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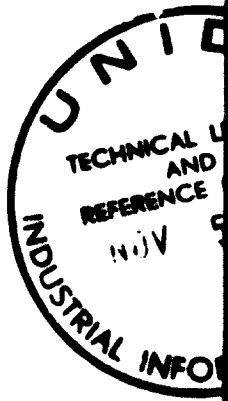
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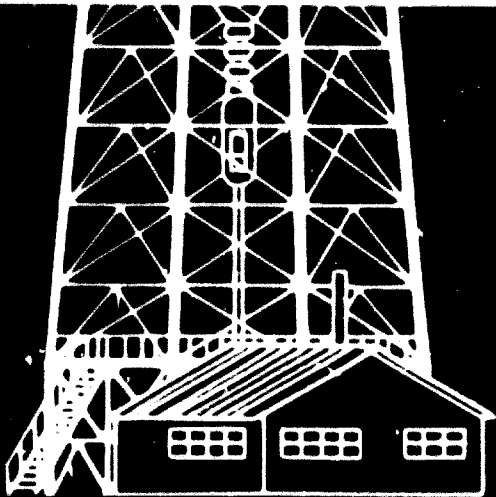
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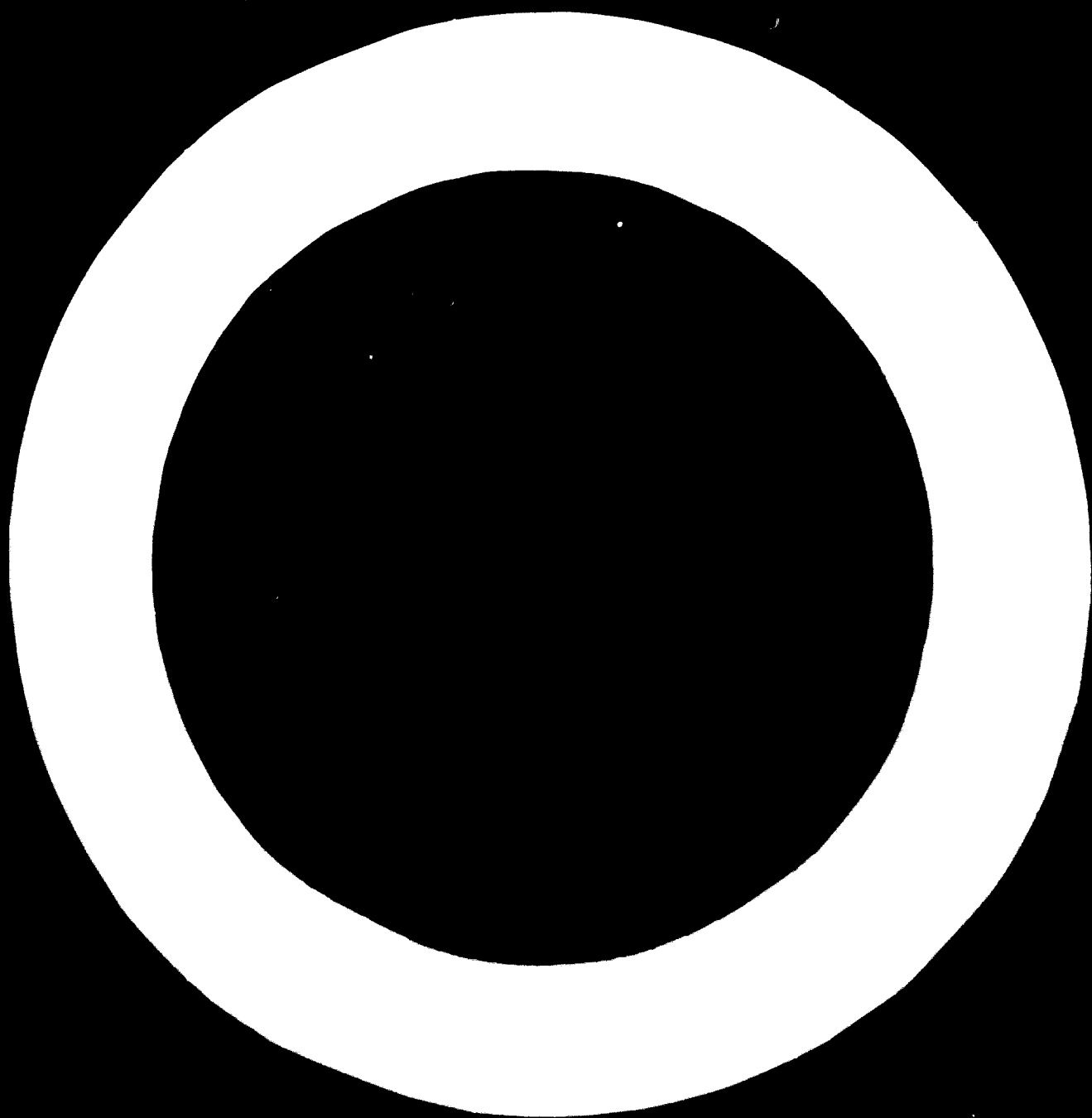
PETROLEUM EXPLORATION

Capital requirements
and methods of financing



UNITED NATIONS





Department of Economic and Social Affairs

PETROLEUM EXPLORATION

Capital requirements and methods of financing



UNITED NATIONS

New York, 1962

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FOREWORD

This report is submitted in response to the recommendations of the first session of the Committee on Industrial Development endorsed by the Economic and Social Council at its thirty-first session (resolution 817 (XXXI)).

The report was prepared by the Secretariat with the assistance of expert consultants, on the basis of available information and certain data obtained from a number of Governments.

The report consists of three parts: (a) the Introduction—pointing out the increasing importance of hydrocarbons among the primary energy resources and noting the peculiar character of the search for petroleum; (b) part I—investigating capital requirements for exploration of petroleum and attempting to establish the range of unit costs for the various operations entailed—such as aerial photography, geological and geophysical methods of exploration, drilling and so forth, and (c) part II, briefly analysing in a number of typical cases the total volume of capital required and the methods of securing these funds under varying conditions, particularly under different economic systems and policies.

EXPLANATORY NOTES

Use of a hyphen (-) between dates representing years, e.g., 1953-1955, signifies the full period involved, including the beginning and end years.

References to "tons" indicate metric tons, and to "dollars" United States dollars, unless otherwise stated.

The term "bilion" signifies a thousand million.

Details and percentages in tables do not necessarily add to totals, because of rounding.

Certain abbreviations have been used: ENI for Ente Nazionale Idrocarburi; MTA for Mining Exploration and Development Institute [Turkey]; PEMEX for Petróleos Mexicanos; PETROBRAS for Petróleo Brasileiro; TPAO for Turkish National Petroleum Company; UAR for United Arab Republic; YPF for Yacimientos Petrolíferos Fiscales [Argentina]; YPFB for Yacimientos Petrolíferos Fiscales Bolivianos.

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INTRODUCTION

1. The purpose of the present report is to investigate the capital requirements of petroleum exploration and methods of financing such exploration. Before embarking on this study, however, it may be useful to consider briefly the role of the petroleum industry in the modern economy and to indicate the factors which give rise to the need for an analysis of the specific problems of petroleum exploration.

THE POSITION OF HYDROCARBONS IN THE CHANGING PATTERN OF PRIMARY ENERGY CONSUMPTION

2. A feature of recent changes in the pattern of primary energy consumption has been the growing importance of hydrocarbons (petroleum and natural gas) as compared with other primary energy sources. The changes in world consumption are summarized in table 1.

Table 1. Changes in world consumption of energy, 1929-1959
(Millions of tons of coal equivalent, except as indicated)

Year and item	Solid fuels	Liquid fuels	Natural gas	Hydro-electricity	Grand total	Per capita consumption (Kilogrammes)
<i>1929:</i>						
By weight	1,367	255	76	14	1,712	867
Percentage	79.8	14.9	4.5	0.8	100	
<i>1959:</i>						
By weight	2,074	1,218	566	79	3,937	1,345
Percentage	52.7	30.9	14.4	2.0	100	

Source: United Nations, World Energy Supplies, 1956-1959, Statistical Papers, Series J, No. 4 (Sales No.: 60.XVII.6).

3. In order to interpret correctly the figures in table 1, it should be noted that in 1959 the United States of America alone accounted for some 35 per cent of world energy consumption and used petroleum products (including natural gas) to cover 73.9 per cent of its needs, whereas in the rest of the world solid fuels remained the most important source of energy. Nevertheless, there has undoubtedly been an absolute increase in the share of hydrocarbons, particularly during recent years and in the industrial countries. An example of this trend is furnished by the Soviet Union, where petroleum and natural gas accounted for 24 per cent of consumption in 1956 and 30 per cent in 1959. The position is similar in western Europe, where the proportion increased from 21.3 per cent in 1956 to 30 per cent in 1959. A similar trend may also be observed in the case of the under-developed countries, because of the very wide range of technical possibilities for the use of hydrocarbons, as illustrated by table 2.

THE VOLUME AND STRUCTURE OF PETROLEUM INVESTMENT

4. A considerable investment effort has been necessary to meet the rapid expansion of demand. It may be noted in this connexion that in the world as a whole, with the exception of mainland China and the other centrally-planned economies, well over one-half of petroleum investment has been devoted to exploration and production. This world-wide average is undoubtedly

heavily influenced by the fact that, in the United States (which accounted for 58 per cent of world investment in the petroleum industry during the nineteen fifties) more than two-thirds of petroleum investment has been channelled into exploration and production in the past decade. Nevertheless, the tendency for exploration and production to account for the major part of investment in petroleum is a universal characteristic (see table 3).

EXTENSION OF PETROLEUM EXPLORATION AND PRODUCTION TO NEW AREAS

5. Because of the importance of petroleum resources to modern economies, there has been a substantial expansion of exploration, and prospecting has been extended to increasingly numerous and less accessible areas. Recent research on the formation of petroleum deposits has made it possible to determine the combinations of geological conditions which warrant exploration. Nevertheless, the presence of the necessary geological strata and rocks in a given area does not necessarily justify the assumption that there are commercially exploitable accumulations of hydrocarbons; the deposits must also be accumulated in particular geological formations known as "traps". Even when all the theoretical conditions seem to be present, exploration is often unsuccessful and sometimes results only in the discovery of reservoirs of water, occasionally accompanied by a little gas. Many examples illustrating the speculative nature of petroleum exploration will be given later in

Table 2. Technical possibilities for the use of the various multi-purpose sources of energy

	Thermal energy			Electrical energy		
	Direct use	After conversion	After conversion	Direct use	After conversion	After conversion
Electricity	X	X	X	X	X	X
Transport						
Air	X					
Road	X					
Rail	X		X		X ^a	X ^a
Sea	X		X ^b			
Industry						
Machine power	X	X	X	X	X ^c	X ^c
Electrical power	X	X	X	X	X	X
Steam power	X	X	X	X	X ^c	
Agriculture (tractors, etc.)	X					
Heating and cooking	X	X	X	X	X ^c	X ^d

^a Electrified lines.

^b No longer used.

^c Technically possible but not yet used.

^d Technically possible and used in New Zealand.

^e Either by direct use of steam and hot water for heating (Iceland) or after conversion into electricity for heating and cooking.

^f Cooking or heating by electricity.

Table 3. Investment in the petroleum industry

I. WORLD^a (EXCLUDING CENTRALLY-PLANNED ECONOMIES OF EUROPE AND MAINLAND CHINA)

1951-1960	United States		Other countries		Total	
	Millions of dollars	Percentage of total	Millions of dollars	Percentage of total	Millions of dollars	Percentage of total
Production, including exploration	37,510	71.9	11,170	37.5	51,680	57.4
Pipelines	2,375	4.5	2,080	5.5	4,455	5.0
Sea transport	715	1.4	7,310	19.3	8,025	8.9
Refineries	5,790	11.1	6,710	17.8	12,500	14.0
Petro-chemicals	900	1.7	765	2.0	1,665	1.8
Marketing	3,880	7.4	5,875	15.6	9,755	10.8
Other	1,030	2.0	865	2.3	1,895	2.1
Total	52,200	100.0	37,775	100.0	89,975	100.0

Source: Chase Manhattan Bank, Petroleum Department, *Capital Investments by the World Petroleum Industry*, by F. G. Coqueron (New York).

^a Including investment in natural gas, but excluding costs of geological and geophysical surveys and leases, which amount for \$8,900 million, of which \$6,000 million was incurred in the United States.

II ROMANIA

1951-1960	Millions of lei	Percentage of total
Exploration of new reserves	6,276	31
Development	10,917	55
Construction of refineries	2,867	14
TOTAL	20,060^b	100

Source: Information communicated to the United Nations by the Government of Romania.

^b 17.2 per cent of total investment in industry (117,722 million lei) 1951-1960.

Table 3 (continued)

III. UNION OF SOVIET SOCIALIST REPUBLICS

1946-1957	Millions of rubles	Millions of dollars	Percentage of total investment
Total investment in the petroleum industry	100,000	11,000	100
Exploration and production	50,000	5,500	50
Exploration proper	14,000	1,600	14
Deep development drilling	16,000	1,730	16

Source: Brenner, *Planirovanie nefteobuvayushchei promyshlennosti* (Planning of the petroleum industry) (Moscow, 1959).

* 10 per cent of total investment in the Soviet Union in 1946-1957.

the report. At this point, attention needs to be drawn to the risks involved and the impossibility of predicting results until a deposit has been reached by drilling, and its size has been estimated.

6. It is likely that the majority of the most easily discovered deposits have been found in the areas already explored. There are, however, still some virgin territories which may hold large resources. Moreover, the exploration of deeper strata is now possible as a result of the steady advances in exploration techniques—i.e., in the detection of structural or stratigraphic traps which may contain exploitable deposits—and the improvement of drilling equipment. It is not uncommon for new deposits to be found below fields already in production.

7. The extension of exploration to new areas has already resulted in increasingly marked changes in the world production picture. Although world production has increased over the past fifteen years at a fairly steady rate of about 6 per cent per annum, the over-all figure conceals substantial changes in the position of the main producing areas. A number of instances of these changes may be deduced from table 4.

8. As the table shows, the number of producing countries increased from twenty-three to fifty-two between 1930 and 1961, and the list of the ten largest petroleum producers has changed considerably. Furthermore, the share of the ten largest producers in total production fell from 98 per cent in 1930 to 89 per cent in 1961, an indication of the trend towards more widespread production which appears to be gathering momentum at the present time.

DEFINITION OF THE TERM "PETROLEUM EXPLORATION"

9. Exploration, in this context, is the stage of operations during which various techniques are applied with a view to finding whether there is a commercially exploitable accumulation of hydrocarbons in a given region. In other words, it is necessary to demonstrate not only that such an accumulation of hydrocarbons is present but also that the oil and gas can be extracted on economic terms, taking into consideration exploitation and development costs and local conditions. Petroleum exploration essentially comprises preliminary reconnaissance work and prospecting. Preliminary reconnaissance includes general geological surveys of the

Table 4. The ten leading world producers of crude petroleum 1930, 1950 and 1961

(Millions of tons, except as indicated)

1930		1950		1961	
United States	123.1	United States	266.7	United States	353.5
Venezuela	20.1	Venezuela	80.0	USSR	166.0
USSR	18.5	USSR	37.0	Venezuela	155.7
Iran	6.0	Iran	32.3	Kuwait	82.7
Romania	5.7	Saudi Arabia	26.6	Saudi Arabia	69.1
Mexico	5.7	Kuwait	17.3	Iran	58.6
Indonesia	5.5	Mexico	10.4	Iraq	48.8
Colombia	2.8	Indonesia	6.8	Canada	29.8
Peru	1.7	Iraq	6.6	Indonesia	21.0
Trinidad	1.3	Romania	5.0	Sahara	15.6
Total of the ten	190.4	Total of the ten	489.6	Total of the ten	1,000.8
Percentage of world production (194 million tons)	98.0	Percentage of world production (523 million tons)	93.6	Percentage of world production (1,119 million tons)	89.0
Total number of producing countries	23	Total number of producing countries	44	Total number of producing countries	52

whole area or basin, photogeological mapping and, where necessary, gravimetric surveys. These operations, which provide an initial, very general idea of the potentialities of the area, usually require only a provisional exploration permit, and not an exclusive license.

10. Prospecting consists of a series of intensive field surveys to determine the possible structures of the area under study. Geological and geophysical methods and procedures are used, leading, where appropriate, to core-drilling. The next step is test-drilling, the only method

of ascertaining that a deposit exists. In many cases, supplementary seismic surveys are necessary. These operations may only be undertaken by the holder of a title to mineral rights, such as a grant of sole exploration rights, where such titles are required by law.

