1933.
NEW ZEALAND.

PRODUCTION OF OIL IN NEW ZEALAND.

STATEMENT BY THE MINISTER OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RIGHT HON. G. W. FORBES).

Laid on the Table of the House of Representatives by Leave.

Arising from their high calorific value, and the ease and high efficiency of their conversion into power, fuel oils have, during the last thirty years, become of great importance to all countries, and particularly owing to the development of motor-car industry.

The following tables show world petrol production and consumption in 1931:—

Production.

	Millions of Barrels (1 Barrel = 35 Imperial Gallons).	Percentage of World Production.
United States	441·3	78·6
Russia	19·8	3·5
Dutch West Indies	16·5	2·9
Canada	13·0	2·3
Dutch East Indies	13·0	2·3
Roumania	12·1	2·2
Persia	10·5	1·9
United Kingdom	5·3	0·9
Mexico	4·2	0·8
Argentina	3·8	0·7
Others	21·8	3·9
	561·3	100·0

The annual production of crude oil throughout the world is of the order of 180 million tons, of which less than 20 million tons are consumed as bunkers at sea. The world's annual production of coal is much greater, and in 1932 amounted to over 1,000 million tons.

Consumption (1931).

	Millions of Barrels.	Percentage of World Production.
United States	405·1	72·9
United Kingdom	28·2	5·1
France	19·1	3·4
Canada	15·8	2·8
Germany	14·0	2·5
Australia	6·0	1·1
Russia	5·4	1·0
Argentina	5·4	1·0
Japan	5·1	0·9
Italy	3·5	0·6
New Zealand	1·7	0·3
Others	46·3	8·4
	555·8	100·0

The consumption figures for New Zealand since 1928 are as follows:—

NEW ZEALAND CONSUMPTION OF PETROL, IN MILLIONS OF GALLONS.

Year.	By Motor-vehicles.	By other Means (Engines, Aero-planes, &c.).	Total.
1928	41·45	2·0	43·5
1929	56·6	3·6	60·2
1930	62·8	3·9	66·7
1931	55·2	5·2	60·4
1932	49·8	5·4	55·3

The value of the imports of petrol and crude oil into New Zealand for the same period were as follows (the values represent the current domestic values in the countries of export plus 10 per cent.):—

Calendar Year.	Motor-spirit.	Crude Petroleum, Crude Residual Oil, Once-run Shale Oil, and Crude Distillate of Petroleum.
	£	£
1928	1,655,000	447,000
1929	2,131,000	328,000
1930	2,090,000	498,000
1931	1,243,000	417,000
1932	1,116,000	373,000

MANUFACTURE OF PETROL FROM COAL.

It is well known that the demand for coal in New Zealand is decreasing, and while it is possible that with the general revival of trade the demand may rise, the industry has had to face the position that unless there is a large increase in population or unless new uses are found for coal the demand may not be so great as in the past. The reduced demand is partly the result of more economic use in power production, partly the competition of hydro-electric power, and partly the increased use of oil owing to its greater convenience, particularly in shipping.

Under New Zealand conditions, except when convenience is a very major factor, coal (or gas) is still pre-eminently the most economic source of domestic or industrial heating, but for conversion into mechanical power for mobile units oil is undoubtedly the most satisfactory fuel.

Oil may be obtained from coal by three different processes—namely, high-temperature carbonization, low-temperature carbonization, and hydrogenation.

High-temperature Carbonization.

This is the usual process operated at gasworks, where coal is carbonized at temperatures of from 1,000° to 1,400° C. While gas and coke are the main products, a small amount of light oil is obtained by distillation of the by-product tar. This does not exceed half a gallon of benzole and naphtha per ton of coal carbonized.

