, and though huge quantities of oil have already been produced therefrom, the limits of the presumably oil-bearing areas have by no means been defined. In order to facilitate the export of Persian oil, a pipe-line has been laid from the fields to Abadan, on the Persian Gulf, and a programme has already been laid down under which large quantities of Persian petroleum will come upon the English markets immediately normal conditions again prevail.

The Egyptian oil-fields have lately witnessed developments upon an important scale, thanks to the enterprise of the Anglo-Egyptian Oil-fields, Ltd., a concern closely allied with the " Shell " Combination, and having as its Chairman, Sir Marcus Samuel, Bart. Commercial supplies of crude oil have been found at several points near the coast of the Gulf of Suez, and a large refinery has been built for the refining of the oil. Down to 1914, the only oil finds of importance had been at Gemsah, where a number of oil gushers were struck, but the field there proved to be one of most irregular formation, and none of the wells gave anything like a permanent yield. Fortunately, in that year a field was discovered at Hurgada, the formation of which was found to be singularly regular, and the yield of which has steadily increased until, at the time of writing, the production of crude oil in it is over 15,000 tons per month. That additional wells have not been sunk and the field further increased has been primarily due to the difficulties of obtaining the necessary plant under war conditions. Some very large wells have already been brought in, but, so far, the petroleum industry in Egypt is quite in its infancy. It is quite obvious, however, that in the next few years the production of petroleum in

Egypt will be increasingly large, and the developments are bound to have a significant bearing upon the oil situation generally.

The same remarks equally apply to the Trinidad fields, where the anticipations of those associated with the pioneer oil operations have been more than fulfilled. Some prolific fields have been opened up, and the production to-day is such that an export trade of considerable magnitude can be maintained. Developments upon the Island were impeded by the total absence of roads in the oil districts, and much pioneer work had to be undertaken before it was possible to commence the serious exploitation of the fields themselves. The crude oil of Trinidad is of both the light and the heavy grades, the former showing remarkable percentages of motor spirit, while the latter is used not only as fuel oil but also for the treatment of roads so as to render them dustless. It is in Trinidad that there is the famous pitch lake, from which for many years large quantities of asphalt have been removed and exported for a variety of purposes. Trinidad asphalt, in fact, is well known all over the world. The potentialities of the Island are rapidly being appreciated, for its geographical position is such that would make it a practical base for the "oiling" of the great ocean-going vessels which are rapidly passing over from coal to fuel oil burning.

While on the subject of oil-fields which are under the British Flag, mention must be made of Canada, whose oil industry has been developed for many years. The principal producing fields are in Ontario, and the town of Petrolia is the centre of the petroleum interests. But the wells are not of the prolific class, and almost without exception show a very poor return for operating. Many of them are sunk only to the shallow strata, and their operation would certainly be profitless were not a system employed by which quite a number of small producing wells are pumped by central power. From time to time, Canada has experienced various oil booms, one of the most recent being that which occurred in Calgary, in 1914. A well showed a small production of high-grade oils, and immediately the country for miles round became the centre of an oil fever, which gradually died down when a number of unsuccessful developments took place. To-day, the output of the Canadian fields is steadily declining, and all efforts to stimulate the production have so far failed. Even a Government bounty of $1\frac{1}{2}$ cents a gallon of oil produced has failed to encourage an increase in output, and it is evident that, unless new fields are opened out, the future offers little hope.

The total production of petroleum to-day by the oil-fields developed in the British Empire represents but about 2 per cent. of the world's total petroleum output: it is therefore clear that, if we intend to secure our oil supplies in the future from territory under the British Flag, large supplementary sources of supply must be found. It is doubtful whether any additional liquid oil regions will be found to produce oil in commercial quantity, for, though several attempts have been made in various parts with this end in view, they have not achieved success, and numerous instances might be quoted where the employment of British capital in an endeavour to bring about this much desired result has met with failure.

The question then arises: Is it possible to augment considerably Empire-produced oils from other means of development? In this direction, the future is full of promise, for, though Nature has not given the Empire freely of liquid oil-producing fields, there are immense areas of oil-bearing shales at home and in our Dominions overseas which can, without great difficulty, be turned into most useful account. It is well known that great deposits of retortable material exist within the Empire's bounds, and many of these deposits are exceedingly rich. At the moment, however, scarcely any have been exploited, and none adequately developed. From time to time, many samples of oil-bearing shales from various parts of the Empire have been sent to this country for analysis, and these have usually been put through Scottish retorts with varying results.

But the unsatisfactory analyses have not been due to the qualities of the shale or torbanite examined, but to the methods by which the distillations were carried out. The well-known consulting oil engineer—Mr. E. H. Cunningham-Craig—made a special point of this in a most interesting article which recently appeared in one of the Empire magazines, and he pointed out that the reasons for the unsatisfactory conclusions arrived at were very simple and obvious. The Scottish retorts are designed to deal effectually with highly inspissated and, as a rule, not very rich, oil-shales. The recovery of the maximum amount of sulphate of ammonia is a desideratum; a sufficient supply of incondensable gases to fire the retort must be produced; while the recovery of the lighter fractions (motor spirit) of the material treated was not an object of the first consideration. For these purposes, says Mr. Cunningham-Craig, large and high vertical retorts are used, the temperature of distillation is comparatively high, superheated steam is blown into the retorts, and a fairly complete extraction of volatile matter is achieved. But to apply such methods to a very rich and fresh torbanite—such as the richer shales of New South Wales—is absurd, involving many practical difficulties and not giving the most remunerative results.

Similarly, the rich oil-shales of New Brunswick (Canada), though more nearly allied to the Scottish shales, differ from them both chemically and physically to such an extent as to require different treatment. Let me now briefly refer to the deposits which are known in the Dominions and Colonies that give promise of yielding oil in commercial quantities by destructive distillation. I will first take the shales of Canada, for though, as I have pointed out, the Dominion's production of liquid oil is steadily decreasing, there are numerous deposits of shales which only await careful exploitation and development in order to render Canada a petroleum-producing country of considerable magnitude. The oil-shales of New Brunswick have been known for many years, yet only a fraction of the area has been yet prospected. Experiments with the shales have shown that they are capable of producing nearly 50 gallons of crude oil the ton of shale treated, while ammonium sulphate has been produced at the remarkable proportion of 77 lb. a ton. Albert County is one of the best shale-fields, and it is here that a Government scheme has now been promulgated. The shales of Nova Scotia are likewise to be commercially developed, but so far no serious attempt has been proposed to deal with the enormous areas in Newfoundland, the Province of Quebec, and other already known regions of Canadian oil-shales.

Australia can boast of very large areas of shales: some deposits have been operated for several years, but others are still awaiting development. From a variety of causes, however, the shale-oil industry of Australia has never been set upon a profitable footing. The Commonwealth Oil Corporation some years ago set out to accomplish much, but the only thing which it seemed to do with energy was to sail to destruction.

Its failure cannot be said to have been due to any absence of the material it set out to treat for petroleum, for at every turn enormous quantities were opened up. It would appear that the immensity of the possibilities which awaited its operations was one of the prime reasons for its premature decay, while there is no doubt that the system it employed was by no means the best for treating the shales. A more simple and less expensive method of retorting the shales would doubtless ensure successful working. In Queensland, Tasmania, and New Zealand the presence of these shales has been proved over extensive areas, and though for the most part they have so far been neglected, there is reason to hope that, in the not distant future, the advantage to be derived from their commercial exploitation will be the more widely appreciated. A most lucrative industry could be built up by the Commonwealth of Australia by the distillation of the torbanites there, and though, perhaps, it is too much to expect that an export trade in petroleum products could be built up, there is no doubt whatever that the large requirements for petroleum products in the Dominion could easily be met by the production from home sources.

The possibilities of developing a shale industry in Africa are not particularly promising, though they are by no means out of the range of probability. In the coal series in the Transvaal, beds of what are known as "oil-shales" are encountered in several localities. The seams generally are thin, and in some cases unworkable, but the material is very rich, and has proved capable of yielding high percentages of crude oil.

In Sarawak (British North Borneo) the "Shell" Company is carrying out most important and highly successful developments, which are bound to have far-reaching and gratifying results in regard to developments under the British Flag.