11. When the results of exploration are favourable, development follows. Development drilling is the only means of determining the extent of the deposit and of estimating its reserves. Development work (geophysics, drilling) is therefore included in the exploration stage because a great many uncertainties are still present even after oil has been struck. Nevertheless, these risks are to some extent comparable to those faced by other industrial ventures. This "normalization" of the risks is *a fortiori* applicable to the calculation of the investment necessary for collecting systems, exploitation and storage facilities and means of transport for the petroleum produced.

THE CASE OF THE DEVELOPING COUNTRIES

12. The subject of the present study is confined to the capital requirements and methods of financing of petroleum exploration, as defined in the preceding section. The approach adopted is expressly designed to be of service to countries in process of development. The national accounts of developing countries generally reflect a number of structural imbalances which affect the budget (inadequacy of current revenue to cover expenditures essential to the nation's economic life), the trade balance (because of heavy imports of capital goods, on which returns are obtained only after a considerable time lag) and the distribution of national income (often insufficient to cover urgent consumption and investment needs).¹

13. In this context, it may be useful to note the specific goals which developing countries normally set themselves. In most cases, developing states are concerned to secure petroleum resources that will free them from reliance on imports by enabling them to cover their domestic needs. In such cases, the government's primary desire is to discover and exploit sufficient petroleum in its territory to stimulate economic development and provide a flexible, reliable and relatively inexpensive source of energy. In the long run the investment necessary to carry out such a programme should be offset by the strengthening of the national economy and trade balance resulting from the elimination of petroleum imports. Various methods may be used to execute a programme of this kind, in which petroleum is regarded as a means rather than an end.

14. In other cases, petroleum production may be a goal in itself, in the same way as the production of any

¹ Despite the restricted scope of this study, examples taken from the exploration policy of the industrialized states will be given. Such examples will, however, only be cited in cases where they might be of assistance in evaluating a specific problem. An attempt simply to transpose such cases into the framework of an analysis intended for the use of developing countries would be misleading.

raw material which is produced primarily for export in order to obtain additional resources for national economic development. In this case, the problem is not so much to finance exploration as to achieve maximum production. In many cases the resources of the country concerned are insufficient to attain this goal and foreign capital is called upon to undertake the exploration operations. This has been the position in several underdeveloped countries whose main resource is petroleum. Their primary concern is to market their oil at the best prices, and the problem has been solved in the past by concluding agreements with foreign companies, usually international in scope, which take the initiative in exploration and pay the government a royalty on each ton of petroleum produced on their concessions.

15. In the course of time, however, objectives may change. For instance, contracts concluded by a government and originally designed only to supply domestic needs may be amended to allow the contracting companies to dispose freely of the petroleum produced. In no case has there been a programme which has led to the results originally envisaged. The planned objectives have been exceeded, or not realized, either as regards the quantity or quality of the oil and gas produced. So far as quantity is concerned, little comment is necessary. The pattern of consuming and producing areas and the regions in which reserves are concentrated result in petroleum being essentially a traded commodity. A policy of national self-sufficiency in this field is unlikely to result in a satisfactory equilibrium or the optimum use of resources. Every country, whether it be petroleum-deficient or whether it possesses a surplus, must necessarily look beyond the confines of its own economy in framing its petroleum policy.

16. Also, the quality of the petroleum produced often fails to satisfy a country's requirements. Although less obvious, this second point is not unimportant. While from heavy crudes the proportion of lighter fractions can be increased by appropriate technical processes and, on the other hand, products suitable for use as motor fuels can be burned in furnaces, such procedures are often uneconomic. Cases thus occur in which the crude petroleum produced cannot meet the requirements of the producing country and the latter must therefore trade its products.

17. These considerations indicate that it is difficult, if not impossible, to establish *a priori* any close relationship between the production goals proposed and the means to be employed to achieve them. They also help to explain the international character of the petroleum industry, resulting from the distribution of the world's consuming and producing areas and the risks involved in petroleum exploration.

18. However, whatever the motive which impels different countries to develop their petroleum resources or to exploit whatever potential they may have as efficiently as possible, it is essential that they should be fully aware of their possibilities in this field; in other words, that they should know to what extent large-scale exploration may be worth while.

Part I. CAPITAL REQUIREMENTS OF PETROLEUM EXPLORATION

CHAPTER I

Principal exploration operations and their cost

A. PRELIMINARY RECONNAISSANCE

19. The various phases of petroleum exploration involve many different techniques, the unit costs of which vary greatly. The total cost of exploration programmes also varies greatly, depending on geographic, economic and other factors and the length of time which elapses before deposits are discovered. It is therefore extremely difficult to obtain any representative figures. An attempt will, however, be made in chapter 1 to analyse the principal phases of exploration work and to estimate their unit cost. Chapter 2 will consider the over all capital requirements on the basis of a few typical examples drawn from completed programmes.

20. The world-wide extension of petroleum exploration, which was mentioned in the Introduction, has been accompanied by a multiplication of operators and an increase in the volume of investment. Petroleum prospectors are being faced with financing problems, which are in some cases new to them. The following is an analysis of some of the basic issues involved.

21. Financing problems in the petroleum industry vary according to the particular stage of operations. This is no doubt true of other industries, but it is especially characteristic of the petroleum industry. The exploration stage is marked by a very high degree of uncertainty and requires substantial financial resources. These two features of petroleum exploration also help to explain why the petroleum industry is characterized by a very high degree of integration and is constantly expanding to new areas.

22. The extraction, transportation and processing of crude petroleum and the distribution of petroleum products involve a normal margin of uncertainty and may be evaluated on the basis of the same economic criteria as other industrial activities. In the case of an integrated organization, they constitute the relatively stable element on which the more risky venture of exploration can be based. Theoretically, the ideal situation is achieved when a suitable dynamic balance is maintained between resources discovered, resources exploited and available markets, due allowance being made for the growth of demand and of consumption. The distinction between exploration and exploitation might therefore be regarded as somewhat artificial. In fact it is impossible to make a complete separation between exploration and its objectives—the production and ultimately the marketing of petroleum. The discovery of petroleum deposits leads to further exploration and provides the capital required to finance new programmes. Although it is easy to distinguish technically between the two stages, it is very difficult to separate strictly exploration costs from production costs in the industry's accounts. Nevertheless, it is undeniable that the special problems of financing in the petroleum industry are principally attributable to the exploration stage and far less to the later stages, the economic behaviour of which is more or less normal.

23. The first step in initiating an exploration programme is a critical and detailed appraisal of all the available geological literature—publications dealing with surface geology, records of the drilling of water wells and other data on the sub-surface geological structure. The preliminary reconnaissance of the territory should also include a survey of general conditions in the area, geographical features, transport facilities, prospective industrial development, etc. All of this information will be required in preparing a more detailed exploration programme. If exploration of the area is not ruled out on the basis of this preliminary general survey, various other methods are used to provide additional data, the choice of methods being dependent on the results of the initial survey. Among these methods are aerial photography, surface geological surveys and geophysical methods, such as gravimetry and magnetometry.

Aerial photography

24. In many countries complete photographic coverage is available, providing a very useful basis for initial geological reconnaissance. If the available coverage is in a form and on a scale suitable for petroleum exploration, much time can be saved. Where photographic coverage is not available, such a survey can be of great value for various purposes, in addition to petroleum exploration, such as mining, topographical surveys, civil engineering projects, the construction of transport facilities, irrigation, etc. The scale adopted for one purpose may not be identical with that appropriate for another and it may therefore be of advantage to make additional surveys on the desired scale, using the facilities provided for the general programme.

25. The photographs must overlap by 60 per cent along the line of flight and by 30 per cent between adjacent strips. A topographical map of the area can be compiled from the photographs. Frequently, the photographs can also be used directly to map the presence of geological features of interest such as outcropping beds and faulting. The main geological features of an area may be identified through stereoscopic examination of vertical photographs. The presence of thick forest cover is a handicap but is not necessarily a barrier to the use of this method, since surface structure and the nature of the outcropping formations tend to be indicated by the type of vegetation and the topography. Where rocks are well exposed, the best routes to reach them may be indicated and no substantial feature of the area photographed should be missed. Under favourable conditions, photogeology can be the quickest and cheapest method of pin-pointing the areas of principal

interest. The cost of operations may, of course, be affected by the need to establish airfields and navigational controls, but these may already exist or in any case be required for other purposes. Weather will also be a factor, as the number of hours during which aerial photography is possible will vary considerably from area to area, whereas the fixed costs will remain constant whether or not photography is being employed.

26. Given good weather and flying conditions, the cost of aerial photographs on a scale of 1:50,000 is about \$1.20 per square kilometre of coverage. The preparation of a topographical map and the geological examination together cost approximately \$4 per square kilometre. According to E. Shearer,² a consultant geologist, the generally accepted figure is about \$2.50 per square kilometre. P. Leicester³ indicates that costs range from \$3.25 to \$6.50 per square kilometre, depending on conditions. The cost is of course substantially affected by the scale adopted.⁴ The most common scale is 1:50,000, but a larger scale may be required for detailed work.

27. Photogeology is, of course, most useful in those countries where no geological surveys have been made. While photogeology does not replace surface surveys—which remain essential—it is a valuable preliminary which saves time and adds to the reliability and accuracy of the surface survey. By the use of photogeology, a company operating in the Sahara was able to complete a reconnaissance map of its exploration area at a quarter of the cost, and in a third of the time, that would have been required using conventional surface survey methods alone. As a result, the company was able to commence productive drilling less than two months after the start of exploration operations.

Surface geological surveys

28. The objectives of surface geological surveys are to ascertain whether there are rocks indicative of the occurrence of petroleum (i.e., source, reservoir and cap rocks) and whether conditions have been favourable for the formation and preservation of any oil or gas accumulation. Examination of outcrops may provide useful information regarding the general nature of the strata (although geological structures may change rapidly with depth) and may facilitate the selection of an initial exploratory drilling site. Further surface geological surveys may be necessary even after seismic work or drilling has begun. They should prove even more useful once the result of these operations is known. The area covered by a geological party in a given period will obviously depend on the terrain and on the amount of detail which is practicable and desirable. In Argentina, for example, seven parties covered 37,000 square kilometres during 1960, which represents 5,000 square kilometres per party per year. In more difficult cases, it may prove impossible for a party to survey more than a few hundred square kilometres per year.

² *Oil and Gas Journal*, 13 January 1958.

³ "Organization of exploration". Paper presented at the United Nations Inter-regional Seminar on Techniques of Petroleum Development, New York, 23 January-21 February 1962.

⁴ For further details see also United Nations *Proceedings of the United Nations Seminar on Aerial Survey Methods and Equipment* (Sales No. 60.11.F.5).

29. It is very difficult to specify any average unit cost for geological survey teams because of the great variation in conditions, particularly as regards the nature of the terrain and remoteness from bases. The published material frequently makes no distinction between the costs of geological and geophysical work (as in the case of the Soviet Union). However, C. T. Jones,⁵ consultant geologist at Tulsa, puts at \$29,000 the cost of 300 days' work by a surface geological party exploring an oil basin in the south-western United States measuring 4,650 square kilometres, half of which is difficult of access. The generally accepted figure for a light geological survey party is about \$3,000 per month or about \$35,000 per year. The cost may, however, be greatly increased if air transport is used. In any case, the cost of surface geological surveys is slight compared to that of the other operations.

Geophysics

30. Geophysical methods are used to explore to great depths for the identification of structures which may contain petroleum. The techniques employed are based on a variety of physical principles and vary in accuracy and cost. Gravity surveys and magnetometer surveys, which employ relatively light equipment, are frequently used for preliminary reconnaissance of extensive areas. Telluric methods are less frequently used. Seismic techniques, which are more expensive and require considerable equipment, are not employed until it is decided to make a detailed survey of a limited area.

(a) Gravimetry

31. Gravity surveys determine variations in the density of underground strata by measuring small changes in mass at different places on the earth's surface. Rocks differ in density and a very large accumulation of high density rocks will result in a local increase in gravity; conversely, a thick layer of sandstone or salt (which are rocks of relatively low density) results in a lower local gravity reading. A fault or a major throw separating terrain composed of rock of different density will be revealed by an anomaly along the fault line. Readings are taken at points spaced according to a suitable pattern (e.g., a grid of one-kilometre squares) and the most advanced instruments can selectively measure gravity variations with a high degree of accuracy.

32. A map of sub-surface anomalies can be prepared on the basis of interpretation of a gravity survey, after making the necessary corrections for latitude and topography. A detailed study involving four or five observations per square kilometre may be made of areas of particular interest. Measurements can be made on land or in water-covered areas. The results must of course be interpreted in the light of the geological information already available.

33. In the article cited earlier, C. T. Jones estimates that the gravimetry operations required to survey the typical basin under consideration would take a survey party 150 days and cost a total of \$48,000 or approximately \$9,000 per party per month. P. Leicester quotes a figure of \$5,600 to \$28,000 a month for land operations and \$8,400 to \$28,000 for marine operations. A 1959 study of costs in the franc zone provided the

⁵ *Oil and Gas Journal*, 13 January 1958.

following figures (representing the cost of one gravity survey party for one month):

	\$
Continental Europe	10,800
Sahara (land)	37,300
Sahara (using helicopters)	60,800
Equatorial Africa (land survey)	27,800

The average figure for a great variety of different types of area is approximately \$34,200. The figures are not comparable to those given by C. T. Jones except for operations in Europe. It is probable, however, that the items covered by the estimates are not identical.

(b) Magnetometry

34. In magnetometer surveys, sub-surface formations are investigated by studying the anomalies in the magnetic field due to differences in the "magnetic susceptibility" of rocks. "Magnetic susceptibility" is high in the case of ferromagnetic substances, such as magnetite and ilmenite, low in the case of crystalline rocks, and extremely low in the case of sedimentary rocks. Magnetic susceptibility ranges from 100 for basic rocks (basalt) to ten for acid rocks (granite) and one for sedimentary rocks. The method is based on the fact that the presence underground of rocks with high magnetic susceptibility distorts the lines of force of the magnetic field, causing anomalies which may be recorded by suitable measuring devices. In practice, magnetometry is chiefly useful as a source of information concerning the interface between the sedimentary formations of a basin and their crystalline substratum. It does not, however, provide any information on the structure of the sedimentary layers themselves. Magnetometer surveys therefore duplicate gravity surveys to some extent. The results of magnetometer work are of assistance in interpreting the results of gravity surveys and vice versa. The two types of survey are generally carried out simultaneously.

35. Ground magnetometer surveys are of little value if the data are distorted by disturbing influences at the surface. Magnetometry cannot be used over water and is expensive in forest or swampland. A method of making magnetometer surveys from the air has been developed and overcomes the drawbacks of the surface method. The air-borne system is somewhat different technically from the surface method. It is much superior from the point of view of rapidity of coverage.

36. In the article cited earlier relating to a typical 4,650 square-kilometre area, C. T. Jones estimates that a ground magnetometer survey would require 150 working party days and cost a total of \$12,300 or \$2,500 per month, whereas an air survey would take sixty days and cost \$13,500, or \$6,750 per month. According to P. Leicester, the cost of an aero-magnetic survey, per kilometre of flight, is approximately the same as that of aerial photography. The previously cited study of operations in the franc zone gives a figure of \$8,000 for a ground magnetometer survey (in the Sahara) and \$5,000 for an air survey (in Equatorial Africa).

(c) Telluric methods

37. These methods, which are not widely used because of the unevenness of the results in different areas, make use of the earth currents present in the surface layers and substrata of the earth. The existence of these currents has long been known, but their use as a means

of investigating sub-surface structures has only been developed in the past twenty years. The currents form broad fields which are horizontal or homogeneous, horizontal substrata, but are deformed and alter in intensity where the strata are folded and heterogeneous. Analysis of such deformations or anomalies can provide information concerning the sub-surface structure.

B. PROSPECTING

38. The more elaborate methods of exploration are not employed until the decision has been taken to make a detailed survey of a particular area and any necessary mining rights have been obtained. This does not mean, however, that geological survey work is at an end. The various methods may be combined. In detailed exploration operations, seismic methods and exploratory drilling are used.