It is possible to recover a further quantity of benzole, suitable for use as motor-spirit, from the gas by the use of a wash oil, or by means of absorbent carbon. This further quantity does not exceed 2 to 3 gallons per ton of coal carbonized. The process is in operation in many places in Great Britain and the Continent, but not yet in New Zealand. Only the largest gasworks in New Zealand could install the requisite plant, and if they did so approximately 400,000 gallons of benzole would be recovered per annum. This represents 0·75 per cent. of New Zealand's consumption of motor-spirit. Even this would increase the coal used for carbonization by 8 per cent., and would provide employment for an additional sixteen men at the works and approximately forty at the mines. Recovery of benzole from coal-gas in the Dominion would therefore appear to warrant some encouragement.

Low-temperature Carbonization.

Coal can also be treated by carbonization at lower temperatures—say, from 450°–700° C., and the main product, if bituminous mixtures are used, is then a free-burning, smokeless coke suitable for use in the domestic grate and comprising up to 75 per cent. of weight of the coal carbonized. In this case there is also a good yield of tar, about 20 gallons per ton of coal carbonized from certain classes of coal, with gas as a subsidiary, but yet an important by-product. If sub-bituminous non-caking coals such as Waikato or Kaitangata are used the yield of tar is somewhat less, being from 16 to 17 gallons per ton, and the carbonized residue, amounting to 55 per cent. of the coal treated, must be briquetted for domestic purposes.

From both the tar and the gas it is possible to obtain a spirit which, after refining, is suitable as a motor-fuel. That which is contained in the tar may be obtained by "fractional distillation"—that is, by heating the tar, separating the vapours given off, and condensing them. The spirit is recovered from the gas by the process of "scrubbing," similar to the method of obtaining benzole from the town gas.

The total yield of spirit from the tar and gas varies from 2 to 4 gallons per ton of coal carbonized, and it has proved itself under test to be an excellent motor-fuel. Much greater yields of tar spirit can be obtained, however, by hydrogenation of the tar and the 20 gallons of tar referred to above would, in this manner, produce 14 gallons of motor-spirit and 6 gallons of Diesel oil.

It is clear that if motor-spirit is to be obtained in large quantities by the low-temperature process, it is in the hydrogenation of tar that it must be sought. Nevertheless, the scale of production which would be possible in New Zealand owing to the limited market for the carbonized residue, either as coke or as briquettes, is such that the necessary capital costs of hydrogenation would not be justified.

It must be noted that in low-temperature carbonization the main product is *coke*, not tar.

It will be seen from the above that there is little hope of effectively producing large quantities of petrol in New Zealand as by-products of *distillation* of coal, since, at the most, not more than 5 per cent. by weight of the coal is converted into petrol.

Hydrogenation.

This, as the name indicates, is a method by which hydrogen gas is made to unite chemically with the solid coal, giving a liquid oil. The process will be understood by reference to the following table, which gives a comparison of the principal types of coal used in New Zealand and imported oil fuels :—

—	Water lost 105° C., *i.e.*, Free Moisture.	Gross Calorific Value B.Th.U. per Pound.	Ultimate Analysis on Dry Ash-free Material.				
			Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.
	Per Cent.						
Bituminous coal (Millerton)	1·3	15,000	84·4	5·6	6·8	1·1	2·1
Sub-bituminous coal (Waikato Field or Southern)	15·0	10,500	73·2	5·4	20·0	1·1	0·3
Lignite (Mataura) ..	30–40	7,500	67·2	5·5	25·6	1·1	0·6
Crude petroleum ..	..	19,000	84–85	11·5–12·5		2·0	
Fuel oil from crude ..	..	19,000	86	12		2·0	
First-grade petrol ..	..	20,000	85·3	14·7	..	..	..

It will be seen that the oils have a greater calorific value than even the best of the coals. Another difference is that the ratio of hydrogen to carbon, from the figures in the ultimate analyses, is 1 to 14 or 15 in the case of the coals, and 1 to 6 or 7 in the case of the oils. The process of hydrogenation of coal consists in bringing about a combination of hydrogen gas and coal substance, so as to increase the ratio of hydrogen to carbon. The coal substance is thus changed from solid to liquid form, and in practice a point can be reached which represents the conversion of 70 per cent. by weight into petrol. High pressures are required, up to 3,000 lb. per square inch, and temperatures of from 400° to 450° C. To increase the speed of the reaction between the hydrogen and the coal substance numerous catalysts have been tried, among the most successful being iron sesquioxide and compounds of molybdenum.