As I have shown, the problem of Imperial oil supply would be far on its way to solution by the development of the various shales in the British Empire, and the pity is that a more progressive policy has not been adopted in regard thereto long before the subject became of such pressing importance. Each of our Colonies—like the Mother Country—is a large consumer of petroleum products, and each is also totally dependent upon imported supplies, yet within the borders of each are to be found dormant deposits of the necessary crude material.

CHAPTER XI

PETROLEUM'S PART IN THE GREAT WAR

A PERUSAL of the preceding chapters of this little work will have made it clear to the reader that petroleum and its products play a most important part to-day in the life of nations: if, however, one would be impressed with the immensely significant rôle which petroleum products have played in the conduct of the great European War, a brief reference to the subject will amply suffice. From the commencement of the Titanic struggle in 1914, it became obvious to those who were most competent to judge that, if victory was to be on the side of the Allies, it was imperative that they should possess sufficient reserves of petroleum products for all purposes, for it was evident then that activity would not be limited to armies on the land, but that the air and the sea would also become battle-grounds whereon the destinies of nations would in part be decided.

Germany, too, saw this; before the war it had been practically dependent upon regular supplies from the United States as well as from Roumania, but the bulk of its requirements came from the former mentioned country. With its States' oil shipments cut off, it turned its attention to securing at least part of its stocks from the neutral North-Western European countries, which, in their turn, were likewise dependent upon America. The ruse worked for some time, and the unsuspecting American exporters shipped cargoes to Denmark, Norway, and Sweden with little idea that the bulk of these were ultimately to find their way into

Germany. It was only when the figures were published in the States as to the abnormally large quantities of petroleum products that had been sent to the European neutral countries that, to the thinking mind, it became obvious something was wrong.

I can modestly claim to have called the attention of the British Government to this underhand proceeding early in 1915, when I not only gave them details of cargoes which had been delivered to various North-Western European ports *en route* to Germany, but also managed to secure the names of vessels all laden with such supplies, which at that time were crossing the Atlantic. Mr. Winston Churchill, to his credit be it said, acted without delay, and within a few days, as the vessels passed the North of Scotland, they were stopped, and—well, to cut a long story short, this country got the petroleum products which, in accordance with the original plan, would have gone to Germany. Some time afterwards there came a voice of protest from one or two interested persons in those neutral countries, for they declared that not a single barrel of petroleum had gone over to Germany, but evidence was soon forthcoming to show how well Germany's ruse had worked for some months, and a prosecution in one of those countries made against an importing firm, for actually sending petroleum supplies into Germany, effectively closed the protest from those who would have liked the enemy's desires to have been undisturbed.

There is not the slightest doubt that Germany at that time was in dire straits for sufficient petroleum products for its military purposes: had the war been somewhat delayed in its commencement, she would have been far better prepared, for, under the auspices of the Government, there had been laid down an elaborate programme for the importation and distribution of Roumanian petroleum products throughout Germany. As it was, the country was unprepared, and, though in other directions every possible precaution had been taken to carry through an elaborate military programme of offence, the prospective dearth of sufficient supplies of petroleum products necessitated the enforcing of the most stringent regulations with regard to the uses of all petroleum products, excepting for military purposes.

The taking of the Galician fields from the Central Armies by Russia gave a serious set-back to Germany's military plans, and it was only when the Russians had to withdraw from Lemberg that the enemy was able to count upon sufficient supplies to meet his military requirements. To an extent, he was even then doomed to disappointment, for, when his armies arrived on the Galician fields, they found that practically the whole of the petroleum reserves had been destroyed, and a large number of the prolific producing wells more or less permanently damaged. Nor, to my mind, was the advance into Roumania prompted by the idea of territorial gains so much as to secure control of the country's oil-fields. Here, again, Germany's desires were in part thwarted, for the efforts of the British Military Mission, to which I refer elsewhere, had been eminently successful.

From that time onward, however, Germany's supplies of petroleum products were secured, and that she turned them to account was a matter of common knowledge. Germany, naturally, greatly valued the acquisition of the Roumanian oil-fields, and it must be to its people a great disappointment that the whole of these immensely prolific regions for oil production are now permanently removed from the nation's grasp.

Unfortunately, the British Government did not seriously appreciate the importance of petroleum products in war as well as peace until the war cloud of 1914 was about to burst. It had taken no notice of the suggestions made from time to time that in our own country there might be vast petroleum reserves awaiting development, and it had not even shown any encouragement to the Scottish shale-oil industry. All that it had done, and even this was on the eve of war, was to invest over £2,000,000 in the Anglo-Persian Oil Company, Ltd., for the development of the Persian oil-fields, so that the Navy could secure ample supplies of fuel oil. But here, however, there were difficulties ahead, for the Persian fields are in the interior of the country and have to rely upon pipe-lines to bring the supplies to the coast.

Everything, therefore, depended upon the security of the pipe-line, and the idea which was in the minds of many who opposed the scheme as to the possibility of supplies being cut off by the activities of the insurgents, was by no means a mistaken one; the pipe-line was, in fact, partially destroyed, and the transport of fuel oil held up for a long time.

As a nation, we have all along had to depend upon imported petroleum products, and, inasmuch as our supplies could be drawn at will from a variety of producing countries, the idea that we might at one time find ourselves cut off from supply does not appear to have occurred to many. No sooner had the war started, however, than we found, owing to the closing of the Dardanelles, that both Russia and Roumania could no longer attend to our requirements, while the Far East, owing to the great ocean journey necessitated to this country (and the quickest way lay through the Mediterranean) could not maintain regular shipments with us. It is fortunate that we found the United States willing, and from the start very desirous, to do all that was possible to help us out of a difficulty; while Mexico, with its wealth of British oil interests, catered in every way for the meeting of the enormous demands we made upon its resources.

To say that petroleum products have played a highly-important part in the conduct of the war is but to under-estimate facts. The importance of their part has been equal to that of the supply of guns and shells, and, when the statement was made in the House of Commons in 1917 that adequate supplies of petroleum were quite as essential as men and munitions, petroleum's part was then not over-stated. Rather would I say it was on the contrary, for, had there been at any time a dearth of any classification of petroleum products, then the vast naval and army organization, both on and across the water, would immediately have lost its balance, and our great fighting units would automatically have become useless. Just think of it for a moment.

To-day, our great naval fighters—take the *Queen Elizabeth,* for instance—rely upon fuel oil for purposes of power, while our second and third line units must also have it, for, whether it be fuel oil or the lighter products of the oil refinery—I refer to motor spirit—it matters not, so far as supply is concerned. The whole of our wingèd fleets in the air must, of necessity, be useless unless they can regularly draw large quantities of motor spirit, and the volume they consume, even on a single trip, would surprise many, though it is not possible here to enter into figures.

At first sight one might be inclined to think that, apart from petroleum products being a very useful adjunct to the organization of battles on land, their use is not of a very real nature, but, if we pause for one moment, our first impressions are disillusioned.

It was my privilege at the end of 1917, thanks to the kindness of the British Foreign Office, to pay a visit to the fronts of France and Flanders, and there to have an opportunity of seeing the part which petroleum products did actually play. The immensity of this importance cannot be easily grasped, nor easily described. We all know the remarkable progress which had been made in regard to the extension of the railway systems throughout the zones of battle, but it will surprise many to learn that it was when the rail-heads had been reached, and between there and the real battle front, that motor spirit had the realm of transport to itself. Tens of thousands of heavy motor vehicles took up the work of transport when it left the railway, and it was this service that was required to see not only that our millions of men daily received their food, but each and every sort of ammunition also. But it was not even when the front line of battle was reached that motor spirit had finished its work. Those great machines of war—the tanks—had to remain stationary if they were not fed by large supplies of spirit, while petroleum, too, took a primary position in the making of the liquid fire which now and again we heard of as causing such havoc to Fritz. But, at its best, the railway was somewhat slow at the Front, no doubt owing to the enormous congestion which was inseparable from the reign of a state of war. Consequently, whole fleets of motor vehicles were employed day and night in a ceaseless stream of traffic, from the coastal ports right up to the zone of battle. Without divulging secrets, it is safe to say that that branch of the service alone demanded millions of gallons of motor spirit weekly.

Both after as well as before battle, the products of petroleum were essential, for, when the Red Cross vehicles took up their humane work of transporting the wounded heroes of the fight, those, too, called for innumerable quantities of motor spirit. And when darkness had fallen the oil lamp came into general use. 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 for light, and all vehicular 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!