Seismic methods

39. In the seismic method a pulse is generated in the ground and the time taken by the elastic waves so generated to penetrate the varying thicknesses of the strata and return to the surface is measured. The pulse is caused by the explosion of a dynamite charge in a small-diameter hole drilled to a depth of a few metres (the method most frequently used), by the explosion of the charge on the surface of the ground or in water, or by weight dropping. The pulse generated is received at the surface by means of geophones, after reflection from the interface between two rock layers or after refraction along such an interface. Interpretation of the rate of travel of the pulse provides information on the depth and geometric form of the reflecting or refracting layers. The rates of travel of the pulses are recorded at a series of firing points and, on the basis of a comparison of the results, a map can be prepared of the underground layers. Detailed study of areas revealing anomalies which might indicate traps provides a means of determining the contours of the possible structure. This brief description does not, of course, indicate the great complexity of seismic operations. The interpretation process is also highly intricate. The "re-interpretation" of seismic data has now become a fairly common practice and has proved highly useful.

40. Seismic surveys are very expensive because they involve large-scale operations requiring complex equipment and highly trained personnel for firing the charges and recording data and for interpreting results. Surveys are generally carried out by specialist firms. It may be useful to quote a few examples indicating the unit cost of seismic surveying, i.e., the cost of one survey party for one month. According to Leicester, the cost may range from \$11,000 to \$110,000 for reflection surveys. C. T. Jones (op. cit.) gives the cost of seismic operations in the typical area under consideration as \$18,000 per survey party-month. In Libya, between 1955 and 1960, the cost appears to have been about \$80,000. In the Sahara, in 1959, the average cost of seismic reflection operations was about \$110,000 and that of refraction operations about \$140,000. In the course of a detailed survey of a small area in South America, the unit cost was as high as \$150,000. In the light of these considerations, the following estimates might be accepted as average figures representative of the likely cost of operations in developing countries:

	per month
Truck operated work under desert conditions	64,000 ± 11,000
Portable equipment in heavy bush	45,000 ± 4,000
Swamp operations supported by land-locks	50,000 ± 4,000

41. The cost of seismic work per survey party-month is much higher for operations over water than for those over land, but much larger areas can be covered in a given length of time. In Equatorial Africa, for example, the cost of a party conducting a seismic survey over water was \$200,000 per month, but the party's output was roughly ten times higher than that of a party operating during the same period in the Sahara.

Drilling and allied techniques

42. At some stage in any exploratory programme it is necessary to obtain direct information concerning the subsurface formations by drilling. Although based on the same principle as that of drilling wells for water, in practice the drilling of oil wells is far more complicated. Oil wells have been drilled to depths of 8,000 metres and depths of 3,000 to 4,000 metres are nowadays quite common. Naturally, the equipment required for drilling in depth is more complex; for example, at a depth of 3,500 metres, the dead weight of the drill pipe will exceed 1,000 tons, and the hoisting equipment has to be capable of lifting it at a reasonable speed. Similarly, in changing bits, the drill pipe has to be broken down into 27-metre sections, which are stacked vertically inside the derrick, commonly more than forty metres in height. Pumps have to be able to force back the circulating mud at a rate in excess of 100 cubic metres per hour in the pipe sections, and total power requirements for a heavy rig may come to 3,000 horsepower, usually provided by diesel engines. The equipment is heavy and bulky but it must be possible to move it from one place to another with a minimum of dismantling and re-erection. Of course, in the case of light rigs, the engines, pumps and hoists are permanently mounted on wheeled chassis, together with a mast to replace the conventional derrick. However, in mountain, jungle or swampy country, the difficulties of moving may be formidable.

43. There are many other complications in drilling. The circulating mud, which in its simplest form is water with colloidal clay in suspension, has the functions not only of cleaning, lubricating and cooling the bit and of bringing the cuttings to the surface but also of supporting the walls of the hole by exerting pressure against them, of filling in porous formations penetrated by the well with clayey substances and finally of counterbalancing pressure of fluids in certain formations and thereby preventing the disastrous blow-out of oil or gas which were so frequent in the days of rope drilling. In view of the many different functions of the mud and the great variety of geological conditions, the composition of the mud has to be continuously controlled and frequently altered during the drilling. The use of muds of density twice that of water is common. The expense of drilling is considerably increased by the cost of buying and transporting mud components as well as by the difficulty of controlling and keeping mud properties within acceptable limits. When extremely open formations are encountered, part or all of the mud may filter through the walls of the well with a con-

sequent partial or total loss of circulation. In such cases it is necessary to thicken the mud and to use plugging materials, and, where the loss of circulation is total, to install a lining which is cemented below the open formation. In exploratory drilling, the driller must always be on the alert for formations containing high-pressure oil and gas which might cause a blow-out. In order to prevent such blow-outs, the drill pipe at the well head is fitted with hydraulically operated rams which are placed between the derrick platform and the ground, and which can be closed at the first sign of trouble.

(a) *Types of well*

44. There are four types of test well:

(i) *Core drills*: before drilling any wells down to the depth of the suspected oil-bearing formations, it is often considered necessary to drill small-diameter holes to a limited depth (a few hundred metres) for the purpose of clarifying and confirming the frequently uncertain indications provided by surface methods or geophysical evidence.

(ii) *Stratigraphic drilling*: One or more stratigraphic tests need to be drilled through the entire sedimentary sequence for the purpose of checking the occurrence of source and reservoir rocks, measuring seismic velocities and obtaining necessary geological evidence of importance in regional studies. A depth of 3,000 metres for such wells is not an uncommon target in the early stages of exploration.

(iii) *Wildcats*: After sufficient information has been obtained, exploratory wells are drilled at selected locations for the purpose of studying the formations penetrated, of noting the nature and the pressure of the fluids in those formations, and finally of finding oil. The depth of these wells varies considerably, since oil or gas accumulations have been found at less than 300 metres and below 6,000 metres.

(iv) *Outstep wells*: If oil is discovered, it is necessary to drill a number of wells to determine the amount and extent of the accumulation before embarking on the expense of development drilling and the installations necessary for production.

(b) *Well logging and testing*

45. In earlier days, only two methods were available for determining the characteristics of formations underground. Qualitatively, different rocks could be distinguished by their relative ease of drilling. For more precise determinations, and for quantitative measurements, it was necessary to examine the drill cuttings brought to the surface or to extract a geological sample by coring. These methods are still used: drilling speed makes it possible to determine exactly where to core, and cuttings and cores permit geological and palaeontological studies and laboratory determination of the physical properties of reservoir rocks. However, coring is expensive and in spite of improvements in techniques, recovery is not always complete. Nevertheless, cores, which may be as much as twenty metres long, provide essential information in exploratory drilling.

46. About thirty years ago, new methods were introduced for measuring various physical properties of formations penetrated by drilling and for providing information relating to the composition of the forma-

tions, their porosity, permeability and fluid content. These methods make possible the precise correlation of the results of different testing procedures as well as the location of oil reservoirs passed through by some wells without being detected; they thus lead in many cases to the discovery of new deposits. The earliest of these methods and the one still most widely used is electrical logging, still called "electrical coring". More recently this method has been supplemented by other techniques whose importance and use are constantly increasing (caliper, radioactivity and sonic logs), and by related techniques concerned with drilling, formations and fluid content (dip and strike of formations, diameter, temperature, etc.). A logging programme may include spontaneous potential, short normal, lateral and induction electric resistivity logs, micro logs and gamma-ray and neutron logs.

47. The average cost of logging is one dollar per metre. From the practical point of view, these logging methods have the advantage that recording instruments are run down into the well on a cable connected to the control equipment. This makes it possible to determine the depth of the various formations with greater accuracy than by examining drill cuttings, and to record several logs simultaneously. The time necessary for these operations is small compared with that required for conventional coring.

48. In exploratory drilling, whenever coring or logging suggest the presence of hydrocarbons, the formation in question is normally tested with a view to determining whether or not there are exploitable strata and to establishing the fluid pressure. This testing is done with the help of an apparatus called a "tester", which isolates the section to be tested from the pressure exerted by the column of mud and permits the formation fluids to flow up the drill pipe. The majority of exploratory wells are "dry holes" in the sense that they contain no oil or gas in interesting amounts.

49. According to Levorsen, in the United States the ratio of successes to failures in drilling wells, irrespective of the magnitude of the discovery, is of the order of one to eight in areas where the traps are structural and geological and geophysical studies can provide accurate information, and of one to twenty in areas where such studies are often useless because the traps are mainly of the stratigraphic type. The Leduc oilfield, which made Canada a major oil producing country, were discovered in 1947 after twenty-eight years of prospecting and the drilling of 133 wells. On the other

hand, the first thirteen fields were discovered in Saudi Arabia, Kuwait, Qatar and in the Bassora region of Iraq by only seventeen wildcats, for proved reserves of the order of 10,000 to 15,000 million tons. Finally, in the Sahara, 23 per cent of the exploratory wells drilled from 1952 to 1958 inclusive were successful.

(c) Drilling programme and costs

50. After oil has been discovered and the necessary outstep wells have been drilled, the next step is the drilling of development wells. This is a much simpler operation since the depth is approximately known and the work is concentrated in a relatively small area. While it is not the purpose of this report to deal with questions of production, it should be borne in mind that even after oil has been discovered, a considerable amount of work and investment is still required for development.

51. Drilling programmes vary considerably and in practice they can never be drawn up in detail and in advance of the commencement of exploration in virgin territory. Thus, there may be cases where no core drilling is necessary or where it is possible to combine the second and third types of well described above. The geological problem may be simple or difficult and chance may influence the amount of time that elapses and the amount of drilling that is done before a discovery. However, in spite of the extreme diversity of possible conditions, some examples of unit costs of drilling may be of interest.

52. Owing to the intense drilling activity in the United States, that country provides an important example, which, however, is not very representative of normal conditions in other countries. Seventy per cent of the world's petroleum equipment (excluding mainland China and the centrally planned economies of Europe) is in the United States. Eighty-five per cent of wells (whether for exploration or development) are drilled there and 83 per cent of all drilling, in terms of total distance drilled, is done in the United States. Ninety per cent of the world's producing wells are in the United States and the infrastructure is therefore highly developed. As one drills deeper, the costs increase more or less in geometric progression: a well 3,000 metres in depth costs considerably more than twice as much as a well drilled to a depth of 1,500 metres in the same area and under similar conditions. In this connexion, a recent report of the American Petroleum Institute gives the following figures for United States dry hole costs in 1959.

Table 5. United States. Relative success of drilling according to basis for locating new-field wildcats

Basis for locating exploratory wells	1958			1959		
	Producing wells	Dry holes	Percentage successful	Producing wells	Dry holes	Percentage successful
Geology	423	3,684	10.2	422	3,711	10.2
Geophysics	71	414	14.7	107	605	15
Geology and geophysics	191	974	16.4	176	926	15.9
Total, technical	685	5,072	11.9	705	5,242	11.9
Non-technical	33	445	6.9	32	494	6.1
Unknown	68	647	9.5	36	523	6.3
TOTAL	786	6,164	11.3	772	6,259	11
GRAND TOTAL	6,950			7,031		

Source: B. W. Blanpied, "Exploratory Drilling in 1959", *Bulletin of A.A.P.G.*, June 1960.

Table 5A. Cost of drilling in the United States

State	Average depth (metres)	Cost per metre (dollars)
Illinois	649	16.08
Michigan	1,005	23.95
North Dakota	1,768	29.53
Mississippi	2,713	32.81
Louisiana (south)	3,230	57.09
Louisiana (off-shore)	3,110	115.49
Alaska	3,200	620.76

53. The wide differences in costs indicated above are due not only to the differences in depth but also to the geological and other conditions encountered. According to the American Petroleum Institute, in 1956 the average cost of 14,006 wells between 750 and 1,150 metres in depth was approximately \$26,500, whereas the average cost of 150 wells over 4,600 metres deep was \$761,700. In this particular example, average cost increased more than five times faster than average depth. A Bureau of Mines' census indicated that from 1954 to 1956 the average cost of dry holes in the United States rose from \$35,400 to \$41,600, or by 20 per cent. On the other hand, in recent years there has been some decline in costs owing to the fierce competition in the industry. The examples cited help to furnish an order of magnitude and some interesting data on the relationship between rising costs and depth of drilling.

54. In Venezuela, in recent years, contract costs for drilling under easy conditions have been around \$16.50 per metre drilled. To this must be added the cost of site preparation. Substantially higher contract prices were reported in 1957 for drilling on land, \$28 per metre for wells 1,950 metres deep in Lake Maracaibo, \$80 per metre for wells 2,500 metres deep.

55. In the franc zone, a study was made for the year 1959 on the costs of development and exploration wells. The costs were analysed with reference to type of drilling—in other words, type of rig required—and are expressed in terms of average costs per metre drilled and rig-months. Heavy rigs are used for wells deeper than 2,500 to 3,000 metres. Medium rigs are suitable for drilling to a depth of 1,200-1,500 to 2,500-3,000 metres. Light rigs cannot be used at a depth beyond 1,200 metres. The results of the study are given in table 6.

Table 6. Costs per metre drilled and rig-month in exploration during 1959

(Dollars)

Type of rig	Metropolitan France	Sahara	Equatorial Africa
<i>Heavy:</i>			
Cost per metre drilled	176	498	372
Cost per rig-month	93,400	198,000	157,600
<i>Medium:</i>			
Cost per metre drilled	89.2	312	151.6
Cost per rig-month	75,200	158,000	126,600
<i>Light:</i>			
Cost per metre drilled	50.8	198	193.8 ^a
Cost per rig-month	56,800	68,000	186,000

^a The cost per metre drilled is higher with light rigs than with medium rigs because only 1,500 metres were drilled with light rigs.

56. In the case of the Soviet Union, A. O. Asan-Nuri has recently provided figures showing the changes

in the costs per metre drilled since 1950 for wells approximately 1,700 metres deep:

	1950	1952	1954	1956	1958	1960
Depth (metres)	1,650	1,793	1,767	1,778	1,773	1,764
Cost per metre drilled (dollars)	69.2	79.5	76.9	59	45.6	37.3

57. According to P. Leicester, with a drilling outfit costing from \$85,000 to \$110,000 and utility services and transport costs totalling \$55,000 to \$110,000, operating expenses in the strict sense of the term may amount to only a few thousand dollars per month. For a 3,700-metre exploration well on land, excluding road construction, site preparation, transportation and

water supply, drilling costs average about \$150,000 per month, although the variation on either side of that amount may be considerable—\$42,000 per month—depending on local conditions, mainly formation conditions. Since it may take from three months to a year to drill a 3,700-metre test well, it is obvious that there is a wide range of possible costs, running from \$330,000

to \$2,350,000, according to the estimates indicated above. Marine drilling costs average about double those of land drilling.

(d) *Recent technical developments*

58. Every year the sciences applied in exploration make important advances, which are eventually reflected in a relative reduction in costs and the possibility of solving increasingly difficult and complex problems. While it is not the purpose of this report to describe the progress that is being made, it would seem useful to mention this as a factor which may affect both the technical and financial planning of operators.

59. There has been very substantial progress in drilling techniques during the last few years. This is the result both of the improvement of conventional (rotary) systems and of the development of new methods, such as turbo drilling which is commonly employed in France and more especially in the Soviet Union, where geological conditions often require the use of very thin circulating muds or even water for drilling. In the Soviet Union turbo drilling techniques have permitted drilling at speeds 1.5 to 3 times faster than can be achieved with rotary equipment. Work is also being done on the development of electrical drilling equipment. One factor which substantially increases drilling costs is the need for the frequent replacement of worn-out bits. Research is being done in many countries on the methods of prolonging the useful life of drilling bits. The improvement of seismic methods of exploration and the increasingly effective use of data through the application of logging methods should make for greater precision in the analysis of problems. All of these factors may well lead to substantial improvement in the conditions of exploration. Nevertheless, exploration will continue to be a risky and generally costly operation.

CHAPTER 2

Capital requirements of petroleum exploration operations

60. The production of petroleum is the culmination of a process which is invariably lengthy and which necessitates the employment of considerable technical and financial resources. Moreover, the volume of activity and expenditure required generally increases from the initial phases until the point where an equilibrium is reached.

A. VARIABLES IN EXPLORATION OPERATIONS

61. These general considerations are borne out by almost all the examples of past experience which have been subjected to analysis. This should not however obscure the fact that each operation is a special case, affected by a series of factors such as local conditions, the speed at which the operators work, the time spent on exploration operations before the first discovery and the time that elapses before exploitation begins.

Local conditions

62. Local geographical conditions are a major factor in determining the scale of operations, the equipment

used, and the capital investment required. Exploration entails progressively more complex and difficult operations requiring transport facilities and considerable industrial equipment. In the developing countries, particularly in the areas under consideration, these facilities are in very many cases non-existent. A minimum of basic equipment must therefore be installed before work can begin. These considerations are particularly applicable when the drilling phase is reached. Geological and even seismic parties are more nearly self-contained units and require relatively little equipment. Drilling is, however, an industrial operation and, as such, raises problems of a different order: the presence or absence of an adequate infrastructure may substantially affect the cost of operations. It should be noted, however, that the development of infrastructure undertaken for the purpose of petroleum exploration may also be of use to the country for other purposes.