Briefly, the process of hydrogenation consists in grinding the coal finely, mixing it with selected catalysts (substances that permit or expedite a chemical reaction while themselves unchanged at the end), and a small quantity of heavy oil and pumping it to a reaction chamber kept at the required temperature to which compressed hydrogen gas is also admitted. The coal absorbs hydrogen and is changed into a liquid which flows from the reaction chamber, and is distilled to remove the petrol. The heavier-oil fraction remaining is treated a second time with hydrogen, until some 70 per cent. of weight of the total coal substance has been converted into petrol. Approximately 20,000 cubic feet of hydrogen are required for each ton of coal hydrogenated.

The hydrogen may be prepared from water-gas, a mixture principally of hydrogen, 50 per cent., and carbon monoxide, 40 per cent., obtained by blowing steam over incandescent coke. The water-gas, together with steam, is passed over suitable catalytic materials, when the steam and the carbon monoxide react to form hydrogen and carbon dioxide. The latter is removed by washing, and further treatment gives hydrogen of satisfactory purity. Some hydrogen may also be prepared by suitable treatment of the fixed gases resulting from the hydrogenation process. The preparation of hydrogen and the power requirements of the plant bring the total consumption of coal to 3½ tons for every ton of petrol produced.

The complexity and cost of the plant and operations may be judged from the fact that of the total estimated production cost of petrol by this method in New Zealand only about one-seventh represents the cost of the raw coal.

Hydrogenation Overseas.

Though the theory of hydrogenation is simple, the practice is difficult and a large capital cost is involved. As is well known, the Imperial Chemical Industries have made researches on the subject during the last ten years which are credibly reported to have involved an expenditure of one million pounds sterling. Work has also been carried out in Germany by the Interessen-Gemeinschaft, or I.G., but they operate chiefly on lignite tars and raw lignites.

Recently the Imperial Chemical Industries, the Interessen-Gemeinschaft of Germany, and the Standard Oil Supplies of America have pooled their resources and patents and the I.C.I. have made arrangements with the British Government to make a start immediately with a large plant to be erected at Billingham-on-Tees to produce 100,000 tons per year of first-grade petrol—*i.e.*, 30,000,000 gallons to be marketed through existing channels. In this plant about 400 tons of coal per day will be put through the process and another 600 tons per day will be required to make the necessary hydrogen and produce the required temperatures and processes in the circuit. It is understood that the capital cost is 2 to 2½ millions sterling, which will be provided by I.C.I. from their existing resources. This is not the total cost, however, since part of the plant for production of hydrogen is already in existence in connection with the production of nitrogenous fertilizers and other allied industries.

It is estimated that the cost of production of petrol at Billingham will be about 7½d. per gallon, including all interest and obsolescence charges.

The British Government has pledged itself to give the petrol produced by the hydrogenation process a preference of 4d. per gallon for nine years reckoned from April, 1935; alternatively a preference of 8d. per gallon for 4½ years or something intermediate as circumstances demand. The constructional work is to be spread over a period of one year and a half, and it is stated that the construction will give employment to seven thousand men directly and five thousand men indirectly.

Position in New Zealand.

It will be appreciated that costs of production in New Zealand are likely to be higher than in Great Britain, even allowing for the probability that coal can be mined cheaper, because of the more favourable seams. It is probable that the cost of production of petrol from coal in New Zealand would be of the order of 11d. to 1s. per gallon (New Zealand currency) for a plant of 20,000,000 gallons capacity per annum—*i.e.*, one-third of New Zealand's consumption, which is presumably as large a plant as it would be wise to install in any one place. The capital costs would be in excess of £3,500,000 (New Zealand). The cost of production per gallon of petrol may roughly be divided as follows:—

	d.
Cost of coal (including that for power)	1½
Interest on capital 5 per cent.	2
Obsolescence: Chiefly process obsolescence	4
Processing and maintenance	3½
Piping to port	?