One day, while at General Headquarters, I expressed a desire to see the methods by which all that world of activity secured its necessary supplies of petroleum products regularly, when once they had arrived in France in bulk. A few days later, I was, accordingly, allowed to visit the immense central depot at Calais, at which all the petroleum products required for use in the organization of transport were dealt with. It is safe to say that at no centre in the world did there exist such an extensive petroleum depot, nor anywhere else was there an organization upon whose perfect working so much depended. Though motor spirit necessarily occupied the first position of importance, practically the whole range of products was dealt with. The motor spirit was received in bulk, but at the depot had to be measured into the familiar 2-gallon can (which was made on the spot) and sent up country in special trains each day. Specially coloured tins denoted the best quality of the spirit, and it was that which was reserved for the numerous aerodromes in France and Flanders. The magnitude of that branch of the depot might be guessed when I state that at the time of my visit considerably over 2,000,000 2-gallon petrol tins were being either stored or filled for up country dispatch.

All kinds of lubricants were also essential for the purposes of war, for even motor spirit itself would be of little use for the internal combustion engines, if the engines could not secure their regular supplies of lubricating oils. These, too, had to be dispatched with remarkable regularity to every section of the battle zones, whilst, as I have suggested earlier, the daily requirements of war necessitated the distribution of illuminating oil in large quantities.

But no reference to petroleum's part in the great European war would be complete were it not to include mention of the way in which supplies of toluol assisted in securing victory to the Allies. Toluol, as is known, is necessary for the production of high explosives, and in the early stages of the great conflict, the output of high explosives was considerably restricted by the absence of sufficient quantities of this necessary explosive primary.

It was at that time that a discovery of the utmost importance was made, for, as the result of investigations carried out at the Cambridge University, it was found that the heavy petroleums of Borneo contained large percentages of toluol.

Sir Marcus Samuel, Bart., the Chairman (and the founder) of the Shell Transport and Trading Company, Ltd., lost no time in apprising the British Government of the discovery, for it is in the Borneo oils that the Shell Company and its allied concerns are chiefly interested.

The offer for the delivery of these immense quantities of toluol was eagerly accepted by the British and Allied Governments, and from that time onward, the supply of high explosives was practically unlimited.

The French and Italian Governments have asserted that, but for this specific offer of toluol, the manufacture of high explosives would have had to remain so limited, that it would have been impossible to bring about an Allied Victory in 1918. Their thanks were publicly extended to the Shell Company at the conclusion of hostilities, and Mr. H. W. Deterding and the Asiatic Petroleum Company were specially thanked, while as far back as 1915, Sir Marcus Samuel, Bart., received the thanks of the British Government for his invaluable war services. It was only after the firing of the guns had ceased on all Fronts, that it was permissible to record in what a remarkable manner these services were rendered.

The exigencies of space have prevented my dealing, excepting in the most brief manner, with this interesting subject: I only hope I have succeeded in showing that, in times of war, as well as in those of peace, petroleum products occupy the position of first importance.

CHAPTER XII

THE SCOTTISH SHALE-OIL INDUSTRY

In view of the great interest which is now being centred in the production of petroleum in the British Isles—thus making this country to a large extent less dependent upon foreign sources of supply—the Shale-oil Industry of Scotland is assuming a new importance, for the reason that it is in the direction of the development of new oil-shale areas in several parts of the country that experts look with a great amount of confidence.

It is specially interesting, therefore, to deal at some length with the growth of the industry, the methods by which the oil shales are operated, and the prospects for its extension.

The name of Dr. James Young, of Renfrewshire, will ever be associated with the commercial exploitation of the oil-bearing shales in the Midlothians, for it was due to his enterprise that the Scottish shale-oil industry really owed its birth and much of its later development. It was while Young was managing a chemical works at Liverpool that his attention was drawn to small flows of oil which came from a coal seam at Alfreton, in Derbyshire. This was in 1847, and after experimenting with the liquid, Young succeeded in extracting therefrom on a commercial scale both a light burning oil and a lubricant, as well as wax. When the supply became exhausted, Dr. Young had an idea to imitate the natural processes by which he believed the oil had been formed. The outcome of this was the well-known Young patent for obtaining paraffin oil and other products from bituminous coals at slow distillation.

The Young process was utilized with much success in the United States until such time as it became unprofitable owing to the largely increasing production in America of liquid oils obtained direct from the earth. It was about this time that a bituminous mineral known as Boghead coal, and existing in the Midlothians, was discovered, and from this Young secured upwards of 100 gallons of oil from each ton treated, but soon this mineral was, in a practical sense, exhausted, and so the bituminous shales, now known as oil-shales, came in for attention. Before passing away from Dr. Young's services in connection with the establishment of the Scottish shale-oil industry, it should be mentioned that he figures very largely in more than one of the earlier Scottish shale concerns. He founded the Bathgate Oil Company, which, in the zenith of its operations, treated 1,000 tons of shale daily, this Company being later merged into the Young's Paraffin Light and Mineral Oil Company, Ltd., one of the large Scottish shale-oil undertakings and well known throughout the world to-day.

The Scottish shale-oil fields, as exploited to-day, cover a belt of territory which is about 6 miles broad and stretches from Dalmeny and Abercorn, on the Firth of Forth, southwards across the fertile tract between the River Almond and the Bathgate Hills to the moorland district of Cobbinshaw and Tarbrax. Throughout this region there are various important mining centres, such as Broxburn, Uphall, East Calder, Mid-Calder, West Calder, and Addiwell; and in connection with the shale-oil industry, upwards of 25,000 persons now find regular employment.

The shale measures on which the shale-oil industry depends, form part of the calciferous sandstone series of Mid and West Lothian and the southern coast of Fife.

The carboniferous system of Scotland may be arranged in descending order in four divisions, as under—

4. Coal measures, comprising red sandstone, shales, and marls with no workable coals, underlaid by white and grey sandstones and shales with numerous valuable coal seams and ironstones.

3. Millstone grit, consisting of coarse sandstones, with beds of fireclay, a few thin coals, ironstones, and thin limestones.

2. Carboniferous limestone series, embracing three subdivisions, the highest of which contains three or more limestones with thick beds of sandstone and some coals, the middle includes several valuable seams of coal and ironstone, and the lowest is characterized by several beds of marine limestone with sandstone, shales, some coals, and ironstones.

1. Calciferous sandstone series, forming two subdivisions. The upper is known as the oil-shale group, and is over 3,000 feet in thickness, and contains, in its highest part, beds of coal, usually of inferior quality, and, farther down, about six main seams of oil-shale, inter-stratified with beds of sandstone, shale, fire-clay, marl, and estuarine limestones.

Although the calciferous sandstone series is well developed in other parts of Scotland, it has not hitherto yielded any oil-shale of economic importance beyond the limits of West Lothian, Mid Lothian, and Fife. Thin seams of oil-shale do occur in various places in the counties of Haddington and Berwick, but, generally speaking, the quantity is not sufficient to be practically worked.

A word or two as to the oil-shales themselves. The shales, as known in the Lothians, are fine black or brownish clay shales, with certain special features which enable them to be easily distinguished in the field.

Miners draw a distinction between "plain" and "curly" shale, the former variety being flat and smooth, and the latter contorted or "curled," and polished or glossy on the squeezed faces. In internal structure, oil-shale is minutely laminated, which is apparent in the "spent" shale after distillation, when it is thrown out in fragments, composed of extremely thin sheets like the leaves of a book.

Before touching upon the methods employed in mining the shale and the treatment it receives during distillation, it is interesting to note that the industry in Scotland has passed through many vicissitudes since its establishment. At that time, the American oil industry was but in its infancy, and the production in the States was utilized mainly on the American markets. Consequently, there was a great demand for the Scottish oils in this country, and in 1870 there were no fewer than ninety small oil-works in the Lothians, the majority of which were operating the shales. It was about this time that the American illuminating oil came over to this country, and a very sorry blow was dealt the Scottish industry. So disastrous was the resulting competition between the Scottish products on the one hand, and the American and Russian petroleums on the other, that one by one the Scottish companies closed down, and, after less than eight years of competition, the number of operating companies had fallen to twenty-six. The decay continued until the number of active concerns in the Scottish shale-oil industry could be counted on one's fingers.

The industry exists to-day simply as a result of the great improvements which have been made in the retorting of the shale, by which larger quantities of products are produced—including ammonia. It is thus able to withstand foreign competition.