Pace of operations

63. The intensity of exploration operations in a given area is clearly conditioned by the objectives of the operator and the resources at his disposal. A decision regarding the optimum pace has to be made in each particular case and cannot be taken without regard to considerations of general economic policy.

Duration of operations

64. The length of the exploratory period is a further factor that should be borne in mind. Although geographical conditions and the intensity of operations may decisively affect the length of the exploratory phase, chance plays a major role. For this reason programmes comparable in other ways may require widely differing periods of time.

65. Some extreme examples may be quoted in this respect: in Australia, where government-subsidized petroleum exploration has been going on since the beginning of the century, \$90 million has been spent in the last ten years, without encouraging results until recently. In West New Guinea, \$112 million has been spent in twenty-five years, leading to the discovery of only three small deposits, the annual production of which has never exceeded 400,000 tons. In Nigeria, \$168 million has been spent since exploration was begun (just before the Second World War); production began in 1958 and exceeded 2 million tons in 1961. In Canada it took twenty-eight years and 133 drillings to find the Leduc field in 1947. In the Middle East, petroleum was first found in 1908, at Masjid-i-Sulaiman in Iran. Exploration was halted by the First World War and resumed in 1920, leading to the discovery, between 1923 and 1939, of large fields in Iran and northern Iraq. Although they were known to be very large even before the Second World War, the petroleum reserves of the Middle East were found to be much greater than had been thought; the discovery from 1945 onwards of the oilfields of Bahrain, Saudi Arabia, Qatar, Kuwait, southern Iraq and the Neutral Zone makes the Middle East now the foremost of the world's great petroleum areas. Furthermore, the total number of exploration and development drillings carried out in the Middle East up to 1956 was roughly 1,500, a thousand times smaller than in the United States, while the size of the reserves discovered represents the greatest yield (per

metre drilled) obtained in the history of petroleum exploration. In this area, several thousand cubic metres of reserves were discovered for every metre drilled as against some ten cubic metres in the United States and thirty to thirty-five cubic metres in Venezuela.

66. Thus no rule can be laid down. Nevertheless, analysis would appear to indicate that exploration is bound to be a long-term operation. The time needed to complete the various operations cannot be reduced beyond a certain point.

Time required to reach production stage

67. Several years are needed for the development of an oilfield and the construction of transport facilities, even if very rapid progress is made, as has been the case in the Sahara and in Libya. The drilling which led to the discovery of the Hassi-Messaoud field in the Sahara was finished in July 1956. By the end of 1957 temporary transport arrangements were installed (pipeline to Tonggourt and railway to Philippeville) and in October 1959 the permanent system was put into operation, consisting of a twenty-four-inch pipeline to the port of Bougie. In Libya, the Zelten field discovered in 1958 was put into production in the last quarter of 1961, as soon as the pipeline had been laid to Port Brega.

68. Petroleum production in Nigeria began to develop in 1961 after the completion in August of that year of the new Bonny Island terminal, at the mouth of the river. Hitherto, 18,000-ton tankers had had to go up the river as far as Port Harcourt, fifty-six kilometres inland, and leave only half loaded to enable them to clear the bar. Thus, the effort undertaken, which is always a gamble, will certainly not produce substantial results until several years after the operation is initiated. This presupposes the ability to commit the necessary capital over a long period.

B. EFFECT ON THE COST OF OPERATIONS

69. The various factors affecting the duration of the different phases of exploration operations have an obvious bearing on the financial aspects of the problem. The amount of capital required for exploration grows rapidly as the operation proceeds from the preliminary reconnaissance to the production stage. Although the available experience does not provide a basis for the formulation of a general rule, it may be of value to consider some examples where analysis of the operations is relatively simple. Where all the phases of development in hitherto virgin territories have been passed through in a few years and the main discoveries have been concentrated in a relatively short period, exploration and production costs may be fairly easily separated.

70. In Canada, the Leduc field was not discovered until 1947. In 1950 the reserves were estimated at 170 million tons; production expanded rapidly, rising from 6.5 million tons in 1951 to 25 million tons in 1959, in which year the reserves were estimated to total 500 million tons. During this twelve-year period (1947-1958), exploration costs totalled \$2,216 million, development costs \$1,147.3 million (roughly half the cost of exploration) and production costs some \$510.1 million. Over-all expenditure thus amounted to \$3,873,600. (See table 7.) A specific example of

experience in Canada has been furnished by L. C. Stevens.⁶ In the case of the Fosterton discovery in Saskatchewan in January 1952, forty wells and eighteen dry holes had to be drilled to define a 3.3 million ton field; further exploration in the area where the first find had been made led to the discovery of ten new fields in 1956, after the drilling of 240 producer wells and 190 dry holes. At that stage about \$19 million had been invested in exploration and drilling. When it was decided to export the oil to the Minneapolis-St. Paul area in the United States, over \$26 million had to be invested in pipelines. Lastly, a refinery with an annual capacity of 1.75 million tons was built at a cost of some \$25 million. The company thus invested \$70 million before reaching the stage of commercial production.

Table 7. Estimated petroleum exploration and production costs in Canada, 1947-1958

(Millions of dollars)

Year	Exploration costs	Development costs ^a	Production costs ^b	Total
1947	16.4	5.9	3.1	25.4
1948	49.5	12.0	4.9	66.4
1949	106.5	32.1	12.1	151.0
1950	103.9	57.5	16.4	177.8
1951	146.1	77.4	20.1	243.6
1952	187.0	114.2	25.8	327.0
1953	188.9	100.5	31.7	321.1
1954	248.4	87.3	37.0	372.7
1955	255.1	168.1	52.0	475.2
1956	297.6	162.4	90.2	550.2
1957	314.1	169.5	112.4	596.0
TOTAL	2,216.2	1,147.3	510.1	3,876.6

Source: Canadian Petroleum Association.

^a Not including cost of pipelines extending beyond the collecting system.

^b Including expenditure in connexion with the utilization of natural gas.

71. In British Borneo, where production began to be developed after the Second World War, exploration costs over an eleven-year period (1947-1957) amounted to 168 million Malayan dollars. This figure includes the cost of topographical, geological and geophysical surveys, and the cost of exploratory drilling on land and, in recent years, off-shore. In addition, once petroleum was found, 668 million Malayan dollars (\$223 million) —four times the exploration costs—were invested to bring the operation to the production stage (drilling, permanent installations, housing, etc., but not including operating costs).

72. The trend of exploration and development costs in the United States, particularly as regards dry hole costs, is also of interest.

	1948	1953	1955	1956
	(Millions of dollars)			
Exploration costs	1,111	1,956	2,183	2,325
Dry holes	462	797	774	909
Other costs ^a	649	1,159	1,109	1,416

^a Canadian Oil and Gas Industries, February 1960.

	1948	1953	1955	1956
	<i>(Millions of dollars)</i>			
Development costs ^a	1,518	2,419	2,449	2,648
Producer wells	1,058	1,762	1,826	1,959
Equipment	362	483	426	477
Total	2,629	4,375	4,632	4,973

^a Including acquisition of land, geological, geophysical and other operations.

^b Including items (buildings, administration, maintenance, etc.) not shown separately.

73. Development costs thus represent 53 to 58 per cent of total expenditure. A special estimate was made in 1959 by R. E. McGill for the Rocky Mountains area. Since 1943 over 700 million tons of petroleum have been found in this area. The proportion of successful drillings in 1944 was 7.5 per cent, as against 18 per cent earlier, while the average size of finds declined from 1.5-2 million tons in 1940 to 350,000 tons after 1953. In 1959, 2,000 geologists and geophysicists were working in the area, seismic party-months totalled 1,200 per year and the area explored was 600 million hectares. In 1956 there were 2,500 dry holes and in 1957, 2,000. The annual exploration costs in the area are estimated at \$350 million, of which \$60 million were for geological and geophysical operations, \$160 million for the acquisition and leasing of sites, and \$130 million for drilling (including \$120 million for dry holes).

74. According to Brenner, the relative proportions of the various stages of exploration in the Soviet Union in the period 1946-1955 were as follows:

	<i>Percentage</i>
Aerial photography	5.2
Geology and geophysics	10.4
Exploratory drilling	72
Structural drilling	12.4

75. In two specific instances it has been possible to take the analysis a stage further: in one case, preliminary reconnaissance totalled approximately \$4 million; the cost of exploratory and appraisal drilling, \$100 million; and development costs (including transport systems), about \$600 million. The figures are only approximate but are none the less useful. Roughly 75 per cent of the over-all requirements, amounting to over \$700 million, were financed by the companies from their own capital. Loan funds were obtained to cover a part of the development costs.

76. Another example, taken from a different area, throws additional light on this subject. In this instance,

preliminary reconnaissance cost about \$4.5 million, prospecting and appraisal \$35 million, and development \$40 million. The development costs in this latter example were relatively low due to the fact that the transport system required had been simple and inexpensive.

C. CONCLUSIONS

77. A number of conclusions may be drawn from the various cases analysed, in particular from the two last examples. (a) In the first place, the preliminary reconnaissance of an area is relatively inexpensive compared with the investments needed for exploration and production. The cost of preliminary reconnaissance was one-twenty-fifth of the cost of exploration and appraisal drilling in the first case, and one-eighth in the second. The order of magnitude of the capital required changes, but no proportional rule can be formulated. (b) Secondly, the need for capital does not end with the discovery of a field. Although, in one case, the development cost was very little greater than the exploration cost, in the other case, the investment required for development and transport facilities was six times greater than that required for exploration and appraisal. The operator must therefore be prepared for a sustained effort if he wishes to secure the fruits of his initial venture.

78. A hypothetical exploration programme budget prepared by P. Leicester and reproduced in table 8 clearly indicates the relative importance and cost of the various phases of petroleum exploration, as well as their timing. The first two years are mainly taken up with preliminary reconnaissance (photogeology, field geology, gravimetry). Exploration proper begins in the third year with a seismic survey, which provides a basis for initial drilling to an average depth of 2,000 metres; this is completed in the fourth year, while field geology and seismic operations continue. Deep drilling (5,000 metres) begins at the end of the fourth year. The data furnished by drilling supplements the information previously obtained and may provide a basis for the revision of the seismic programme. There is a close interrelation between geophysical surveys, drilling, and the geological interpretation of the results; these operations proceed simultaneously from the fourth year onwards and should, sooner or later, confirm or disprove the presence of petroleum in the area. It should be noted that, just as a discovery of hydrocarbons in the course of drilling may lead to nothing if the field is not commercially exploitable, an unsuccessful exploration programme does not necessarily mean that the area should be completely written off as a potential oil producer.

Table 8. Simplified hypothetical seven-year programme budget

	1st YEAR	2nd YEAR	3rd YEAR	4th YEAR	5th YEAR	6th YEAR	7th YEAR	CAPITAL \$	RUNNING COSTS \$
PHOTO- GEOLOGY		FLYING 52,000 Km ² at \$5.40 per Km ²						1,000	200,000
FIELD GEOLOGY		INTERPRETATION 12 months at \$800 per month							9,600
		1. 24m at \$2,000 p/m						6,000	48,000
		2. 36m at \$1,500 p/m						8,000	54,000
		3. 72m at \$1,200 p/m						30,000	84,000
CORE- DRILLING				Capital: Rig Facilities and Transport Units				190,000	180,000
GRAVITY				12m at \$15,000 p/m				22,000	220,000
				1. 22m at \$10,000 p/m				20,000	260,000
				2. 26m at \$10,000 p/m				140,000	2,880,000
SEISMIC								130,000	3,200,000
								120,000	2,720,000
DRILLING				Medium Light Rig 2,000 metres, at \$90,000 s/m; 30m				1,800,000	2,700,000
				1. 36m at \$90,000 p/m				3,000,000	6,880,000
				2. 48m at \$90,000 p/m				2,600,000	2,230,000
				3. 36m at \$90,000 p/m				5,000,000	7,000,000
				Heavy Rig 5,000 metres, at \$160,000 s/m; 43m				13,067,000	31,218,000
				Medium Heavy Rig 3,500 metres, at \$116,000 s/m; 26m				3,960,000	
OVERHEAD		Buildings, facilities, administration, maintenance, stores, etc.						9,107,000	9,107,000
									\$40,325,000
									or \$15,545,000
									Capital recovered in fuel rentals etc.
Yearly Running Costs (Capital, overheads and rents excluded)		419,600	2,632,400	4,354,400	5,734,400	4,914,400	3,888,000		
Cumulative Total (Running Costs only)		882,400	2,834,800	7,189,200	12,923,600	17,838,000	21,718,000		

p/m = per party/month; s/m = per string/month; m = months

PART II. METHODS OF FINANCING PETROLEUM EXPLORATION

79. In the first part of this report an attempt has been made to give a general idea of the order of magnitude of the capital required to undertake large-scale petroleum exploration in a given territory. A number of questions have to be considered in this connexion, but what makes the problem unusual is the type, rather than the amount, of the capital needed. The reasonably representative examples given at the end of part I show that loans have as a rule been only a minor factor in financing exploration, accounting for only 15 to 18 per cent of the total capital invested. The explanation of this state of affairs is to be sought in the character of the ventures financed, which determines the type of funds required.

80. All the loans considered relate to the financing of development costs. The loans, whether long-term (approximately fifteen years) or medium-term (five years) and whether obtained from banks or through bond issues, were contracted for a specific programme, whose economic viability could be assessed with a reasonable degree of certainty. The percentage of loan funds may be 50 per cent in the case of oilfield development and equipment costs and as high as 75 per cent in the case of pipelines (e.g., 50 per cent long-term bond issue or bank loan and 25 per cent medium-term bank loans). Pipeline construction involves fewer risks than field development and a smaller proportion of the funds required needs to be provided from the operator's own resources.

81. It is contrary to the principles of sound management to finance exploration with funds from outside sources.⁷ Borrowed money should be used for undertakings whose economic viability is sufficient to ensure the regular payment of interest and repayment of the principal. Many examples prove that exploration operations cannot furnish this degree of security. For example, in Guatemala, oil companies invested \$40 million between 1956 and 1959 and no petroleum was produced. In Gabon, sums of the same order were invested for many years in exploration in the hinterland without discovering any commercially exploitable deposits. Discoveries were eventually made in the coastal region, after a complete change of method, and it will be many years before the investment is amortized. In Turkey, a large international company abandoned operations after several years of effort and the expenditure of \$20 million. Many more examples could be given, but those cited show that, despite the diversity of geographic conditions and legal structures, explora-

⁷A departure from this general rule, although not yet significant in practice, may be noted in the decision of the United States Export-Import Bank "to authorize financing and guarantees for equipment sold to government-owned as well as private oil companies for use in exploration or refining" (*The New York Times*, 25 March 1962), as well as in the loans granted by the Soviet Union to certain Asian countries.

tion is an aleatory venture and the risks are considerable. Exploration tends therefore to be financed by the operator from capital or reserves, or by self-financing. While there is no guarantee that the funds will not be lost, there is obviously a hope that the ultimate return will be much higher than that attainable from conventional investments. There are in fact virtually no examples of petroleum exploration operations not financed by risk capital.

82. Although individual exploration programmes inevitably involve an element of risk, it might perhaps be possible, on the basis of a series of operations spread over a long period in different areas, to achieve a rate of return that would offset the risks of single operations. This method is, of course, of mainly academic interest so far as the developing countries are concerned. It can only be put into practice by companies or institutions operating internationally. As will be seen, it is the practice of such companies to rely on their own resources to finance exploration.

83. A wide variety of methods have been used to finance petroleum exploration. Every avenue appears to have been explored. The various procedures are in any case not necessarily mutually exclusive. The state may intervene directly on a more or less monopolistic basis in the industry itself or may simply stand as a purely regulatory authority, although, even in the latter case, the state plays an important part since its supervision and encouragement may have considerable influence on the intensity of exploration programmes. Some countries have relied on private, frequently foreign, capital to finance programmes. Others have worked through an exclusive state monopoly. Whatever the point of departure, in many developing countries, there appears to be a growing trend towards mixed types of financing in which public capital and private capital are associated.

CHAPTER 3

State monopolies

84. The countries in which petroleum development programmes are the responsibility of state monopolies may be divided into two groups: the centrally planned economies, where such an approach is an integrated part of the general economic system, and the mixed economies, where many sectors are the province of private enterprise and, in some cases, the only activity entrusted to a state monopoly is petroleum exploration and, usually, production.