These figures indicate the important part which interest on capital and obsolescence plays and appear to indicate clearly that we must await the first six months' operations of the plant to be erected in England in the hope that experience will show that the capital cost may be reduced. It would appear that a larger remission of duty would be necessary in New Zealand than is the case in Great Britain. The total coal used by such a unit as the above would be of the order of 240,000 tons per year, which, with modern methods of mining for regular production, would hardly employ more than of the order of 300 men in the mines, though there would probably be another 350 men employed in the works. The steady employment of this number of men would, of course, give occupation in other industries and services, but there is no data to show how many. There would be considerable employment during erection and it would be a matter for consideration as to what money would be returned to the State both in the form of saved employment pay and from receipts for taxation. It does not appear that these advantages would at present offset the enormous interest charge on the capital involved and obsolescence charges.

Allied Industries.

There is another consideration in connection with the success of such a project in New Zealand—namely, the development alongside of hydrogenation of other intimately associated chemical processes such as the production of ammonia for fertilizers and the economic utilization of carbon dioxide, which is a by-product of the production of hydrogenation. Judging by experience elsewhere, hydrogenation cannot well stand by itself. Both Billingham and the Interessen-Gemeinschaft works at Leuna illustrate the intimate way in which apparently each chemical manufacture must be linked together if even a small measure of economic success is to be attained. There is a further possibility in the hydrogenation of coal in that by controlling the catalyst, fair yields can be obtained in the main and subsidiary processes of such materials as phenols and formaldehyde, the bases of the synthetic resins and moulded products industries which are at the present time undergoing rapid expansion. It would thus be unwise to consider hydrogenation of coal for oil by itself, and the production of ammonium compounds such as ammonium nitrate and possibly ammonium phosphate would need to be considered alongside. There is, of course, the point of view of Defence, regarding the production inside the country of petrol and of nitrogen compounds, which latter are the basis of explosives. Moreover, all these factors enter into the question of a suitable site. It is important that the production of petrol should be near the centre of large consumption or, alternatively, that it should be produced as near as possible to a port, since the cost of piping would add considerably to the unit cost. It is difficult to estimate on this point, but it clearly indicates that coal resources near the centre of consumption of petrol or near a port are the only ones which need be considered.

Another question to consider is the availability of large supplies of water for cooling.

Taking the whole evidence into consideration, it would appear safest to wait for a few years until the experiments at Billingham has been thoroughly completed on the large scale at present under consideration.

Refining of Imported Crude Oil.

Suggestions have been made from time to time that New Zealand should import crude oil, but that the refining should be carried out in New Zealand. In the early days of the industry refining was carried out by simple distillation; afterwards methods of cracking were available which gave a higher yield, and at present the average yield of petrol from crude oil is approximately 45 per cent.

Hydrogenation of oil is now being carried out by the Standard Oil Company at New Jersey, and larger yields are likely. It will be seen, however, that under present conditions the amount of crude oil used is over twice the amount of petrol produced, so that any saving of transport due to the decreased risk with crude oil is probably more than offset by the greater bulk to be carried; moreover, some of the by-products of the cracking or distillation process would be produced in too large a quantity to be wholly consumed in New Zealand. Consequently, until the processes are more firmly standardized the present procedure of importing petrol seems the most economic.

In connection with the increased tendency towards the use of Diesel engines for lorries and motor-vehicles and the possibility of their expansion to the motor-car, it is worthy of note that the design of motor-engines should proceed alongside any alterations in the type of fuel oil which may be developed.

General Theoretical Energy Consideration.