To-day, it is estimated that nearly 4,000,000 tons of the Scottish shales are treated every twelve months by the several operating oil companies. The most important of these concerns—the Pumpherston Oil Company—has been regularly operating since 1883, and, inasmuch as it deals with by far the largest quantities of shale treated, a brief account of its operations will be of advantage in enabling the reader to understand the methods by which a total of nearly 400,000 tons of oil are produced each year in Scotland.

The operations of the Pumpherston Oil Company are upon a scale of considerable magnitude, for the Company's works comprise the crude oil plant, the sulphate of ammonia plant, oil and wax refineries, etc. The Seafield and Deans works, 7 and 4 miles distant respectively, possess only crude-oil and sulphate-producing plants, the refining plants being confined to Pumpherston. The Company's works cover 100 acres, while the shale fields extend over many thousands of acres in and around the district of Pumpherston.

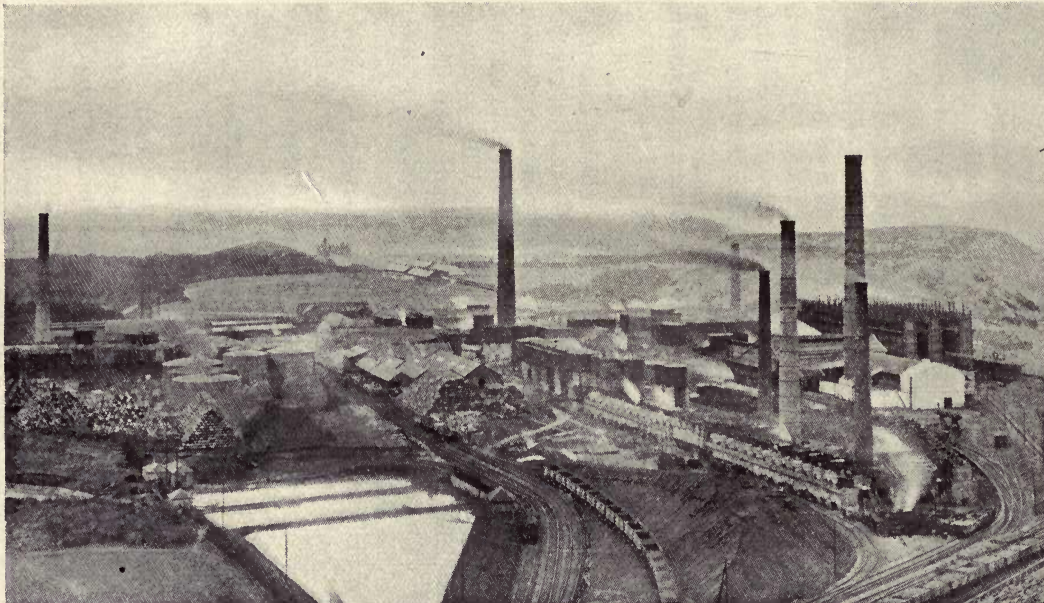
As has already been mentioned, the shale fields so far operated lie, in the main, in the Lothians, and, as one motors by road from Edinburgh to Glasgow, the shale country is passed through. Before the commercial development of a shale field, trial borings are sunk, now more generally by means of a diamond bore, for by its revolving action a solid core is obtained which readily shows the character and inclination of the strata passed through. When a seam of shale has been found by boring operations, and the exact position and depth of outcrop determined, it is necessary, before sinking a mine, to put down a trial shaft for the purpose of making sure as to the true gradient at which the shale is lying, and the thickness as well as the quality of the same.

In the shales in the Pumpherston district there are five distinct seams, dipping from 29 degrees to 38 degrees, and the mine is driven in the middle seam, the other seams being entered by level cross-cut mines driven from one to another. Each of these seams is worked separately, the cross-cut shown in the sketch serving the purposes of communication and transit. In some cases, where the inclination of the shales is at a different angle, it is necessary to sink a vertical shaft, and this method is applied to the series known as the Mid-Calder.

The usual dimensions of the inclined shaft are a width of from 10 to 12 feet, and the height is from 6 to 8 feet. If the sides of the shaft prove to be of a soft nature, as is generally the case with the shale at the crop, walls are run up and the roof is supported by larch crowns, but, where the shale is hard and the roof good, then the less costly method of timbering is adopted.

The supports to the roof in many cases are fixed "centre" fashion, dividing the shaft into two unequal parts. The smaller division has generally a width of just over 3 feet, and is used for haulage ropes and water pipes, while the larger division is utilized for winding. During the progress of sinking, levels are broken away in the seam at regular distances, and driven so as to get communication with, and drive headings to form, the outer mine. These headings are driven in the same direction as the sinking mine to the levels above, until they connect with the outer mine or shaft. The outer mine is then used for winding the shale up to the surface, and the other is kept for sinking purposes, and by this means winding and sinking can go on simultaneously.

The seams of shale in the Midlothian fields vary generally from 4 to 10 feet in thickness, say 7 feet as



GENERAL VIEW OF THE PUMPHERSTON WORKS

an average, and, on the whole, they are comparatively free from ribs of unproductive rock. With a thickness of 7 feet, experience has shown that the method best adapted for the efficient working of the shale is "stoop and room," but in the case of two seams of shale, separated by a bed of foreign material of sufficient thickness for packing, the long wall method proves the more suitable. The "stoop and room" method, however, is more generally used throughout the Scottish shale district than any other, its chief characteristics being the (1) "whole" or first working, and (2) the broken or second working. The whole working consists of a series of excavations made in the shale, whereby it is divided into rectangular blocks or pillars. These excavations are called rooms, one set being driven at right angles to the dip of the shale and at regular distances from one another, and commonly called "levels"; another set, driven to the rise of these levels and at right angles to them, being usually known as "ends" or "upsets." The latter are broken off the levels at regular intervals and driven upwards to meet the levels above.

The shale miner holes as far as he can reach—probably three or more feet—and brings down the shale by blasting, the process being repeated until he penetrates a distance of from 9 to 12 feet from the face at road-head. The shale, being loosened from its natural bed, is then placed in "hutches," which are taken to the bottom of the shaft by either horse or chain haulage (much as with coal), and then the journey to the mouth is commenced. Before leaving the question of shale mining, it should be explained that the shale miner is subject to dangers much as his colleague in the coal-pit, but the volume of gases found in the shale seams is not so great as in the coal measures. These, however, are of an explosive nature, the most common being fire-damp.

Once above ground, the shale is conveyed to breaking machines by endless wire-rope haulage. Passing through the machines, it is broken into suitable sizes for distillation, and drops into hopper-shaped hutches. These hutches have a capacity of about a ton, and each in turn is conveyed to the top of the retorts on an inclined scaffold by an endless chain. The shale then falls by the operation of a lever into a hopper or magazine communicating directly with the retorts, one hopper with a storage capacity of 24 hours' supply of shale being connected to each retort of the Pumpherston Company.

This Company's retorts—they are patented—are in use at the various works of the Pumpherston Company, and are an interesting feature to visitors. The shale is fed by gravitation into cylindrical-shaped retorts, and built vertically in ovens of four, each oven having four chambers. The upper portion is of cast-iron, 11 feet long by 2 feet in diameter at the top, and slightly enlarged toward the bottom. Heat is applied externally from the incondensable gases obtained from the distillation of the shale, and this heat is made to circulate round the retort. In the case of the poorer qualities of the shale, however, the heat is assisted by producer-gas. The heating gas enters near the bottom portion of the retort, which is of fire-brick, along with a certain quantity of air, and a high temperature—from 1,200° F. to 1,600° F.—is maintained, in this portion converting the nitrogen of the shale into ammonia, which is preserved by a continuous supply of steam delivered at a slight pressure at the bottom of the hopper.

The oil gases are distilled from the shale in the cast-iron portion of the retort at a temperature of about

900° F., and, along with the ammonia gas, are drawn off by the exhausters through a branch pipe at the top of the retort, through the atmospheric condensers, from which the condensed liquid oil and water containing ammonia flow into a small separator tank. It is here that, owing to their different specific gravities—for one is lighter than the other—they assume different levels, and are thus drawn off into separate tanks. The gases then pass through ammonia scrubbers, in which they are washed for ammonia, and then through the naphtha scrubbers, where the lighter gases, which could not be caught in the atmospheric condensers, are washed with oil, and a good quality of light oil or naphtha is recovered. The incondensable portion passing from these scrubbers is burned in the retorts as previously mentioned. With a shale of average yield, the retort can be heated by these incondensable gases from the distillation, and a surplus obtained for burning under steam boilers.