A. CENTRALLY PLANNED ECONOMIES

85. The term "centrally planned economy" in this context is applied to countries where the bulk of the economy is publicly owned and centrally planned. While

the petroleum economies of these countries have a number of similar characteristics, there is considerable variation among them. For example, the Soviet Union, which is the largest country in the world (22.4 million square kilometres) and covers one-sixth of the world's land area, contains sedimentary basins of considerable extent (10 million square kilometres). In addition, it is a developed country with a population enjoying a per capita income comparable to that of the countries of western Europe. Because of the immensity and diversity of its territory, the Soviet Union provides a large enough geographical area for risks to be properly spread. Petroleum problems can therefore be tackled on a "continental" scale. Thus, in the case of the Soviet Union, the establishment of a balanced autonomous system appears possible and consistent with a quasi-optional development of resources.

86. So far as the other centrally planned economies are concerned, and in particular Romania, the problem would obviously be wholly different if their activities were limited to their national territories, but this is not the case. The requirements of the planned economy countries other than the Soviet Union and Romania are met through the production of these two oil producing States.⁸ The petroleum economy of Romania, whose requirements are not on the same scale as its production potential, is therefore to be considered in an international context. Moreover, the Soviet Union and Romania are trying to provide their oil industry with markets in the rest of the world, thus enhancing the economic values of their resources, as is shown by the recent revival of their exports of crude petroleum and petroleum products under trade agreements with countries other than the centrally planned economies, in particular the industrialized countries of Europe. Even in a centrally planned economy, it is therefore true to say that the petroleum industry must be viewed in an international context.

87. Methods of exploration and development in the Soviet Union are not very different from those used in other oil producing countries. According to Brenner,⁹ "The petroleum industry is among the branches of Soviet industry which absorb most capital.... The capital invested between 1946 and 1957 totalled 100 billion roubles (old) (\$11 billion)—10 per cent of the Soviet Union's total investments". During the same period, investment for exploration and production amounted to 50 billion roubles (\$5.5 billion), including 30 billion (\$3.3 billion) for exploration alone. This sum includes 16 billion roubles (\$1.7 billion) for the drilling of deep appraisal wells, and exploration proper would therefore appear to account for almost 15 billion roubles (\$1.6 billion), about half for deep drilling and the remainder for geological and geophysical surveys and core drilling. The results were satisfactory. Production rose from 21 million tons in 1946 to 98 million in 1957 and 148 million in 1960, and the upward trend continues. However, in order to achieve this success it was necessary to mobilize a potential which is very

⁸ The pipeline system under construction in eastern Europe is an outcome of the joint petroleum policy of the member countries of the Council for Mutual Economic Assistance (CMEA).

⁹ Brenner, *Planovaniye nefte dobyvayushchei promyshlennosti* (Planning of the petroleum industry) (Moscow, 1959).

substantial, even on the scale of the Soviet Union, and far from marginal in comparison with total investment.

88. Although the methods of financing used are conditioned by the structure of the Soviet economy, their analysis may, if correct, be helpful in a comparative study of the various aspects of the problem. All the financial resources of Soviet oil enterprises (drilling and production trusts, etc.) are obtained from the general budget. Production is subject to strict cost accounting and prices are calculated on the basis of the over-all exploitation and amortization costs of the wells and production costs over a fifteen-year period. For accounting purposes, the amortization of drilling costs is started on the first day of the month in which production begins. The amortization figure includes the cost of drilling for water injection and appraisal wells. The calculated amount of the amortization is paid into the amortization fund of the State Bank. Exploration costs proper do not appear to be subject to amortization.

89. The enterprises pay their profits (the difference between their theoretical costs and the actual price, after deduction of the payment into the Enterprise Fund) into the Sovnarkhoz budget or the general budget. They also pay taxes. Thus, although there is no offsetting at the trust or Republic level in the Soviet Union, the capital invested is recovered at the federal level and made available for the financing of subsequent development. On the other hand, funds for exploration, in particular for geological and geophysical operations, appear under a special item in the general budget. There is no guarantee of repayment and the appropriations can be regarded as being in a sense analogous to "risk capital". The analogy may perhaps be somewhat artificial, in view of the structure of the Soviet economy, but it appears to reflect the actual situation, even in a large country with a highly planned economy.

90. In Romania,¹⁰ out of a total investment of 141,722 million lei (\$23,500 million) between 1951 and 1960, 20,060 million lei (\$3,500 million) were invested in the petroleum industry. The distribution was as follows:

	Millions of lei	Percentage
Discovery of new reserves	6,276	31
Development of fields	10,917	55
Refinery construction and expansion	2,867	14

Petroleum production between 1951 and 1960 having been of the order of 100 million tons, the investment per ton of petroleum produced was as follows:

	Lei-ton
Discovery of new reserves	62.7
Development of fields	109.1
Refinery construction and expansion	28.6

91. During the same period, Romania's production of crude petroleum increased from 4.15 million tons in 1948 to 11.5 million tons in 1960. Between 1949 and 1960 109.5 million tons of crude petroleum and 37.9 billion cubic metres of natural gas were produced, compared with 62.2 million tons and 16.5 billion cubic metres during the corresponding preceding period. The level of drilling activity in 1960 was six times higher

¹⁰ Information communicated to the United Nations by the Government of Romania.

than in 1947, the year preceding nationalization. All operations were financed from national income exclusively without any use of foreign capital.

B. OTHER COUNTRIES

92. State petroleum monopolies are also found in mixed economy countries. It is not proposed to give a complete list, but to analyse a number of representative examples. The first two examples examined are of "total" monopolies of somewhat different types: *Petróleos Mexicanos* (PEMEX) in Mexico and *Petróleo Brasileiro* (PETROBRAS) in Brazil.

93. In many other countries, there has recently been a tendency to relax the state monopoly, to varying extents and by different methods, in favour of private industry. The underlying significance of these differences, some of which are perhaps fortuitous or the result of local historical factors, is not always easy to understand, but analysis may be of assistance in explaining the different approaches adopted by developing nations in dealing with the petroleum problem. In this connexion, it is proposed to examine below the case of Argentina, which has retained a state monopoly while enlisting the co-operation of private or foreign enterprises, and the cases of Turkey and Bolivia, which have maintained a state enterprise but have deprived it of its monopoly.

Mexico

94. In Mexico, an exclusive state monopoly has, since 1938, operated a developed industry and substantial petroleum assets. Mexican production was the world's second largest in 1921 with 27 million tons, but it subsequently decreased, falling to 4.5 million tons in 1932. Since that date, it has steadily increased and is more than sufficient to meet domestic demand.

95. The new Director-General of PEMEX has described the organization's aims in the following terms: "Our industry's most important activity is undoubtedly continually to discover new reserves of petroleum and gas and to ensure that production is always sufficient to satisfy the ever expanding consumption of petroleum products".¹¹ As the Mexican state monopoly is not concerned solely with exploration and production, it is difficult to determine how much capital is specifically allocated to exploration proper. Analysis of the methods of financing used is difficult and might be arbitrary.

96. The financial situation of PEMEX cannot be analysed on a year-by-year basis because no accounts were published until 1958. However, the balance-sheet for 31 December 1958 showed that the company's financial assets represented an inadequate proportion of its long-term debts and that its liquidity ratio was low. According to Bermudez,¹² PEMEX investments between 1947 and 1957 were financed as follows:

	<i>Millions of pesos</i>
Reserves	3,116
Debt	2,998
New capital	24

¹¹ PEMEX, *Report of the Director-General*, 18 March 1960.

¹² Cited by W. J. Levy, *The Search for Oil in Developing Countries*.

97. Before 1947 and after nationalization, a total of approximately 500 to 600 million pesos was invested by PEMEX.¹³ The investment was financed mainly by loans, chiefly from the Export-Import Bank and the *Nacional Financiera*. During the first twenty years of operation of the monopoly, PEMEX appears to have made only a negligible contribution to investment programmes. Furthermore, PEMEX could not meet its commitments to the State and owed considerable arrears of tax. On 31 December 1958, the accumulated deficit totalled 215 million pesos.

98. Assuming that reserves were used solely to maintain the existing level of operations, it would seem that new investments were financed almost in their entirety by long-term or short-term loans and by arrears of debts to the State. In the 1959 financial year, the PEMEX debts to the State or other Mexican institutions were consolidated in the form of ninety-nine-year 8 per cent bonds. The process is in many ways analogous to an expansion of capital by the contribution of new funds. Provision for the payment of interest was no doubt made in order to enable PEMEX to demonstrate its economic viability. In any event, the experience of PEMEX over the past twenty years clearly shows that the development of petroleum resources, even in a country seeking only to satisfy its own requirements, calls for self-financing and that borrowing does not offer an appropriate solution.

99. This is the diagnosis made by the Mexican leaders themselves. The latter saw that PEMEX would be unable to achieve the expanding equilibrium necessary to achieve its goals unless it was assured of adequate resources of its own. For this reason the price level (which was low before nationalization) was raised concurrently with the reorganization mentioned above. At the same time, PEMEX had to contract heavy foreign debts to finance its programme and meet its foreign currency requirements. The company is continuing the consolidation of its external loans over a twelve-year period and in 1959 it negotiated further loans with foreign countries totalling \$90 to \$100 million, i.e., 1,000 to 1,200 million pesos. These funds are to be used mainly to finance infrastructure works and expand refinery capacity; they were to be employed for investments yielding a certain return which will make it possible to service the loans. They should make it possible to cover foreign currency requirements and release additional resources for investment in exploration. The exploration programme has in fact taken on new scope. There has been a substantial increase in metres drilled, from 945,000 metres in 1950 to 1,605,000 in 1960. The number of exploration wells has also steadily increased (81 in 1959, 103 in 1960). Profits in 1959 and 1960 were insufficient to cover further investment programmes and in 1960 PEMEX had to request a moratorium on its debts to the State.

100. Since 1959 PEMEX has been unable to obtain the foreign capital as it can no longer enter into contracts with foreign interests for the development of exploration. After 1948 PEMEX made use of foreign assistance in an effort to regain the ground lost during

¹³ J. R. Powell, *The Mexican Petroleum Industry, 1938-1950* (Bureau of Business and Economic Research, University of California, 1956), page 168.

the war. The first service contract was signed with Cities Service. Two further contracts were concluded with CIMSA, a company of American "independents", which received a form of exploration permit. CIMSA financed all operations and was to be repaid from subsequent production. The situation later changed and the Mexican monopoly has become stricter. This has resulted in a certain degree of vulnerability, indicated by the fact that in 1960 PEMEX was still covering almost 70 per cent of its investments by loans.¹⁴

101. PEMEX has probably not been a financial success, due to a price structure artificially maintained below the world level. Despite this fact, it has succeeded in meeting demand and has maintained a purely Mexican "petroleum enterprise". In recent years, Mexico's petroleum imports have steadily decreased and exports have increased (except in 1960 because of American import restrictions). In addition, exports of natural gas to the United States are now helping to strengthen the foreign trade balance.¹⁵

102. The output of crude petroleum is slowly increasing (by about 5 per cent a year) and the volume is still greater than domestic demand, but the product-mix obtained from Mexican crudes does not fully correspond to domestic requirements. Proved reserves are of the order of 350 million tons, representing twenty-five years at current rates of production. Finally, side by side with its refining operations, PEMEX has begun to develop a large-scale petro-chemical industry. PEMEX now supplies nine-tenths of the country's commercial energy. These results have been in large part achieved by financing by the State which has invested altogether over 2.3 billion pesos and has undoubtedly had to accept a considerable loss in tax revenue.

103. Investment by PEMEX in 1960 totalled 2.45 billion pesos and 2 billion pesos in 1961.¹⁶ It may be useful to compare these figures with the figures for the Mexican national income and State Budget in 1959, which were, in millions of pesos:¹⁷

National income	100,000
National budget (including public investment, 1,676.8 million pesos)	8,498.9

104. This development has resulted in a change from the previous deficit in the petroleum balance (excess of imports over exports by value) to a surplus, benefiting the national economy as a whole.

Brazil

105. In Brazil, as in Mexico, petroleum exploration and production is the sole prerogative of a state controlled monopoly (PETROBRAS). There are, however, considerable differences between PETROBRAS and its Mexican counterpart. To begin with, it inherited nothing like the same potential when it was established

¹⁴ "PEMEX on its New Path", *Petroleum Press Service*, April 1961.

¹⁵ In 1960, natural gas production, totalling 9.6 billion cubic metres was double the figure for 1957 and three times the figure for 1954. This expansion was made possible by the development of transport facilities and the construction of new processing units.

¹⁶ *Petroleum Press Service*, April 1961.

¹⁷ United Nations, *Statistical Yearbook, 1960* (Sales No.: 61.XVII.D).

and its operations were therefore far from being balanced. Moreover, PETROBRAS is not a pure state enterprise but a Brazilian-financed "mixed" company in which the State holds a majority of the shares. Furthermore, while its operations extend to transportation, refining, distribution and petro-chemicals, it has no monopoly in those activities, although it will of course benefit from any expansion in them. This explains to some extent why a large proportion of its resources can be devoted to exploration and development.

106. The funds allocated to the latter sector represented about 35 per cent of total investments between 1955 and 1959 and under the 1957-1961 plan were to amount to 30 billion cruzeiros out of a total investment of 55 billion, with 20 billion earmarked for exploration alone. The objective of PETROBRAS is, indeed, to close the country's petroleum gap, which is a heavy burden on the balance of payments (petroleum imports cost some 250 million dollars a year). During the last three years its investments have trebled, rising from 7,841 million cruzeiros in 1958 to 24,409 million cruzeiros in 1960. Of the latter sum, 4,325 million cruzeiros, or 17.7 per cent, were spent on exploration and 2,139 million, or 8.8 per cent, on development.¹⁸

107. Lastly, PETROBRAS differs from PEMEX in its methods of financing. The machinery devised for the state monopoly was designed to achieve two objectives: to encourage, with more suitable initial financial resources, the development of a national petroleum industry on a much larger scale than the National Petroleum Council had previously done; and to make the operation a self-financing one, with reinvestment of the operating profits enabling the Company gradually to attain the higher level of investment needed by the petroleum industry, without calling upon public funds.¹⁹ The capital of PETROBRAS—4 billion cruzeiros at the time of its formation—was divided between the Federal Government (72.15 per cent on 30 December 1955), the member states and the Federal District (22.28 per cent) and the communes (5.57 per cent).²⁰

108. The proportions have changed very little since then, and on 31 December 1960 were as follows:

	Percentage
Federal Government	65.5
Member states	27.0
Communes	6.8
Others	0.7

109. A sixth capital increase approved at the General Meeting on 9 November 1960 raised the PETROBRAS capital to 40 billion cruzeiros, 28,311 million of which had been paid up by the end of December 1960. Thus, 11,689 million cruzeiros remained to be paid up in 1961, 11,491 million in ordinary shares and 198 million in preference shares. However, it should be remembered that the capital increases were carried out at a time of general inflation.

110. Growing attraction to private individuals of the preference shares issued for public subscription was noted. During the 1960 financial year, 490,432 shares

¹⁸ PETROBRAS, *Relatorio das actividades de 1960*.

¹⁹ PETROBRAS, *Brazil, Summary of Statistical Data on Petroleum and Activities of PETROBRAS* (Rio de Janeiro, 1958).

²⁰ *O Que é a PETROBRAS*, October 1956.

of this type, to a total value of 98,086,400 cruzeiros, were subscribed. This meant 2,355 new shareholders in this category, raising the number of holders of preference shares to 13,817. A substantial proportion of the dividends distributed to shareholders has been re-invested, new money of this type representing 6 per cent of the total financing between 1953 and 1959 (5 per cent in 1960). In addition to its initial capital, PETROBRAS also had other substantial resources with which to meet its needs. Those resources were derived in the first place from the price policy followed, which was the reverse of that followed in Mexico. Brazil has retained the Caribbean import prices as parity. It has also imposed heavy protection duties on refined products. The total funds thus made available through its operations enabled PETROBRAS to finance from its own resources nearly 36 per cent of its total investments between 3 October 1953 and 31 December 1959.²¹ In addition to this substantial and stable income,

²¹ Under article 13 of Law 2004 establishing PETROBRAS, a part (15 per cent) of the single tax levied on imported and locally refined petroleum products under Law 1749 of 28 November 1952 is paid to PETROBRAS. This tax brought PETROBRAS 2,064 million cruzeiros in 1958, 3,456 million cruzeiros in 1959 and 4,114 million cruzeiros in 1960. Under article 14 of Law 2004 PETROBRAS also receives the proceeds of a tax levied on imported vehicles, which amounted to 418 million cruzeiros in 1958, 730 million cruzeiros in 1959

PETROBRAS has been allocated the proceeds of a series of miscellaneous taxes or duties payable by taxpayers on oil and automobiles.