It will be appreciated from the foregoing general considerations that it is essential that coal should be converted from a solid mass into a fluid for convenience of application in many branches of industry, and that for this purpose two processes are available, the first gasification and the second hydrogenation for oil. Although hydrogenation gives us about 30 to 35 per cent. of petrol on total coal used, including that for hydrogen and power, while gasification gives us less than 5 per cent. of petrol, there is in the latter case the fuel value of the gas, &c., and actually the waste or loss of energy by the latter process is approximately only 20 per cent. of that contained in the material treated and consumed. In hydrogenation, however, in spite of the larger yield of petrol, the actual loss of energy involved is more than 60 per cent., and the object achieved is the production of a substance which at the present time Nature itself is yielding in plethoric quantity. Whatever the merits of either processes may be, it is a matter of first interest to the coal industry that they should be watched and tested. Encouragement of research by colliery-owners and coal-merchants would be an important step in the right direction. Synthesis of products at high temperatures and pressures, now possible because of the development of steels to withstand these conditions, is only in its infancy, and it may well be that such processes applied to coals may eventually produce commodities of greater intrinsic value than oil.

PRODUCTION OF FLOW OIL OR PETROLEUM.

Petroleum is particularly widespread throughout the world, despite the general belief that there is a very limited quantity available for future generations. From the geographic standpoint, petroleum may be located in any part of the world. It has been found in the Arctic Circle, on the Equator, and in the temperate zones.

An oil-pool is primarily a geologic phenomenon. It occurs within some kind of porous reservoir rock, never as a lake of oil, and is definitely associated with some type of geologic structure. It exists because in relation to its structure the escape of crude oil in any direction is prevented by impervious rocks which seal the reservoir.

Man's earliest prospecting for oil was dependent upon the surface indications in the form of seepages, oil-flow, asphalt deposits, gas, mineral waxes, bituminous shales, saline ground waters, stunted vegetation, or a combination of these. However, the existence of oil is not limited to such places, nor is it necessarily true that deposits are located under seepages, for the oil may have migrated laterally through the lower earth-layers for some distance.

The industry has been forced, because of the tremendous cost involved in drilling a well—with chances of bringing in a dry hole—to call in every branch of known science that may throw light upon the definite finding of oil. The geologist and the engineer, the physicist, the chemist, the palæontologist, are all brought into the picture, contributing their collective knowledge as to the best location for the well.

First comes the geologist, with his special training, to survey the ground at close quarters, identifying the age and types of structure located there. He examines "outcrops" of rock which jut from the earth's surface, determining their ages, whether they are soft and porous or hard and solid, and deducting from position and arrangement the probable formation under the surface. Soft, porous rock or sand formations are more likely to contain oil than hard solid ones.

More than surface indications are necessary, however, to determine the presence of petroleum, and the geophysical prospector is called upon to investigate the properties of the sub-surface earth. He makes use of instruments, some of which have long been associated with the mineral industries, while others are only now being developed to fit present conditions. Several of these instruments simply record variations in the earth's natural forces. Others, on the contrary, take advantage of the physical properties of the substances of which the earth is made, but employ man-made disturbances in order to identify such properties. The outstanding advance of the past year has been the development of seismic reflection methods to outline or contour subsurface st ucture.

There is, of course, nothing absolutely definite in locating oil. The drill itself is the answer. During the year 1930 a total of 21,165 wells was completed in the United States of America, of which 11,577 struck oil, 2,885 found gas, and 6,703 were dry, these last representing over £32,000,000 loss for the oil industry.

THEORIES OF OIL ORIGIN WITH APPLICATION TO NEW ZEALAND.

The many theories accounting for the oil found in rocks, may, in a general way, be divided into two groups, one group assuming the oil to be derived from the remains of animals and plants and the other ascribing it to chemical reactions in the interior of the earth. Naturally, one cannot reproduce geological conditions in the laboratory, and no theory can be proved beyond the shadow of doubt. Nevertheless, the facts of distribution of petroleum combined with those derived from controlled experiments make it most probable that the oil of commerce is organically produced, from fish, molluscs, sea-weeds, or land plants, as well as from the tiny hard-shelled animals (foraminifera) and plants (diatoms) that live in the sea in countless myriads.