What is doubtless a very unique feature of the Pumpherston retort is the mechanical arrangement for withdrawing the spent shale continuously, and thus keeping the whole mass inside the retorts in constant movement. Below each pair of retorts is fixed a hopper made of cast-iron, and fixed to girders supported on the brick piers or columns between the ovens. At the top of each hopper, and immediately underneath the bottom of the retorts, is fixed a cast-iron disc or table, with a space left between its edge and the sides of the hopper. The whole mass of shale in the retort rests upon the table, the space permitting some to pass over the edge. Through the centre of the table a steel spindle projects, on the upper end of which is fixed a curved arm, and this, when rotated, pushes some of the shale off, causing it to fall over the edge of the table into the hopper below. The shaft carrying the curved arm passes through a stuffing-box on the hopper, and has a ratchet and lever fitted to the lower end, actuated by a rod of T-iron which is made to travel horizontally, and is driven by a small electric motor. The motion is comparatively slow, the arm making but one revolution in about 20 minutes, but the action is most satisfactory, the through-put of shale being regulated at will.

The ammonia water got from the atmospheric condensers is pumped through a heater, in which it is raised in temperature by the waste water flowing from the still, and passes into the top of the still, which is circular in shape, about 30 feet high, and has a series of cast-iron shelves or trays fixed horizontally every 2 feet or thereabouts from the top to near the bottom. Steam is put into the bottom of the still at a pressure of 40 lb., and passes to the top through a series of conical arrangements on the shelves carrying with it the volatile ammonia, while the water, after traversing the whole area of each tray, passes out into a concrete tank containing a cast-iron worm, which is the heater already referred to, for the ammonia water on its way to the still. During its progress from the top to the bottom of the still, the water is diverted into a chamber containing milk of lime, setting free the fixed ammonia which cannot be got by steaming.

The steam and ammonia gas liberated in the still pass over into a large lead-lined tub or saturator, and bubbles through holes in a lead worm placed round the circumference at the bottom of the vessel. Sulphuric acid is at the same time run into the saturator, and, at a certain temperature, sulphate of ammonia is formed. The sulphate falls into a well, formed in the centre of the bottom of the vessel, in which are placed two steam ejectors, and these blow it out along with some liquor. This mixture is delivered into hutches having perforated bottoms, through which the ammonia liquor drains off, the solid sulphate being left in the hutch. This is now run by an overhead railway to the drying or storage stalls, and from these it is packed up and dispatched to the market. The exhaust steam and waste gases from the saturator are passed into the retorts, and utilized for the formation of ammonia from the shale, while the spent water is pumped to the spent shale bing, and thoroughly filtered before being allowed to escape from the works.

For dealing with the weak acid water recovered from the refinery, the Pumpherston plant consists of lead-lined tubs or crackers, into which a quantity of the acid water is run, and saturated with ammonia gas until it is near the salting point, when it gravitates into settling vessels in order to separate any tar carried over with the acid water. The clear liquid is then drawn into the saturator, where it is quickly converted into sulphate and blown out in the manner already described.

So up to date is the whole of the system governing the treatment of the shales and the resulting products, that the pumping of water from the mines, the haulage of the shale to the refineries, as well as driving of machinery in the works, is performed by electric power, the exhaust steam from the engines driving the generators, as in the case of the sulphate of ammonia exhaust, being sent to the retorts for use in the production of ammonia.

The process of refining the crude oil obtained from the shale into the various products is somewhat complicated and perplexing to those unassociated with the industry on account of the many distillations and treatments which have to be carried out before a good marketable article is produced. The following outline, however, will give a fair idea of the process adopted throughout Scotland.

The crude oil is delivered at the refinery into large tanks, which are placed at a sufficient height to feed the stills by gravitation. The crude oil is allowed to settle for twelve or more hours at a temperature sufficiently high to separate any water that may have passed the test at the retorts, and after this water has been run off, the oil is fed into the centre boiler of a battery of oil boilers. The lightest fraction of the oil—ultimately motor spirit and illuminating oils—is distilled off the feeding boiler and condensed in a coil of cast-iron pipes immersed in water in a tank, cold water being continuously run into the tank, while heated water is run off. The boilers on each side of the feed vessel receive their oil by a pipe connecting with the bottom of the latter, and they also distil over the lighter portion of oil with which they have been fed, the heavier portions passing on to a third boiler, where the process of distillation is repeated.

The oil now left is delivered into a cast-iron pot-still, in which it is ultimately distilled to dryness, the residue left in the still forming oil coke, which is valuable as a fuel on account of its high percentage of fixed carbon and low yield of ash. Steam is admitted to the still in large quantities at all distillations. The various stages of distillation are carried through in almost identically the same manner as that of crude oil, and, therefore, need not be described in detail.

The treatment or washing of the oil to remove the impurities that cannot be eliminated by distillation, consists in stirring the oil by compressed air for a given time in an iron vessel, with a fixed quantity of sulphuric acid, allowing it to settle, and running off the heavy mixture of tar and acid which separates. The acid-treated oil is then run into another similar vessel, treated with a solution of caustic soda, settles, and the soda tar which separates is run off. The acid tars are steamed and washed, the resulting acid water being sent to the sulphate of ammonia house for the manufacture of sulphate of ammonia, whilst the tar is mixed with that from the soda treatments and burned under the stills as liquid oil. As there is more than sufficient of this tar to distil all the oil at the various stages, the distillation is carried out without cost for fuel, excepting that necessary for steam-raising purposes.

A portion of the oil distilled at the second distillation, or green oil stage, is sent from the stills to the paraffin sheds to be cooled and the scale extracted, this eventually being made into paraffin wax. Stored in tanks until brought down to atmospheric temperature, the oil is pumped into the inner chamber of a cooler, which consists of a series of four vessels having inner and outer compartments. At the same time, anhydrous ammonia is forced into the outer compartment or jacket, and absorbs heat from the cooler, freezing the oil in the inner jacket into a pasty mixture of liquid oil and solid crystals of wax.

This mixture is then pumped into filter-presses, where a portion of the oil flows away through the cloth, while the wax is left behind in solid cakes, still containing a quantity of oil. These cakes are delivered by conveyors to the back of the hydraulic presses, where they are wrapped in cloth and placed on shelves between iron frames in the presses, most of the remaining oils being thus squeezed out. The material obtained from the hydraulic presses is known to the trade as paraffin scale, and as it is discoloured by the small quantity of oil which cannot be removed by pressing, a process of sweating by steaming in large brick compartments is adopted, in order to remove the oil. The scale, consequent upon the removal of the oil therefrom, becomes whiter and of higher melting point, and after further treatment is finally passed through filter paper and run into moulding trays. When cooled, this product is known as paraffin wax, of which there are many grades. One cannot enter into the technical arrangements involved, for obvious reasons, the chief one of which is that these cannot interest the reader; but sufficient has already been written in this chapter to suggest to the reader the perfection which has now been reached in the treatment of the shales of the Midlothians.

As to the future, it is full of promise. There is no doubt that for many years to come the full force of foreign competition, as it has existed in previous times, will not be felt. There is a free field for Scottish enterprise in connection with the distillation of its oil-bearing shales. Nor is the region for development limited to its present area. Reports point to the fact that much area of commercial ground exists, not only on the eastern side of Scotland, but also in the north and north-west, while it is already an open secret that those responsible for the conduct of Government operations are viewing with favour even the liquid extraction of oil from certain areas not far distant from the zone of the present operations. The Scottish shale-oil industry has, so far, managed to defy competition from abroad to an extent which is reflected in the balance sheets of the several operating companies, whose yearly dividends have been from 50 per cent. downward during recent years.

One thing is certain, and that is, the Government is well aware that there are great possibilities associated with the shale-oil industry of Scotland, and it is not only watching developments with direct interest, but is doing all in its power to foster the industry, and by all means possible encourage the exploitation of areas so far not commercially developed. At some future date there is a great possibility that the present area for developments will be largely extended, and as this is written, there is much evidence forthcoming to suggest that this commercial development of new lands will not long be delayed.