III. A further source of capital for PETROBRAS is the levy, payable by privately owned refineries, of 9 per cent of the c.i.f. value of their imports of crude oil and 50 per cent of their net profits on refined products manufactured from imported crude. Through this levy, PETROBRAS received from the private refineries 1,390 million cruzeiros by the end of 1959. The funds received by PETROBRAS from these different taxes since its formation amount to 23,291 million cruzeiros and represent about one-third of the company's financial resources. However, it should be noted that in recent years the Company's own income has provided a steadily growing proportion of its total resources, as table 9 shows.

and 1,512 million cruzeiros in 1960. Article 48 of the same Law provides for the payment of a special contribution by industrial firms based on the quantities of liquid hydrocarbons which they consume. This contribution amounted to 560 million cruzeiros in 1958, 389 million cruzeiros in 1959 and 492 million cruzeiros in 1960. Finally, article 15 of the same Law provides for the payment of an annual contribution by owners of automobiles, boats and aircraft in exchange for certificates which are to be replaced by preference shares or bonds in the Company.

Table 9. PETROBRAS resources

(Millions of cruzeiros)

Item	1955	1956	1957	1958	1959	1960
Gross operational profits	1,021	2,817	4,705	7,766	13,333	15,477
Undistributed profits	—	64	972	2,719	3,628	6,998
Reinvested dividends	—	102	605	773	1,059	1,464
TOTAL, own resources	1,021	2,983	6,282	11,258	18,020	23,939
Income received under articles 13, 14 and 48 of Law No. 2004	936	1,300	2,557	3,012	4,575	6,118
Levy on owners of vehicles	446	472	416	7	11	2
TOTAL, fiscal resources	1,382	1,772	2,973	3,049	4,586	6,120
TOTAL, over-all resources	2,403	4,755	9,255	14,307	22,606	30,059

Source: PETROBRAS, *Relatorio das actividades de 1960*.

112. These figures show that, while the *absolute* contribution of the State has increased, the *relative* importance of state support in the over-all financing of PETROBRAS operations has declined considerably. Also worthy of note is the relatively modest share, during the period 1953-1959, of the resources derived from amortization (4 per cent of the total). This is not unusual in the case of an enterprise which, unlike PEMEX, is of relatively recent creation and is in the process of expansion. Furthermore, up to 1959 the funds obtained through borrowing were fairly low (about 9 per cent)

113. Brazil has also evolved an interesting system of covering the foreign currency requirements of PETROBRAS. The Company is credited monthly by the Bank of Brazil with the equivalent of about 80 per cent of the savings in foreign currencies resulting from domestic petroleum operations. However, this

monthly quota may not be less than 3 per cent or more than 5 per cent of the total income from exports.²²

114. The total public funds allocated to PETROBRAS may be compared with the following figures for the Brazilian economy in 1959 (in millions of cruzeiros):²³

National income	1,460,900
National budget:	
Federal Government	156,044
States and Federal District	66,314

115. PETROBRAS has not yet obtained any substantial results from its exploration. At the time of its formation, almost the whole of the country's petroleum requirements had to be imported, domestic sources pro-

²² PETROBRAS, Brazil, *Summary of Statistical Data on Petroleum and Activities of PETROBRAS*.

²³ United Nations, *Statistical Yearbook, 1960*.

viding only 2 per cent of the crude oil requirements and only 5 per cent of the refined products. Imports, which in 1953 totalled \$247 million or 17 per cent of the country's total imports, amounted to more than \$281 million in 1958 and in 1960 were still running at \$257 million—all this despite the efforts of PETROBRAS, the country's consumption of petroleum having doubled since 1953. Nevertheless, substantial savings in foreign currency have been achieved through those efforts, which have resulted in a refining capacity of more than 15 million tons a year, a tanker fleet of more than 500,000 tons deadweight and a crude oil production of 4 million tons. In 1960 the Brazilian petroleum industry saved \$169 million in foreign currency, or \$25.5 million more than in 1959. Of those foreign currency savings, \$85 million were made on refining, \$75 million on production and \$9 million on ocean transportation.

116. Despite the substantial exploration effort, proved reserves are still under 100 million tons. The following figures give an idea of the expansion in exploration activities during the past few years:

	1956	1958	1960	
Drilling rigs	29	53	62	
Number of holes drilled:				
Exploratory	7	58	93	
Development	40	81	141	
	TOTAL	47	138	234
Metres drilled	71,387	209,170	319,016	

Altogether, almost \$300 million were spent between 1955 and 1960 on exploration outside the already productive Reconcavo Basin in Bahia: the results of this expenditure have been rather disappointing.

117. It is easy to see the apparently substantial differences between the methods of financing adopted by PETROBRAS and those by PEMEX, differences which in any case are largely justified by their past, since one of the two monopolies inherited an established exporting industry while the other had to start from nothing. But on analysis those differences will be seen to be more evident in form than in substance. In the case of PETROBRAS the problem was one of providing it with adequate resources of its own. In the case of PEMEX deficits had to be made good *a posteriori* by "capital" contributions from the State. These two examples will illustrate the need for large sums of "risk" capital. This need has led some States to experiment with new methods of financing in which private capital can be associated with state enterprises.

Argentina

118. In Argentina an attempt is being made to associate private capital with the work of a state enterprise which has a monopoly in the field of petroleum. This is a reversal of previous policy and it would have been interesting to analyse in detail the reasons for this change of policy by the Yacimientos Petroliferos Fiscales (YPF). However, since YPF has issued no report giving details of its financial arrangements before 1958, the only basis for a study are the official statements and press comments published when the first contracts were signed.

119. The principles on which YPF operates (at any rate since 1958, the year in which the main objectives to be attained in the field of petroleum were outlined), are expressed in the introductions to its reports for the financial years 1958, 1959 and 1960. The reports show that the aim of the YPF operations is "the utilization of the oil contained in the sub-oil of Argentina in order to eliminate the need for imports"²⁴ and, in 1959, that "YPF is returning to its traditional policy of utilizing domestic crude oil only, so speeding up the advance towards the desired objective: a situation where the country will be self-sufficient in this field". However, YPF is even more ambitious, since by 1958 the prospects were so encouraging that it could assert without risk that there was a possibility of Argentina becoming an oil exporting country, "though not, of course, until the nation has increased its present low level of consumption, which is typical of the industrially underdeveloped countries, through the intensification of production of domestic petroleum, which must be the main factor in that development".

120. Thus the Argentine authorities are hoping for as rapid as possible an expansion of production, even beyond the needs of domestic consumption. At the same time, YPF stated (1959) that, "as universally acknowledged, the oil industry, even as an economic proposition, requires a very large volume of capital".

121. Yet the Government's policy is no longer to finance expansion from public funds. YPF refers to this in its 1959 report, when it stated that "it lacks the necessary capital to finance the desired expansion and that capital cannot be expected from the State in view of the repeated directives on the subject issued by the country's economic authorities". This official position was reconfirmed subsequently, notably in 1961 when any supplementary governmental subsidy was refused.

122. It is true that until that date public funds (from the Treasury and the National Energy Fund, and miscellaneous contributions and appropriations for the YPF "expansion plan") had, to judge from the balance-sheet of 31 December 1958, provided a very high proportion of YPF's capital requirements. Relatively little came from its own resources or outside contributions. Owing to the impossibility of distinguishing between short-term and long-term credits, no exact proportions can, however, be established and any discussion must therefore be in general terms. By the end of 1960, the situation had improved in a number of respects: the "own reserves" and "other creditors" items were considerably higher than in 1958, and new YPF bonds had been issued. However, the additional contributions from the State and the National Energy Fund appear to have exceeded 6 billion pesos between 1 January 1959 and 31 October 1960. Faced with the apparent contradiction of having to expand the country's oil potential and hence the exploration effort without the aid of government subventions, YPF took three steps. Firstly, it launched a programme of austerity and cost-reduction. Secondly, it sought loans, particularly abroad. This is the probable explanation of the increase in the "other creditors" item in the balance sheet. Some of the loans were tied in with the

²⁴ In 1957 Argentina consumed 12,100,000 tons of petroleum products and produced 4,542,000 tons of crude oil.

conclusion of contracts for the supply of equipment. Such a formula became possible once the investments could be expected to yield some return. The loan made in early 1961 by the Export-Import Bank also comes into this category. This was the first loan made by that organization to an oil concern.

123. As the third and last step, YPF was authorized to conclude contracts of various kinds with private domestic and foreign firms. This *de facto* relaxing of the monopoly was accompanied by its *de jure* strengthening through the Law of 12 November 1958, article 2 in particular. Since 1958, two types of contracts have been concluded by YPF with foreign firms. The first are ordinary service contracts, similar to those also concluded by such monopolies as PEMEX and PETROBRAS. The second, covering exploration and development, are marked by the fact that YPF's co-contractor acts as operator, provides the finance and shares (in differing proportions) in the risks of the "venture".

124. All the contracts studied have one common feature. They are designed, in accordance with the objective mentioned earlier, to provide YPF and the Argentine economy as soon as possible with enough local oil to cover the country's needs. It will be interesting to see how the terms of those contracts change when the co-contractors are asked to dispose of and export the crude oil produced. Such an eventuality is probably close at hand, for while consumption in 1960 did not increase greatly in relation to 1957 (12.5 million tons), output had almost doubled (9 million tons). In 1961 a further 36 per cent increase in production was recorded (12.5 million tons). This increase in output resulted, in 1960, in immediate reductions of 38 per cent in Argentina's imports of crude oil and 30 per cent in those of refined products as compared with 1959. Foreign currency payments for those imports were \$124.5 million in 1960 as against \$174 million in 1959, a saving of \$49.5 million. The 1961 foreign currency payments are believed to have been in the region of \$80 million, a further saving of \$44.5 million as compared to the previous year. The fact that Argentine production has doubled in two years has meant a saving of nearly \$300 million a year in the country's oil imports. Since the end of 1961 Argentina has started exporting crude oil.

Turkey

125. Turkey provides another interesting example. Unlike Mexico, where the state monopoly took over a fully developed industry, Brazil, where the state monopoly had to start from nothing, at any rate in so far as exploration was concerned, and Argentina, where the state monopoly, while retaining control over operations, has secured the assistance of domestic and foreign private companies, Turkey offers the case of a monopoly which has been abandoned after twenty years of experience but without the State giving up its own activities in the field of petroleum. The search for oil in Turkey began at the end of the nineteenth century, when private companies which had been granted exploration permits drilled a few shallow holes without obtaining results. The 1926 Petroleum Law being somewhat unfavourable to private capital, no concessions were granted to private companies and in 1929 pros-

pecting was nationalized. Exploration began in 1933 with the creation of the Petroleum Exploration and Development Administration, a state organization which drilled its first hole in 1934. In 1935 the Government's petroleum activities were taken over by the Mining Exploration and Development Institute (MTEA), which retained the monopoly until 1954. Exploration was carried out with the assistance of American companies working under contract. A shortage of capital appears to have hampered the work.

126. After geological reconnaissance, drilling began and led to the discovery of oil at two places in south-east Turkey near the Syrian frontier: at Ramani in 1940 and Garzan in 1951. In 1954 the reserves were estimated at some 10 million tons and the potential production capacity at 300,000 tons a year, although actual production was only 60,000 tons a year owing to the inadequacy of the transportation and refining facilities. When Law No. 6326, which was designed to encourage the investment of foreign capital, was promulgated on 7 March 1954, Turkey's domestic consumption was in the region of one million tons a year. The one refinery, installed near the producing fields in order to meet local requirements, had a capacity of 70,000 tons a year. Imports of petroleum products needed to satisfy domestic demand represented an outlay of \$40 million. In nineteen years MTEA had spent between \$20 and \$24 million on oil exploration.²⁵ These figures may be compared with the following data on the Turkish economy in 1959 (in millions of Turkish liras):²⁶

National income	40,095
National budget	5,980
Public investments	1,917

127. Since the entry into force of the new Petroleum Law, some twenty foreign companies have been granted concessions covering a total area of about 100,000 square kilometres. The state's activities have been taken over by the Turkish National Petroleum Company (TPAO), a mixed company of which 49 per cent of the capital may be subscribed by private investors. The National Company enjoys no privileges except for those areas in which work had already been carried out by MTEA. As a result of the granting of concessions to foreign private companies, the Turkish Government received royalties amounting to 2.5 million liras in 1956 and 2.8 million liras in 1957. Under the 1954 Law, Turkey was divided into nine districts, districts III and IV in the north-east of the country being partially closed to exploration at the present time. In 1960 the TPAO output was raised to 360,000 tons, all of it processed at its refinery at Patnos, the capacity of which has just been increased to 650,000 tons a year.

128. Although the results obtained by the Turkish monopoly in twenty years do not seem very impressive, it should be noted that in eight years—from 1953 to 1961—the major companies have still made only a few minor discoveries, while their exploration expenses from 1955 to 1959 are estimated at \$62.5 million, to which must be added the \$6.5 million spent by TPAO. The largest group has given up after investing \$20 million and drilling eleven dry holes. However, investment is

²⁵ W. J. Levy, *op cit.*

²⁶ United Nations, *Statistical Yearbook, 1960.*

continuing at the rate of \$2 million a month. The work done by MTA between 1933 and 1954 enabled the Turkish Government to obtain a general picture of the country's oil potentialities. Those preliminary surveys made it possible for the private companies to start drilling very soon after the concessions were granted under the Law of 1954.²⁷ Turkey's policy since 1954 appears to have enabled the State to retain a certain measure of control and activity in this field without forfeiting the assistance of the major groups and their capital.

Bolivia

129. The case of Bolivia is somewhat similar to that of Turkey, since the state monopoly established in 1936—the Yacimientos Petrolíferos Fiscales Bolivianos (YPFB)—came to an end in 1955, at any rate in respect to oil exploration and production. There is, however, one basic difference, in that the first discoveries of oil in Bolivia were made by a private company in 1922 and 1926 and that when that company was expropriated, YPFB, like PEMEX in Mexico, inherited a commercial-scale production which had started in 1931. Acting as an independent body responsible directly to the head of the Government, YPFB was authorized to conclude private contracts for the development of its concessions. When the new Petroleum Code was issued in 1955, YPFB production was 350,000 tons. After rising to 465,000 tons in 1957, it has since fallen steadily owing to the restrictions on investment resulting from the currency stabilization policy inaugurated by the Government in 1956 in order to stem the rapid inflation.²⁸ Since then YPFB has had to be content with financing its operations from its own resources. The situation deteriorated still further in June 1957 as a result of the reduction of 20-25 per cent in the domestic prices of petroleum products and of the lack of foreign currency.

130. Since publication of the new Petroleum Code, many foreign companies have been attracted to Bolivia and have obtained concessions, but their labours have not yet been crowned with success. At the end of 1959 it was estimated that these companies had spent about \$55 million on oil exploration, \$25 million in 1959 alone. With the further increase in expenditures, \$100 million have been spent on exploration by the foreign companies from the time of publication of the Petroleum Code up to 1960.

131. These are substantial expenditures when compared with YPFB's capital expenses in 1957-1958 of \$38 million, including \$10 million derived from foreign loans.²⁹ YPFB is said to be contemplating an increase in production to 2.5 million tons in three years, which presupposes the existence of proved reserves of some 50 million tons instead of the present 17 million, and expenditures amounting, according to YPFB, to \$23 million spread over four years.

²⁷ The main reasons why drilling could be started immediately included the existence of 1:25,000 topographical maps for most areas of the country, the fact that detailed geological and geophysical surveys of the sedimentary basin had already been made by MTA, and the subsequent preparation, also by MTA, of 1:100,000 geological maps of the whole country.

²⁸ Between 1952 and 1956 the rate of exchange rose from sixty bolivianos to 7,760 bolivianos to the dollar.

²⁹ W. J. Levy, *op. cit.*

132. YPFB is now losing 23,000 million bolivianos, or \$2 million, a year and was recently authorized to keep 50 per cent of the sums due to the State under contracts concluded with private companies. Because of the official policy of maintaining prices below world prices, YPFB cannot mobilize its own financial resources and the State has been forced to meet the costs of exploration from its own budget.