The mud, sand, and limestone constantly being laid down on the sea-floor contain all these organisms; the amount in the aggregate is vast. From the weight of the later overburden, from earth stresses, from heat rising from below, and from cementation by infiltering solutions, these deposits are consolidated into the sedimentary rocks which form a large proportion of the present land. Petroleum in one or other of its many forms is in all rocks of this kind, but its occurrence in amounts that allow of its profitable extraction by man is comparatively rare. Heat and pressure have affected large areas of sedimentary rocks so intensely that the oil they originally contained is now destroyed or driven out. Such are the schists of Otago and Marlborough and the shattered sandstones and slates of the Southern Alps, the Kaikouras, and the main ranges of the North Island. In these rocks it is as hopeless to expect oil in commercial amount as to look for it in the lavas of Hauraki and Tongariro or in the granites of Nelson and Fiordland. The rocks that may yield oil in payable quantity, though they may be compact and strong, still have pore space between the component grains of the bands of sandstone and are covered by strata impervious enough to prevent the ready escape of oil. Though the physical condition of the rocks is much more important than their age, sediments favourable for the occurrence of petroleum are most common in the younger part of the geological rock column, and are most abundant in what are known as the Tertiary and Cretaceous periods of the geological time scale. These rocks have not been so deeply buried or subjected to so many earth stresses as those of greater age. Roughly, the Tertiary rocks were laid down between two and sixty million years ago and the Cretaceous from sixty to a hundred million years ago. Marine sediments of these ages or areas covered with gravel moraine or volcanic ash beneath which such formations do, or may, occur occupy about two-fifths of New Zealand's land-surface.

In general, the sediments as they are deposited, even those richest in organic remains, contain but a small proportion of oil or of substances that yield oil, and where petroleum occurs in commercial amount, it has segregated from a considerable body of rock. Owing to the compaction of the beds under the gradually increasing overburden, to the filling-up of the voids, to the increase of temperature with depth, and to a number of other causes the oil tends to leave the mud and to enter the sand-beds. Along these it migrates from areas of high to areas of low pressure, always seeking to escape to the surface. But if, as very commonly happens, earth stresses have faulted, folded, or otherwise disturbed the original horizontal layers of sediments, "trap" structure are formed in which the oil accumulates and from which it cannot escape. In such places, masses of porous rock become saturated with oil and form what are popularly called "oil-pools." The petroleum such reservoirs contain exudes from the pores and enters any bore that may be drilled and which penetrates them.

There are many oil-seepages and gas-emanations widely scattered over New Zealand, but in some of the districts containing such indications conditions are present which geologists, from a close study of producing oil-fields, know to be definitely unfavourable. The conditions are promising, however, where relatively soft marine strata cover wide areas and contain porous sandstones lying between shales twice or more times as thick again. In the five districts in which the indications of oil are unusually strong these favourable geological conditions are also present. These districts are Taranaki, the East Cape, Gisborne region, the Murchison basin, and North Westland.

The Maoris knew of the strong oil escapes from the shallow sea floor near New Plymouth long before the coming of Europeans. Since 1866 numerous wells have been sunk in the neighbourhood, several have yielded considerable amounts of oil, one, still flowing vigorously, has given about half a million gallons, and the small area between New Plymouth and the Breakwater has yielded altogether over two million gallons. There are at least three oil-horizons, the most productive being a little over 2,000 ft. below the surface. East, south, and west thick volcanic debris covers the whole district, for many miles and obscures the structure of the oil-yielding strata. These rocks, however, are exposed in eastern and northern Taranaki, and consist of Tertiary sandstone and mudstone many thousands of feet in thickness, and these, though strong faults occur, are in general, folded only gently. The three or four bores drilled in eastern Taranaki, though they yielded shows of oil, were unsuccessful but were quite inadequate to test the many square miles of possible country, or even the known structures. At New Plymouth, from what can be made of the bore logs and from general considerations, the beds have gently dipped. Close to the west, volcanic rock rises through the Tertiary sediments and forms the steep-sided hill of Paritutu and the neighbouring Sugarloaves, and these may be connected in some way with the accumulation of the oil.