CHAPTER XIII

A FEW NOTABLE PETROLEUM ENTERPRISES

No brief survey of the petroleum industry would be complete were reference not made to a few of those remarkable commercial undertakings in various parts of the world whose interests are not only closely associated with it, but to whose energies has been due much of the expansion that has been witnessed in every direction during the past few decades. It is safe to assert that, had it not been that the petroleum industry has, in its various industrial and commercial aspects attracted the attention of some of the finest financial and business houses in the world, the wonderful progress which has been recorded would, for the most part, have been impossible.

The first place must of necessity be given to that much maligned amalgamation of capital, the Standard Oil Company of New Jersey, which was formed as far back as 36 years ago by Mr. John D. Rockefeller and his associates for the primary purpose of developments in the petroleum industry of the United States. At that time, the petroleum production of America had become quite a factor in commerce, but it was, obviously, in want of a guiding hand which could not only place it upon a basis of solidity, but which would tend to remove much of that gambling element which had become almost part and parcel of all developments. The Company, at the head of which were several gentlemen who had already made themselves famous in the land of oil, launched out in several directions, and, through the numerous subsidiary concerns which it soon created, it owned very extensive oil-bearing properties in practically every oil-field of the States, while it built quite a network of pipe-lines for the conveyance of the oil from the fields to the refineries, and from the refineries to seaboard. It erected and equipped oil refineries, and, so as to provide the much-needed foreign markets for American petroleum products, it built its fleet of oil tankers; and, lastly, opened depots for the distribution of American petroleum products all the world over.

At one time, the ultimate success of its vast operations was open to question, and many there were who predicted that one day it would ignominiously pass on to the list of oil failures. Indeed, it nearly came to this on one or two occasions, and it was only owing to the remarkable perseverance of those at the head of the Company's affairs that prevented headlong disaster. The Standard Oil Company soon became an integral part of the petroleum industry of the United States, with which it grew up and steadily assumed a position of world-wide importance, though one which was not unassailable. Its ultimate success was the chief cause for the multiplication of its critics, and volumes have been written of its wrong-doings by writers whose knowledge of the petroleum industry was mostly based upon wilful ignorance of facts. Consequent upon a decision of the United States Supreme Court some seven years ago, which held that the Company was violating the Anti-Trust Law of 1890, the Standard had to rid itself of its various subsidiary companies (over thirty in number), but it still controls almost a similar number of concerns to-day which are actively engaged in the production of crude oil and natural gas. It also owns several of the largest refineries in the States, while its fleet of oil tankers will, when present building is completed, be considerably over 300,000 tonnage. Its capital is $100,000,000, and during the last twelve years it has paid in dividends over 400 per cent., in addition to an additional cash distribution of 40 per cent.

The Standard Oil Company of New York is another immense concern which, with a capital of $75,000,000, has its headquarters in the Standard's palatial building at 26 Broadway, New York, and interested principally in the refining industry, its facilities permitting of 20,000 barrels of crude oil being treated daily. Another very prominent company is the Standard Oil Company of California, with its capital of $100,000,000. This Company not only produces its crude oil, but refines it, and engages in the export business. Its refinery at Point Richmond, California, is reported to be the largest in the world, for it can treat 65,000 barrels of crude oil daily. Its fleet of tankers and barges for the export trade is capable of carrying at one trip over 100,000 tons of products, and, for the purposes of its land transport, it possesses pipe-lines over 1,000 miles long.

Perhaps the second place of importance in regard to the petroleum enterprises of international influence should be given to the "Shell" Transport and Trading Company, Ltd., whose headquarters are in London, with that well-known oil pioneer, Sir Marcus Samuel, Bart., as its Chairman. Formed just over twenty years ago for dealing primarily as a transporter of petroleum products in the Far East, the "Shell" has steadily and continuously extended the sphere of its operations, until the result of a carefully thought out policy is seen in its activities in almost every oil-field of the world. Just over ten years ago, the Company made an amalgamation with the Royal Dutch Petroleum Company, or, to give it its correct name, the Koninklijke

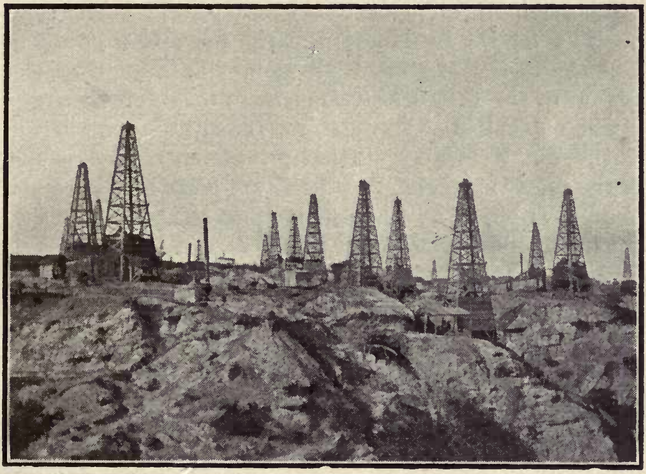
Nederlandsche Maatschappij tot exploitatie van petroleum-bronnen in Nederlandsch Indie (whose capital is £12,500,000), and by reason of so doing it materially increased its international position and importance. The "Shell"—Royal Dutch Combine to-day has a controlling interest in some of the largest operating companies in Russia, Roumania, California, Mexico, Venezuela, and other oil regions, one of its most recent extensions being in its advent into the petroleum industry of Trinidad. The "Shell" Company has a record for successful industrial expansion which is achieved by few companies in the world of commerce: its capital is now £15,000,000, and in dividends it has distributed over 300 per cent. Among the "Shell" Company's associated concerns, that of the Anglo-Saxon Petroleum Company, Ltd., which is responsible for the ocean transportation of the petroleum products of the Combine, takes first place, with its capital of £8,000,000; while the Asiatic Petroleum Company, Ltd. (capital, £2,000,000), ranks but second. Had space permitted, I would have liked to have dealt at length with the really remarkable manner in which this Company has trod the road of progress: its inception and consequent successful expansion reveal the master mind of Sir Marcus Samuel, Bart.

The sudden rise to fame of the oil-fields of Mexico gave birth to what may safely be referred to as one of the most enterprising amalgamations of capital in the long list of concerns associated with the petroleum industry, and it is gratifying to note that this enterprise was solely due to the well-known firm of Messrs. S. Pearson & Sons. Lord Cowdray, as the head, was not slow to recognize the vast opportunities which awaited the development of the Mexican fields, and the formation of the Mexican Eagle Oil Company, in 1908, with a capital of now $60,000,000 (Mexican), or about £6,125,000 sterling, was the initial result of his efforts. It was just about this time that the serious fuel oil era opened, both in this country and others, and it was evident that, for the purpose of adequately distributing the products of Mexican oil (and these include the whole range of refined oils, as well as fuel oil), there was room for the operations of a large and influential company. The Anglo-Mexican Petroleum Company, Ltd., was accordingly formed, with Lord Cowdray's son (the Hon. B. C. Pearson) as Chairman, and a capital of £2,000,000, to deal with the importation and distribution of Mexican petroleum products on the English market. Its success was assured from the first, and the increasingly important part which Mexican petroleums now play on the English market (and even more particularly for Government purposes) show the significance of its operations. Just when this edition was going to press (April, 1919), the official announcement was made that the "Shell" group had acquired control of the Mexican Eagle Oil Company—a fusion of interests without a parallel in the history of the petroleum trade.

The Mexican products are transported from Mexico to this country, as well as many others, by the large fleet of Eagle oil tankers, the property of the Eagle Oil Transport Company, Ltd., which admirably managed concern of £3,000,000 capital is also presided over by the Hon. B. C. Pearson.

Another highly important enterprise in the world of petroleum is that of the Burmah Oil Company, Ltd., which, as its name suggests, is occupied with the petroleum industry in Burmah, and catering for the almost unlimited needs of the Far East in regard to refined petroleum products. It controls enormous acres of oil-bearing territory held under lease from the Burmah Government, possesses extensive refineries at Rangoon, and has quite a fleet of oil tankers. Its capital is three and a half millions sterling, and its consistent success may be judged from the fact that it has paid over 400 per cent. in dividends. Of comparatively recent date, the Burmah Oil Company has turned its attention to other fields, particularly to Trinidad, but it is in connection with the development and subsequent operations of the fields of Burmah that the Company is chiefly concerned.