133. To conclude, there would appear to be subtle differences between the methods chosen by the countries with a state monopoly to finance the search for oil. While the centrally planned economies, as well as Mexico and Brazil, have retained a complete monopoly, the development of exploration has led the other countries studied to seek out ways of associating private capital and public funds. The systems thus being established in these countries closely resemble those developing in countries which have started from a diametrically opposed position, i.e., where exploration and development of petroleum resources was originally entirely in private hands and where government participation in the development of these resources has tended to increase.

CHAPTER 4

Financing from private sources

134. Except in mainland China and the centrally planned economies of Europe, the great bulk of petroleum exploration and production throughout the world has been financed from private sources, although in a number of countries (mainly small producers) the situation may not correspond to the over-all picture.

Table 10. Shares of States in world petroleum production, 1961^a

Item	Thousands of tons	Percentage
World, excluding centrally planned economies	932,155	100
Private	878,495	94.25
State	53,660	5.75
Mexico	15,200	
Argentina	12,500	
Sabara	9,600	
Brazil	4,720	
Austria	2,370	
Yugoslavia	1,400	
Colombia	1,350	
Chile	1,200	
UAR	1,100	
Gabon, Congo (Brazzaville)	880	
Italy	700	
Turkey	400	
Others ^b	2,240	

^a The figures are in large part estimates.

^b Including the share of production controlled by the State in such countries as Bolivia, Burma, the Federal Republic of Germany, France, India, Iran and Peru.

135. It is somewhat difficult to define state intervention in the various producer countries, since it ranges

from direct monopoly to simple financial participation. From a strictly financial point of view, it might have been thought that the State's share in production was equivalent to its percentage share in the capital of the producing companies. But it would appear more useful to retain the criterion of initiative in operations and to limit consideration, for example, to the production of companies the major part of whose capital is held by the State. On this basis the production of British Petroleum could be counted as produced with state participation. Even making this calculation (which is somewhat artificial, having regard to the way the company is run and its field of activity) the figure for the government's share in world production, outside

of the centrally planned economies, would only be in the region of 15 per cent.

A. PRIVATE OPERATIONS

136. A distinction should be made between companies operating on an international scale and those operating in one country only. Because of the size of the resources and petroleum potential of the United States, some American petroleum companies may play an international role while the operations of others are limited to the United States or even to particular phases of the industry. It may therefore be useful to analyse the distribution of production among the various companies.

Table 11. Estimated crude petroleum production of international companies, 1960
(Millions of tons, except as indicated)

Area	Standard N.J.	Gulf	Texaco	Standard Calif.	Mobil	Shell	BP	CEP	Total of the eight	Others	Total production
North America	25.2	17.4	22.8	14.5	11.5	16.2	0.2	0.1	107.9	265.1	373.0
Latin America	65.9	10.6	10.5	3.5	7.9	49.0	1.6	—	149.0	48.5	197.5
Western Hemisphere Total	91.1	28.0	33.3	18.0	19.4	65.2	1.8	0.1	256.9	313.6	570.5
Europe	2.1	1.7	—	—	1.1	1.3	0.1	—	6.3	8.4	14.7
Africa	—	—	—	—	0.2	1.6	1.0	3.2	6.0	4.4	10.4
Middle East*	28.8	43.5	22.9	22.9	16.6	21.0	74.0	17.0	246.7	15.9	262.6
Far East	2.1	—	4.1	4.1	2.0	11.3	—	—	23.6	2.3	25.9
Eastern Hemisphere Total	33.0	45.2	27.0	27.0	19.9	35.2	75.1	20.2	282.6	31.0	313.6
TOTAL	124.1	73.2	60.3	45.0	39.3	100.4	76.9	20.3	539.5	344.6	884.1
Planned economy countries	—	—	—	—	—	—	—	—	—	167.2	167.2
WORLD TOTAL	124.1	73.2	60.3	45.0	39.3	100.4	76.9	20.3	539.5	511.8	1,051.3
Percentage of total production	11.8	7.0	5.8	4.3	3.8	9.6	7.3	2.0	51.6	48.4	100.0

* Breakdown of production according to financial participation; no account taken of supply contracts.

These eight international companies thus account for 51.6 per cent of total world output, over 61 per cent of world

output outside mainland China and the European centrally planned economies, and almost 85 per cent of output if mainland China, the European centrally planned economies and North America are excluded.

137. The operations of the international companies are not restricted to petroleum exploration and production. All have direct outlets to consumer markets of which they supply a very large part in many countries. The balance between their various branches of activity varies but all have a sufficient degree of "integration" to ensure the stability necessary to their development. The companies thus possess relatively complete experience on the technical and commercial level, and consequently on the economic level too. On the financial level, moreover, their methods are of interest: the integrated companies have hitherto balanced their over-all operations in such a way as to permit the self-financing of a large part of the investment needed for the exceptionally rapid expansion of capacity required to meet demand. Little recourse has been made to outside sources, compared with the situation in other sectors. The international companies can therefore be said to finance exploration from their own funds.

138. This conclusion also holds good for the majority

of the private American companies, as table 12 shows on page 24.

139. Even where private exploration companies have not reached a sufficient level of production to finance their own exploration operations, they call upon their shareholders and hardly ever cover these costs by borrowing.

B. LEGAL SYSTEMS ADOPTED BY DIFFERENT COUNTRIES

140. A wide variety of approaches have been and still are, adopted in this field. They vary according to the main object of the state authorities. While there can be no question of a detailed analysis, or even a complete list, of such approaches, countries may be divided into two groups, those which grant general or limited petroleum concessions on a contractual basis within a broad framework of mining legislation, and those which have enacted specific legislation in the field of petroleum.

Table 12. Origin and use of the funds of the thirty-two major American petroleum companies, 1950-1960

(Millions of dollars)

Year	Available profits	Dividends paid ^a	Funds available for investment	Capital expenditure ^b	External funds required
1950	3,080	724	2,356	1,971	— 385
1951	3,706	884	2,822	2,620	— 202
1952	3,902	939	2,963	3,233	270
1953	4,379	1,019	3,360	3,489	129
1954	4,592	1,041	3,551	3,760	209
1955	5,200	1,163	4,037	4,081	44
1956	5,866	1,324	4,542	5,347	805
1957	6,318	1,414	4,904	5,636	732
1958	5,531	1,419	4,112	4,526	414
1959	5,892	1,468	4,424	4,469	45
1960 ^c	6,200	1,520	4,680	4,450	— 230

Source: K. E. Hill, *The Changing Oil Industry*. Published by Eastman, Dillon Union Securities and Company, New York. Figures from the Chase Manhattan Bank, February 1961.

^a Including minority holdings.

^b Including investments in non-consolidated companies.

^c Estimates.

141. A large number of states have not begun by enacting general legislation and have preferred to proceed by means of concessions. The purpose of such single or multiple contracts, which bind the state to one or several companies, is to regulate the entirety of the legal and fiscal relations between the prospector, the operator and the state authorities. Two of the main producer States of the Middle East—Saudi Arabia and Kuwait—today still belong in this category. Iran had long been bound to one petroleum company by an exclusive concession. In some cases, the concession may cover the whole of the country's territory. In Venezuela, the contract system has been juxtaposed upon a system of special legislation, but the latter has undergone such rapid change that the various agreements have acquired a character of their own, and it may be said that in Venezuela, as in other countries, piecemeal arrangements are still the rule.

142. Other countries have enacted special or general legislation, either at the outset or some time after the petroleum resources of their territories has begun to be exploited. Libya and Nigeria may be cited in this connexion. In all the cases considered, the State's essential object seems to have been to exploit its petroleum resources beyond the level necessary to meet the needs of its domestic market. These States were therefore concerned to stimulate a maximum of investment with a view to rapid development and maximum exports of the oil produced. In these particular cases the state's role is restricted to determining the framework of its relations with the prospector or producer and taking the necessary legislative steps to attain the goal which it has set itself.

Conventional methods of stimulating maximum investment

143. It should be mentioned that most of the specific legislation in this field regards a multiplicity of operators as an important stimulus. Such legislation is therefore contrary in principle to the method used by the States of the Middle East at the beginning of their petroleum history, whereby one single body sometimes comprising

different petroleum companies (e.g., Iraq Petroleum Company) was responsible for all operations throughout the area, and occasionally under several concessions with different geographical boundaries. This was the case in Kuwait, Bahrain, Qatar and Iraq, for example. It is true that in countries using the contract method, there is now a trend towards a multiplicity of operators, especially when new concessionary companies are brought in to the coastal areas of the country's territory (off-shore exploration).

144. These contracts or legislations normally contain basic provisions designed to guarantee the security and stability of investment. Thus, in all such legislation exploration entails the right to exploit the discoveries and this is expressly formulated in individual agreements of the Iraq Petroleum Company or Saudi Arabian type. This right is granted exclusively to the prospector. It is consolidated for a given period, taking into account the general conditions in which its holder is entitled to exercise it. The length of Middle East concessions used to run from sixty years (Aramco for example) to seventy-five years (Iraq Petroleum Company or Kuwait Oil Company). In general, the contracting party also enjoys appropriate safeguards in the event of disagreement, in many cases through international arbitration arrangements. In addition, most concessions guarantee the holders favourable conditions in regard to operations, transport and passage of personnel and equipment, use of the necessary sites, etc. In exchange, local needs may have first claim on production, and there are various obligations, such as the compulsory use of local labour.

145. The systems mentioned further include provisions designed to accelerate operations, either by prescribing a minimum rate of operations, or by making provision for a high return on the investment. The agreements or laws in question often stipulate that if less than a certain sum is invested in the concession over a given period, the contract becomes void. But these provisions, which oblige the license holders or concessionary companies to maintain a certain level of activity, are probably less effective than fiscal measures.

146. There are other methods of stimulating private investment in exploration. Some consist of backing up private funds by state contributions. For example, under the system which operated in France for a short period, the private shareholders of exploration companies, and petroleum exploration financing companies subscribing to an increase in the capital of an exploration company, had to contribute only half the amount of the subscription, the other half being covered by the Petroleum Support Fund, a special treasury account. The stimulus to the production of petroleum in France provided through the Petroleum Support Fund is also a means of stimulating investment in exploration. The matching sums are only paid when the corresponding amount is actually invested in exploration. All the countries considered in this chapter follow the practice of sharing the profits fifty-fifty between the State and the company—or did so until recently.

147. In some countries, the system of depletion allowances also tends towards the same objective. It may take different forms but the principle is generally the same: the petroleum producer is allowed to reinvest

a part of his profits tax free in exploration operations, in order to offset the depletion of his field. This form of amortization has been taken up in a number of countries, notably in the French 'niche' system.²⁹

148. With regard to fiscal measures, reference may also be made to the favourable terms accorded in France to petroleum exploration financing companies, investment companies created under the decree of 20 May 1955.

Results obtained under the various systems

149. Middle East production has increased tenfold in fifteen years, rising from 26 million tons in 1945 to 263 million in 1960. During the same period Venezuela's production trebled, rising from 48 to 151 million tons. In 1960 the Middle East and Venezuela accounted for almost 40 per cent of world production. The results are summarized in table 13.

²⁹ The concept of depletion allowances was first introduced in the United States but, in that country and in Canada, it takes the form of a net tax deduction without any conditions attached.

Table 13. Crude petroleum production in the main producing countries of the Middle East and Venezuela, 1945-1960

(Millions of tons, except as indicated)

Country	1945	1950	1955	1960
Kuwait	—	17.3	54.8	81.9
Saudi Arabia	2.8	26.6	47.5	62.1
Iran	17.4	32.3	17.1	52.2
Iraq	4.8	6.6	32.7	47.5
Qatar	—	1.6	5.4	8.2
Neutral Zone	—	—	1.3	7.3
Bahrain	1.0	1.5	1.5	2.3
Middle East, TOTAL	26.3	88.5	162.3	265.2
World production	352	523	773	1,076.0
Percentage of Middle East in world production	7.5	16.9	21.0	24.6
Venezuela	48.0	78.3	112.4	152.9
Percentage of Venezuela in world production	13.6	15.0	14.6	14.2
Percentage in world production of the Middle East and Venezuela together	21.1	31.9	35.6	38.8

Source: United Nations, *Economic Developments in the Middle East, 1958-1959* (Sales No.: 60.II.C.2), and United Nations Statistical Office.

Income in the countries concerned has increased as a result of this continuous expansion of production, except in Venezuela (see paragraph 154).

Table 14. Direct payments by petroleum companies to governments of some Middle East States

(Millions of dollars)

Year	Iran	Iraq	Kuwait	Saudi Arabia	Year	Iran	Iraq	Kuwait	Saudi Arabia
1953	—	144	169	226	1957	213	144	308	303
1954	9	191	194	281	1958	272	237	354	302
1955	91	206	282	275	1959	263	212	400 ^a	308
1956	153	193	293	283	1960	286	266	450 ^a	330 ^a

Source: For the years 1953-1958, United Nations, *Economic Developments in the Middle East, 1958-1959*; for 1959 and 1960, *Middle East Economist and Financial Services* (New York), May 1961.

^a Including payments by the American Independent Oil Company operating in the Neutral Zone (Kuwait).

^b Including payments by the Getty Oil Corporation operating in the Neutral Zone (Saudi Arabia).

Petroleum payments represent 27 per cent of government receipts in Iran, 47 per cent in Iraq, 60 per cent in Venezuela and 81 per cent in Saudi Arabia.

150. The systems considered have also permitted the development of petroleum resources, as is shown by the growth of proved reserves in the Middle East. During the period 1938-1960, the world's proved reserves of crude petroleum increased almost tenfold, from 4.25 to 41.5 billion tons. During the same period, proved reserves in the Middle East increased thirty-sixfold, from 0.7 to 25 billion tons, compared with a 4.5-fold increase in the rest of the world, from 3.55 to 16.5 billion tons. In 1960, the Middle East had 61 per cent of the world's proved reserves of crude petroleum, as compared with 16.5 per cent in 1938.

151. The question arises as to whether this kind of experience is valid for countries with sub-soil resources less rich than those of the Middle East, since in most of the cases referred to the initiative came from companies anxious to ensure optimum yield. In this connexion, two further examples may be quoted which appear to show that the international companies have no systematic policy in this field. In Libya, a new country which became independent in 1951, exploration undertaken in 1956 began to bear fruit in 1958. In four years, between 1956 and 1960, 105 wells were drilled, twenty-eight of them productive. In mid-1960, thirty-two drilling rigs were in operation and the capacity was over 3.3 million tons a year (66,000 barrels per day). In November 1961, the first shipment of crude from Zelten was loaded at Port Brega, which is linked to the deposit by a 160-kilometre pipeline. Reserves are estimated to be in the region of one billion tons. Production was 850,000 tons in 1961 and is expected to reach 9 millions tons in 1962. In Nigeria, a general reconnaissance was begun by exploration teams in 1937, but work was interrupted during the Second World War. Drilling was begun in 1951. The first oil was discovered in January 1956. Production was approximately 2.2 million tons in 1961. Reserves are estimated to be about 30 million tons.

Recent trends in countries where exploration is financed from private sources

152. Two trends have recently become apparent: in some cases efforts have been made to increase the financial benefits accruing to the treasuries of the producing countries, while in others a fundamental change has been made in the respective roles of the State and of private companies in petroleum exploration and exploitation. In certain cases, the two trends have developed simultaneously.

153. As far as the financial benefits accruing from operations are concerned, two practices have developed: the introduction of an auction system for mining permits; and modification of the fiscal regulations governing exploitation.

154. The latter method has been adopted by Venezuela, which recently increased the tax on profits from 50 to 60 per cent. This increase in taxation, at a time when the world market is abundantly supplied, caused an abrupt slowing down of petroleum operations and an almost complete cessation of exploration. The number of wells drilled in Venezuela fell from 1,190 in 1958 to 440 in 1960. The number of exploratory wells included in this total fell from 190 to a little under

sixty during the same period.³¹ The oil companies' estimated net profits in 1960 were \$300 million (as against \$427 million in 1959 and \$523 million in 1958). In 1960 new investments totalled only \$377 million (compared with \$391 million in 1959 and \$579 million in 1958). Total revenue from the petroleum industry has fallen regularly since 1958-1959, when it was 3,381 million bolivars (\$1,010 million). The figure for 1959-1960 was only 3,140 million bolivars (\$935 million) and for 1960-1961 2,977 million bolivars (\$890 million). In order to stimulate the petroleum exploration programmes of private companies, the Ministry of Mines and Hydrocarbons accordingly decided in October 1961 to remove the restrictions hitherto imposed on private companies drilling in areas adjoining national reserves. This example shows how difficult it may be to find the point of balance that will ensure optimum fiscal yield.