Indications of oil and gas are widespread in the East Cape – Gisborne district, where the rocks are of younger Cretaceous and Tertiary age, both sets containing great thickness of favourable rocks. The oil, however, is chiefly derived from the Cretaceous beds among which are massive layers of black shale which most geologists consider a likely source of petroleum. The structure of the beds is decidedly complex. The Cretaceous strata were strongly folded and partly destroyed by erosion before the Tertiary sediments were laid down. During and after the deposition of the latter the whole region was deformed on several occasions. A considerable amount of boring has been done, but only a few barrels of oil have been obtained; most of the numerous trap structures or anticlines, however, are not drilled and several of those that have been bored are not properly tested. There are great practical difficulties in boring in the disturbed Cretaceous rocks, and some wells had to be abandoned before the desired objective was reached. The oil-seepages, gas-emanations, mud volcanoes, salt springs, and other indications are so widespread, while in addition thick promising strata cover so large an area that the undertaking of further drilling is very desirable. The general structure, however, is so complex that no well should be bored without the most careful geological and geophysical exploration.

Geological conditions, though similar, are probably not so favourable in southern Hawke's Bay and eastern Wellington, which form the southern part of the same petroliferous area.

The Murchison basin is an area of Tertiary rocks sixty miles long and up to twelve miles wide, enclosed in the mountains of western Nelson. There are 20,000 ft. of Tertiary sandstones, mudstones, and conglomerates which are thrown into a series of folds. Oil seeps out at several points along faults, but so far only one well has been drilled and this was unsuccessful at a depth of 3,474 ft. The folds are sharp and broken, and no drilling should be carried out without careful detailed mapping.

The strongest oil seepages in New Zealand are at Kotuku on North Westland, about twenty miles east of Greymouth. The surface gravels over an area of several acres are heavily impregnated with petroleum which readily collects in any holes that are dug. The area is in the extensive lowland which stretches southwards as a rather narrow strip to Ross and northwards between the Southern Alps and the Paparoa Mountains towards Reefton. Unfortunately, gravels and moraine largely conceal the Tertiary sandstone, mudstone, and limestone that seems to underlie the whole area. The results of a good many bores at Kotuku are unsatisfactory for the total yield is only a few hundred barrels. Two bores reached the underlying ancient rocks. Here there seems to be a gentle anticline somewhat complicated by faulting. Untested structures in the region some distance from Kotuku are worthy of careful investigation.

Much of the search for oil in New Zealand has been carried out on the fatalistic principle that the success of prospecting is so uncertain that no care or skill is required in the selection of the sites of bores. Some wells have been sunk because a seepage was close at hand, others because the access was good, and others after a most cursory geological examination. Such methods have provided costly failures. Though the uncertainties of drilling are known full well, the success of approved methods of locating bores is so manifest that disregard of geological consideration bespeaks negligence.

Conclusion.

It will be seen from the foregoing that the chances of finding "flow" oil in New Zealand, sufficient for her requirements and possibly also for those of Australia are reasonably good. Even if found, however, economic development under present world conditions is largely influenced by the cost of transport presumably by pipe-line, to the nearest port or centre of distribution. Nevertheless, the evidence submitted justifies an extensive geological and geophysical programme, the cost of which is extremely small compared with the interest on the capital cost involved in the production of oil by other methods. The possibilities of finding flow oil must be considered in connection with any proposals for hydrogenation, and it is preferable that these possibilities should first be investigated by an intensive programme during the next few years.

Approximate Cost of Paper.—Preparation, not given; printing (680 copies), £8 10s.

By Authority: G. H. Loney, Government Printer, Wellington—1933.

Price 6d.]