The Anglo-Persian Oil Company, Ltd., which is closely allied to the Burmah Oil Company (capital, £5,000,000) by reason of its large interest therein, has come into prominence during recent years, owing mainly to its agreement with the British Government, in which the latter invested over £2,000,000 of the public moneys in the enterprise. The Company acquired its petroliferous concessions from several interests, including the Burmah Oil Company and the late Lord Strathcona, which had been granted to them by the Persian Government. When I mention that the Company's concessions cover an area of, approximately, half a million square miles, and on which petroleum has been found in quantity on the majority of the small areas already examined, the significance of the enterprise will be somewhat appreciated. There is no doubt that the company's success is doubly assured, and, from this point of view, the investment of the public moneys in the undertaking has been sound finance, especially when one considers the important part which petroleum products under British control must hereafter play. As a matter of fact, the proposition is a well-paying one to-day, and it is asserted that the Government's interest is already worth no less than £20,000,000. Persia as an oil-producing country will occupy a very prominent place. The Company has immense petroleum-producing fields: it has its pipe-line to seaboard, and its refineries, situate on the Persian Gulf. It has possibilities without end, and there is no doubt that it will avail itself of most of them. The Company also now owns the entire capital of three formerly German-owned concerns in



A FEW OF THE BURMAH COMPANY'S PROLIFIC PRODUCERS

London—the British Petroleum Company, Ltd., the Homelight Oil Company, Ltd., and the Petroleum Steamship Company, Ltd. It has already been publicly announced that, by these acquisitions, the Anglo-Persian Company, Ltd., will, when normal times prevail, enter the English market as distributors of Persian petroleum. The question of transport need not here be considered, for the Anglo-Persian Oil Company owns the entire capital of the British Tanker Co., Ltd. The Company thus has the producing and refining possibilities: the acquired concern of the Tanker Company, together with that of the Petroleum Steamship Co., will suffice to bring its products to the English market, while the large distributing organizations of the British Petroleum Company and the Homelight Oil Company, owning depots all over the country, will offer easy facilities for the distribution of the petroleum products imported. My argument all along has been that the advent of the British Government into this enterprise—I will not call it a speculation, though at one time it looked like it—places all that private enterprise, which in the past has brought all the products of petroleum to our own doors at a reasonable and competitive price, at absolute discount. Ever since the petroleum industry assumed proportions of international magnitude, and we became more or less (I should have said more than less) dependent upon our necessities being met by petroleum and its products, private enterprise has always kept us well supplied. It has sunk its money—sometimes never to return—on behalf of the public weal, and just at the moment when the catering for the multitudinous consumers becomes shorn of its gambling aspect, the Government, by its arrangements with the Anglo-Persian Oil Company, Ltd., institutes what, in a mild way, is preference, if not Government monopoly. There is, of course, room for all, but I am rather inclined to agree with Sir Marcus Samuel, that these public moneys might have been turned to more useful account. In this respect I would mention the potentialities of Trinidad, Egypt and British Borneo, which, though under the Empire Flag, owe not the slightest portion of their success to Government assistance.

One might go on to interminable length in briefly referring to the great concerns whose operations have been responsible for the expansion of the world's petroleum industry to its present magnitude, but the exigencies of space prevent this. The brief list of companies already referred to represents an amalgamation of capital to the extent of nearly £120,000,000 sterling, though this cannot be considered as representing more than one-half the total world's investments in petroleum enterprises.

So far, I have not touched with the magnitude of the petroleum companies operating in the distributing oil trade of England, though, to some extent, this may be gathered from the references to such companies as the "Shell," the Anglo-Mexican Petroleum Company, etc

Practically the first company of any magnitude to distribute petroleum products in this country was the Anglo-American Oil Co., Ltd., which has actively engaged in this branch of commerce for the past thirty years. It imported and dealt in American oils long before the advent of the companies before mentioned, and, to-day, is certainly one of the largest—if not the largest—company so engaged. Its name is known in every hamlet in the country: its tank cars are seen on every railway, and its depots are to be found in every centre throughout the length and breadth of the land. Its name is legion. Its capital is £3,000,000, and it is to the Anglo-American Oil Company that, throughout the clatter of European War, the credit is due for having supplied us with those almost unlimited quantities of petroleum products so necessary both on sea and land, for it is the largest importer in the Kingdom. As its name implies, the "Anglo" deals mostly in American petroleum products: it was at one time the importing concern of the Standard Oil Company, but to-day it purchases broadcast in an endeavour—and a very successful one, too—to supply the British consumer with all the petroleum products he requires.

The present chapter deals, I feel, most inadequately with the general question of concerns whose interests are directly allied with that of petroleum: in fact, it was not my desire to give an encyclopaedia of the thousands of companies so engaged, but, rather, to suggest the names of a few which have secured world-wide distinction.

CHAPTER XIV

STATISTICAL

The World's Output of Petroleum

The world's total production of crude oil for 1917, and for the period of years 1857 to 1917, is given in the following table. The details are given in barrels, which, divided by seven, will give the output in tons.

Country	Production. 1917. Barrels of 42 Gallons.	P.C. of Total.	Total Production 1857-1917. Barrels of 42 Gallons.	P.C. of Total.
United States ...	*335,315,601	66·98	4,252,644,003	60·89
Russia	†69,000,000	13·78	1,832,583,017	26·24
Mexico	55,292,770	11·04	222,082,472	3·18
Dutch East Indies	‡12,928,955	2·58	175,103,267	2·51
India	†8,500,000	1·70	98,583,522	2·41
Galicia	5,965,447	1·19	148,459,653	2·13
Japan and Formosa	2,898,654	0·58	36,065,454	0·52
Roumania	2,681,870	0·54	142,992,465	2·05
Peru	2,533,417	0·51	21,878,285	0·31
Trinidad	1,599,455	0·32	5,418,885	0·08
Argentina	1,144,737	0·23	3,047,858	0·04
Egypt...........	1,008,750	0·20	2,768,686	0·04
Germany	995,764	0·20	15,952,861	2·30
Canada..........	205,332	0·04	24,112,529	3·50
Italy	50,334	0·11	947,289	0·01
Other countries ..	†§530,000		927,000	0·01
Total	500,651,086	100·00	6,983,567,246	100·00

* Quantity marketed.
† Estimated.
‡ Includes British Borneo.
†§ Includes 19,167 barrels produced in Cuba.

The Petroleum Import Trade of the United Kingdom

The imports of petroleum products into the United Kingdom for the past seven years are given in the following table. Those for **1917** are only approximate quantities inasmuch as, toward the end of the year, the Custom House authorities decided for the time being not to compile such statistics for general use. The figures in every case are given in gallons—

Oils.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Petroleum (Crude) .	74,334	12,742	1,108,900	15,105,588	—	—	—	—
,, (lamp) .	142,575,869	146,030,093	157,141,241	150,131,233	141,424,353	126,840,494	120,000,000	148,021,234
,, (lubricating)	60,526,599	69,327,061	67,962,493	66,646,512	69,974,170	80,443,694	85,000,000	102,244,220
,, (Gas Oil) .	58,008,508	73,273,526	65,949,677	83,105,346	88,089,202	57,160,493	33,000,000	41,079,752
,, (Fuel Oil) .	33,074,138	48,135,845	95,062,187	212,675,855	27,288,850	22,646,669	14,000,000	*842,356,837
,, (Other prdcts	3,447,786	963,856	24,178	17,942	705,353	1,728,092	900,000	—
Motor Spirit . . .	67,926,563	79,590,155	100,858,017	119,030,155	146,334,702	163,965,834	140,000,000	193,074,560
							Total	1,326,776,603

* These figures include the fuel oil also used for Admiralty purposes. During 1917 these figures were approximately 420,000,000 gallons, but the quantities were kept secret until the termination of the war.

America's Crude Oil Production During the Past Fifty Years

The output of crude petroleum in the oil-fields of America during the past fifty years has been as under, the figures being given in barrels of 42 gallons (usually reckoned at seven to the ton)—

Year.	*Barrels.*	*Year.*	*Barrels.*
1869	4,215,000	1894	49,344,516
1870	5,260,745	1895	52,892,276
1871	5,205,234	1896	60,960,361
1872	6,293,194	1897	60,475,516
1873	9,893,786	1898	55,364,233
1874	10,926,945	1899	57,070,850
1875	8,787,514	1900	63,620,529
1876	9,132,669	1901	69,389,194
1877	13,350,363	1902	88,766,916
1878	15,396,868	1903	100,461,337
1879	19,914,146	1904	117,080,960
1880	26,286,123	1905	134,717,580
1881	27,661,238	1906	126,493,936
1882	30,349,897	1907	166,095,335
1883	23,449,633	1908	178,527,355
1884	24,218,438	1909	183,170,874
1885	21,858,785	1910	209,557,248
1886	28,064,841	1911	220,449,391
1887	28,283,483	1912	222,935,044
1888	27,612,025	1913	248,446,230
1889	35,163,513	1914	265,762,535
1890	45,823,572	1915	281,104,104
1891	54,292,655	1916	300,767,158
1892	50,514,657	1917	335,315,601
1893	48,431,066	1918	360,000,000

Roumania's Crude Oil Production During the Past Fifty Years

Roumania's crude oil production for the past fifty years is given in the following table in barrels of 42 gallons (seven to the ton). The officially recorded output goes back as far as 1857, when the twelve months' yield was just under 2,000 barrels. During 1861, the production passed the 10,000 barrel mark for the first time, and six years later reached 50,000 barrels for the year. The figures are as under—

Year.	*Barrels.*	*Year.*	*Barrels.*
1868	55,369	1893	535,655
1869	58,533	1894	507,255
1870	83,765	1895	575,200
1871	90,030	1896	543,348
1872	91,251	1897	570,886
1873	104,036	1898	776,238
1874	103,177	1899	1,425,777
1875	108,569	1900	1,628,535
1876	111,314	1901	1,678,320
1877	108,599	1902	2,059,935
1878	109,300	1903	2,763,117
1879	110,007	1904	3,599,026
1880	114,321	1905	4,420,987
1881	121,511	1906	6,378,184
1882	136,610	1907	8,118,207
1883	139,486	1908	8,252,157
1884	210,667	1909	9,327,278
1885	193,411	1910	9,723,806
1886	168,606	1911	11,107,450
1887	181,907	1912	12,976,232
1888	218,576	1913	13,554,768
1889	297,666	1914	12,826,578
1890	383,227	1915	12,029,913
1891	488,201	1916	10,298,208
1892	593,175	1917	2,681,870

Mexico's Remarkable Progress in Crude Oil Production

Fourteen years ago, the crude petroleum production in the oil-fields of Mexico was officially recorded for the first time. Its remarkable progress since that time will be seen from the following table, the figures being in barrels of 42 gallons—

Year.	*Barrels.*	*Year.*	*Barrels.*
1904	220,653	1912	16,558,215
1905	320,379	1913	25,902,439
1906	1,097,264	1914	21,188,427
1907	1,717,690	1915	32,910,508
1908	3,481,610	1916	39,817,402
1909	2,488,742	1917	55,292,770
1910	3,332,807	1918	64,605,422
1911	14,051,643		

Galician Crude Oil Production

The output of crude petroleum in the Galician fields during the past thirty years is given herewith—

Year.	*Barrels.*	*Year.*	*Barrels.*
1888	466,537	1904	5,947,383
1889	515,268	1905	5,765,317
1890	659,012	1906	5,467,967
1891	630,730	1907	8,455,841
1892	646,220	1908	12,612,295
1893	692,669	1909	14,932,799
1894	949,146	1910	12,673,688
1895	1,452,999	1911	10,519,270
1896	2,443,080	1912	8,535,174
1897	2,226,368	1913	7,818,130
1898	2,376,108	1914	5,033,350
1899	2,313,047	1915	4,158,899
1900	2,346,505	1916	6,461,706
1901	3,251,544	1917	5,965,447
1902	4,142,159	1918	4,341,050
1903	5,234,475		

Germany's Crude Oil Production

Official figures were first recorded of Germany's crude oil production in 1880, when the total output for the twelve months was about 9,000 barrels. For the past thirty years, the yearly output has been as under—

Year.	*Barrels.*	*Year.*	*Barrels.*
1888	84,782	1904	637,431
1889	68,217	1905	560,963
1890	108,296	1906	578,610
1891	108,929	1907	756,631
1892	101,404	1908	1,009,278
1893	99,390	1909	1,018,837
1894	122,564	1910	1,032,522
1895	121,277	1911	1,017,045
1896	145,061	1912	1,031,050
1897	165,745	1913	1,002,700
1898	183,427	1914	936,400
1899	192,232	1915	960,430
1900	358,297	1916	948,320
1901	313,630	1917	995,764
1902	353,674	1918	820,310
1903	445,818		

Exports of Petroleum Products from the United States

The following table gives the total export movement of petroleum products from the United States from the year 1865, when American petroleum products commenced to have an international overseas market—

Year.	*Gallons.*	*Value in Dollars.*	*Year.*	*Gallons.*	*Value in Dollars.*
1918	2,714,430,452	344,290,441	1891	710,124,000	52,026,000
1917	2,596,900,000	253,021,000	1890	664,491,000	51,403,000
1916	2,607,482,000	201,721,000	1889	616,195,000	49,913,000
1915	2,328,725,000	142,941,000	1888	578,351,000	47,042,000
1914	2,240,033,000	139,900,000	1887	592,803,000	46,824,000
1913	2,136,465,000	149,316,000	1886	577,628,000	50,199,000
1912	1,883,479,000	124,210,000	1885	574,628,000	50,257,000
1911	1,768,731,000	105,922,000	1884	513,660,000	47,103,000
1910	1,546,067,000	99,090,000	1883	505,931,000	44,913,000
1909	1,561,671,000	105,999,000	1882	559,954,000	51,232,000
1908	1,443,537,000	104,116,000	1881	397,660,000	40,315,000
1907	1,257,430,000	84,855,000	1880	423,964,000	36,208,000
1906	1,257,949,000	84,041,000	1879	378,310,000	40,305,000
1905	1,123,334,000	79,793,000	1878	338,841,000	46,574,000
1904	984,424,000	79,060,000	1877	309,198,000	61,789,000
1903	941,699,000	67,253,000	1876	243,660,000	32,915,000
1902	1,106,208,000	72,302,000	1875	221,955,000	30,078,000
1901	1,034,643,000	71,112,000	1874	247,806,000	41,245,000
1900	967,252,000	75,611,000	1873	187,815,000	42,050,000
1899	999,713,000	56,273,000	1872	145,171,000	34,058,000
1898	1,034,249,000	56,125,000	1871	149,892,000	36,894,000
1897	973,514,000	62,635,000	1870	113,735,000	32,668,000
1896	890,458,000	62,383,000	1869	100,636,000	31,127,000
1895	884,502,000	46,660,000	1868	79,456,000	21,810,000
1894	908,252,000	41,499,000	1867	70,255,000	24,407,000
1893	904,337,000	42,142,000	1866	50,987,000	24,830,000
1892	715,471,000	44,805,000	1865	25,496,000	16,563,000

Russia's Crude Oil Production During the Past Fifty Years

The output of crude petroleum in the Russian oil-fields during the past fifty years is given in the following table. For the purpose of comparison, the figures are given in barrels of 42 gallons, rather than in poods (62 to the ton) which is the usual manner of recording Russian quantities. The figures are as under—

Year.	*Barrels.*	*Year.*	*Barrels.*
1869	202,308	1894	36,375,428
1870	204,618	1895	46,140,174
1871	165,129	1896	47,220,633
1872	184,391	1897	54,399,568
1873	474,379	1898	61,609,357
1874	583,751	1899	65,954,968
1875	697,364	1900	75,779,417
1876	1,320,528	1901	85,168,556
1877	1,800,720	1902	80,540,044
1878	2,400,960	1903	75,591,256
1879	2,761,104	1904	78,536,655
1880	3,001,200	1905	54,960,270
1881	3,601,441	1906	58,897,311
1882	4,537,815	1907	61,850,734
1883	6,002,401	1908	62,186,447
1884	10,804,577	1909	65,970,250
1885	13,924,596	1910	70,336,574
1886	18,006,407	1911	66,183,691
1887	18,367,781	1912	68,019,208
1888	23,048,787	1913	62,834,356
1889	24,609,407	1914	67,020,522
1890	28,691,218	1915	68,548,062
1891	34,573,181	1916	72,801,110
1892	35,774,504	1917	34,700,000
1893	40,456,519	1918	22,582,000

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