155. In this connexion it should be mentioned that the policy of States may vary with the stage of development of their petroleum economy. Governments naturally attach more importance to encouraging investment in exploration when rates of production or discovery are low and development is still in the early stages. After the first discoveries, Libya decided to modify the arrangements originally established by the law of 1955. While it would be out of place to make an analysis of the new provisions at this point,³² it may be noted that the principal changes were financial or fiscal, the depletion allowance being abolished and the original rates of amortization being reduced. In addition, the new regulations increase annual rents and establish a system of bidding for new concessions.

156. The modification of arrangements for the division of profit is sometimes coupled with measures to promote direct and public national participation in industrial operations. Almost all major petroleum producing States where exploration was carried out by private companies have made efforts to promote a national industry. The extent of such efforts has varied. In some cases new concessions have been refused to non-national companies. The measures taken have been of various kinds, usually involving public intervention (direct or indirect), although in some cases steps have only been taken to encourage the formation of companies in which national capital (private or public) predominates.

Iran

157. In Iran the National Iranian Oil Company was set up to undertake operations in the petroleum industry on behalf of the State. The formation of this Company substantially modified relations between the State and exploring companies. These relations were governed by the Agreement of 29 October 1954 with the Consortium (a group of international companies), while the National Company assumed responsibility for a wide range of operations not specifically connected with petroleum. In addition, it appointed two directors in the two companies forming the Consortium. Operations were carried out by the companies which purchased their share of

³¹ Between 1958 and 1960, the number of wells rose from 2,190 to 2,238 in South America, from 192 to 261 in the Middle East and from 8,106 to 8,785 in the world as a whole, excluding the planned economy countries and the United States. In the United States, the figure fell from 57,936 to 55,616.

³² See *Petroleum Press Service*, September 1961.

the Consortium's production at current prices. Thus, no financing problems substantially different from those associated with conventional concessions arose. In addition, the National Company tended to assume a role ancillary to that of the Plan and the General Budget.

158. The law of 29 July 1957 introduced a number of innovations, establishing the basis for future operations outside the areas reserved for the Consortium under the 1954 Agreement and defining the conditions governing operations by the National Company. In the case of exploration, the Company could operate directly or through contracts with private or foreign organizations. In fact, the Company undertook both forms of operation. The Company was faced with heavy costs in connexion with the distribution of petroleum products and the development of infrastructure facilities. It continued the exploration operations started in 1951 by the Iranian Oil Company (whose assets it took over) and exploited the discoveries. The costs were so high that the Company could not meet them from the funds accruing from payments by the Consortium and had to borrow substantial sums. In addition it was unable to undertake further exploration. The Company accordingly used the powers open to it under the Law of 1957 to promote the resumption of exploration outside the Consortium areas. The Company may open certain areas to Iranian or foreign prospectors, either under contract or through mixed organizations (in which the Company must hold over 30 per cent of the capital).

159. The prospecting companies are required to pay an annual rent to the National Company and may in some cases be asked to pay a premium. When petroleum is produced, the rents and payments may be accounted as exploitation costs. When the National Company's participation in the partnership is over 50 per cent, however, the other partners may assume responsibility for exploration costs instead of paying annual rent. This provision, with some minor changes, is embodied in the three contracts recently concluded by the National Company with the Iranian subsidiary of the Italian Ente Nazionale Idrocarburi, the American Pan-American Company and the Canadian Company, Sapphire Petroleum Company. In these cases, the National Company and its partner formed an association with equal participation. If petroleum is produced, development and exploitation costs will be financed by the partnership, each of the two shareholders bearing its share of the costs. The partnership would repay the exploration costs to its shareholders, at a minimum rate of ten cents per barrel produced. In the event of an exploitable discovery, the position would therefore be the same as if the partner had paid the National Company a rent equal to half the exploration costs. In other respects the usual fifty-fifty rule applies. The arrangement provides the National Company with financial resources and also, in the event of success, with a means of financing future expansion.

Kuwait

160. In Kuwait, a Kuwait national oil company was set up at the end of 1960, 60 per cent of its capital being held by the State and 40 per cent by local nationals. Kuwait has entered into advantageous agreements in this field, notably with a Japanese company in respect of the Neutral Zone and recently (15 January 1961) with Shell in respect of an offshore area. Under the

contracts, the Ruler of Kuwait reserves the right to participate in the Company if oil is discovered. Under clause 12 of the agreement with the Arabian Oil Company, the Ruler is guaranteed the right to take up 10 per cent of the Company's capital at par value. Clause 23 of the agreement with Shell Petroleum Development enables him to acquire 20 per cent of the company's capital on payment of a sum equal to 20 per cent of the expenses actually incurred up to the date of the discovery. It is not clear whether the intention is that the national company should assume responsibility for such payments. The funds to be used to finance these costs are therefore not determined.

Venezuela

161. In Venezuela, in addition to increasing the royalties payable by private companies, the State set up a national oil company in April 1960. The Company, which had long been planned, had in all probability not been set up earlier because of the difficulties of financing it. The Venezuelan Government appears to wish to reserve all the territories not granted to this Company. The Company has begun operations in Lake Maracaibo, but no information is available on the progress or objectives of the operations or the methods of financing. However, in October 1961, the Venezuelan Oil Corporation announced that it was prepared to study proposals from private companies for the joint exploration and production of petroleum in accordance with the Government's new policy. It is also understood that the Iraqi Government has a similar project to set up a para-state organization in the field. Libya already has a national oil company but its capital is believed to be largely of foreign origin.

162. Although the trend described above is general, its scope is limited. It no doubt results from the desire of Governments to derive the greatest possible advantage from their natural resources by participating in their development. Two examples of this trend are provided by India and the United Arab Republic, while in Indonesia, where concessionary companies produce large tonnages of petroleum, there appears to be a trend towards a policy involving a greater degree of State intervention.

Recent trends in countries where exploration is financed from public and private sources

India

163. India did not begin to develop its petroleum resources until the nineteen fifties and it was only in 1955 that the Indian Government decided to embark on a large-scale petroleum development programme designed to enable the country to meet its growing needs. Effort is required in all sectors of the petroleum industry, but is particularly urgent in the field of exploration. Since 1955, substantial allocations of the order of \$10 million for a five-year period have been set aside to finance direct state operations and an Oil and Natural Gas Commission has been set up in the Ministry of Industry. At the same time, the Government has begun to participate in certain private exploration programmes. In 1956, on the eve of its second five-year plan, the Indian Government took a step of major importance when it declared in its Industrial Policy Resolution that it was placing the petroleum industry

in the public sector and had decided to invest \$61.6 million in petroleum exploration.

164. On the eve of the third five-year plan, however, the Indian Government, considering that the effort which the State would have to make in order to balance resources and requirements in 1970 might be inconsistent with the accomplishment of other fundamental tasks, decided to turn to private companies and foreign sources and to associate them in its efforts, without losing its control over the industry. It is planned to invest \$242 million in the petroleum industry, out of a total investment of \$14,700 million in the public sector. Numerous negotiations have been initiated with the object of creating new partnerships between the Oil and Natural Gas Commission and exploration companies (Ente Nazionale Idrocarburi (ENI) and, in particular, the Burmah Oil Company) or of securing the technical assistance required by the Indian Government in view of the multiplicity of the tasks undertaken simultaneously by the Oil and Natural Gas Commission (Soviet technical assistance in some areas; the recent contract with the French Petroleum Institute for the Jaisalmer region). The agreement with the Burmah Oil Company is regarded by the Indian Government as a model which it hopes will be adopted by other enterprises.³³

United Arab Republic

165. Until 1956, petroleum exploration and exploitation in the United Arab Republic were entirely in the hands of foreign private companies. In 1956, the Government set up a public establishment, the General Petroleum Authority, empowered to engage in the whole range of petroleum operations and to have capital holdings in other organizations. In 1957, the General Petroleum Company was set up. Its capital is at present held by the Economic Institution and may belong only to Egyptians. The General Petroleum Company has three small fields, where production started in late 1959 and has been increasing regularly (135,000 tons per annum). The second five-year development plan, which came into force on 1 July 1960, places considerable emphasis on petroleum development. In mid-1960 the Government also invited bids for the exploration of the western desert where it hopes that oil will be found. The conditions provide for a fifty-fifty division of profits in the case of companies which accept domestic (not necessarily state) participation and a royalty higher than 50 per cent of the profits, payable to the State, if there is no participation by national capital.

166. No tender has yet been made under these conditions. During 1961 the State also tightened its hold over the economy. Foreign concerns now fall into three categories: those which are 100 per cent nationalized (banks, insurance, public transport); those in which

³³ By purchasing an additional 15.75 per cent of the shares of Oil India, Ltd. at par value from the Burmah Oil Company for cash, the Government increased its holding in this company to 50 per cent, the same as that of Burmah Oil. In future, each financial partner will bear its share of the costs, the foreign currency being provided by the Burmah Oil Company. In calculating profits, a deduction will be made for the past and future exploration and development costs of Oil India. This is thus neither an agreement with the usual fifty-fifty sharing of profits nor an association such as ENI has entered into with foreign governments.

the Government already has a holding, which it will ultimately increase to at least 50 per cent; and those in which the State takes over individual holdings exceeding £E 10,000 (\$29,000). In all cases, 4 per cent fifteen-year government bonds will be given in exchange for these holdings. For example, the Government's share in Anglo-Egyptian Oilfields was increased from 26 per cent to 55 per cent; all the other shareholders had to surrender half their shares. Compensation in the form of government bonds is based on the Cairo Stock Exchange quotation before the promulgation of the nationalization decrees. The same procedure was applied to a small, local importing and distributing concern, wholly Egyptian-owned, while individual holdings of more than £E 10,000 in the Société française des pétroles SERCO (SERCOP) will be acquired by the Government, which already holds more than 49.4 per cent of the shares.

167. No other oil companies have yet been affected by the decrees promulgated but the Government seems determined to keep private capital out of the key sectors of the economy. Reference should also be made to the agreement concluded in November 1961 by the Government of the United Arab Republic with the Italian concern, ENI. The first part of the agreement relates to the opening of a credit of £E 50 million which will be used to found an Egyptian petro-chemical industry and to import the equipment necessary for expanded petroleum exploration in Egypt. Under the terms of the second part of the agreement, the Government grants ENI an exploration permit and, if necessary, a concession of 26,200 square kilometres in an area lying between the Nile Delta, the Suez Canal and the Red Sea. This agreement is similar to that concluded by ENI in Iran, providing for a fifty-fifty division of profits, the assumption of exploration costs by ENI, and equal partnership with a state concern.

168. The United Arab Republic has been trying for some years to develop petroleum exploration in its territory. To achieve this aim, a number of oil concerns have been incorporated in the public sector; the State thus acquiring substantial petroleum assets with no fresh capital outlay. The problem of financing the management, and particularly the growth, of these assets, mainly through exploration, remains to be solved. The agreement concluded with ENI is an initial step in this direction.

Indonesia

169. Until recently, the big international groups have been responsible for developing petroleum resources in Indonesia. After the achievement of independence in 1949, the granting of new concessions was suspended pending the enactment of new petroleum legislation, as the Government had not yet decided on the future status of the petroleum industry. The Presidential decree regulating the petroleum industry was not promulgated until 1960. Although existing concessions will remain in force for a limited but still indeterminate period, the exploitation of oil and gas in new areas will be undertaken only by the State. While all petroleum activities must be carried out by state undertakings, the latter may appoint private companies as contractors provided that the contracts are ratified by law. Negotiations between the three main foreign

companies and the Government for a new agreement having been suspended, the Government decided at the end of August 1961 that, in future, earnings would be shared on a sixty-forty basis. Three state enterprises are already active, but in view of the increase in the budgetary deficit and the amount of financial aid received from abroad for industrial development, they seem unlikely to obtain the funds necessary for petroleum exploration and development.

170. It may thus be seen that countries where exploration was originally financed by private capital alone have recently adopted a new attitude towards the development of their petroleum resources. However different the policies followed in this respect, no government can now disregard petroleum problems, on the solution of which industrial development and the achievement of higher standards of living so largely depend.

Conclusions

171. Today, 22 per cent of the world's population (United States, Europe and the Soviet Union) consume 78.5 per cent of world petroleum production. These figures bring out the enormous potential demand for petroleum throughout the world, more particularly in the developing countries. For example, India, with 400 million inhabitants (14 per cent of the world's population) consumes only 6 million tons of petroleum (0.6 per cent of world consumption). If the Indians consumed as much petroleum per capita as the French, India would need 220 million tons per year (21 per cent of present world production). In 1960 India produced 450,000 tons. This basic imbalance in consumption is accompanied by a similar imbalance in production. Almost two-fifths of the world's crude petroleum is produced by six countries whose combined populations represent just over one per cent of the world total and whose petroleum consumption barely exceeds two per cent of the world total.

172. Various conclusions may be drawn from these figures. The need to secure an over-all increase in the supply of oil to keep pace with rising living standards is obvious. If, as is hoped, the efforts to develop the poorer countries are successful, there will certainly be a massive increase in the demand for hydrocarbons. This increased consumption will, in turn, be a factor in development. The problem of oil exploration is therefore crucial for the developing countries, but it has many changing and sometimes conflicting aspects. Some of the developing countries produce twenty times more oil than they need; the majority have scarcely any. Whether a country is rich in oil or has none at all, the government must concern itself with the petroleum industry for it is vital to the economy. Considerations of national security have induced the big industrial countries to ensure the availability of minimum supplies of petroleum. At the economic level, the trade balance of some countries is weakened by oil imports; for others, national wealth depends largely on finding means to exploit their petroleum resources.

173. This almost universal eagerness to make the best use of petroleum resources explains the variety of

development schemes which have been adopted and the diversity of methods used to finance investments.

174. It is not the purpose of this report to express any judgement on the methods described, still less to recommend any one method rather than another. The adoption by governments of a given petroleum policy is often dictated by historical and psychological considerations. Certain rules must nevertheless be observed if the best solution is to be found to the problem of petroleum, especially in the developing countries, whose goal is rapid expansion in all sectors.

175. Whatever the method chosen for financing exploration, it is essential to realize that the capital may well be lost. If this eventuality is not accepted at the beginning, it will have to be recognized later. Whatever the results of the operations, accumulated debts will then have to be consolidated. In these circumstances banks are naturally unwilling to make loans for exploration operations. This unwillingness does not extend to all phases of petroleum development, but simply to the highly speculative exploratory phase. No exploration programme should therefore be launched before there is an assurance that the necessary means of financing it are available.

176. The more that is known about a country's petroleum potential, the easier it will be to obtain the capital needed to finance the development of its petroleum resources. Even if preliminary reconnaissance does not furnish certain evidence, it may provide a guide for subsequent operations and encourage prospectors to undertake them. This phase is relatively inexpensive and has been completed or is on the point of completion in many countries. The surveying of possibilities should undoubtedly be continued or started, where necessary. Subsequent phases of development cannot be undertaken without a detailed economic analysis of the different factors involved. The decision to go ahead is obviously influenced by political or other considerations, but it can only be made in the context of an economic model of which all the elements are known. If the "petroleum adventure" demands the allocation of a large part of a country's economic potential, the uncertain profitability of this investment will have to be weighed against the safer yield of other investments in different sectors of the national economy. Such an analysis becomes easier, if only by reason of the alternatives which may be available, if it is undertaken in an international context. The problem of exploration, production and supply in a given country can then be studied in broader perspective. Except in special and essentially temporary conditions, it may be stated that isolationism makes for insecurity and that autarchy is inconsistent with the optimum use of a country's economic potential. This is particularly true of petroleum development. For both technical and economic reasons, petroleum development, in every country, requires to be undertaken in an international framework.

177. Many possibilities exist within this broader framework. The future depends at the international level on increasingly close co-operation between the industrialized and the developing countries. It is only by unvarying efforts in this spirit that it will perhaps be possible to solve the continuing problem of maintaining supplies in the context of expanding consumption.

ASIA

BURMA

CAMBODIA

CEYLON

CHINA

HONG KONG

INDIA

INDONESIA

JAPAN

KOREA, REPUBLIC OF

PAKISTAN

PHILIPPINES

SINGAPORE

TAIWAN

VIETNAM, REPUBLIC OF

EUROPE

AUSTRIA

GREECE

IRELAND

IRELAND

ITALY

LUXEMBURG

NETHERLANDS

NORWAY

PORTUGAL

SPAIN

SWEDEN

SWITZERLAND

TURKEY

UNION OF SOVIET SOCIALIST REPUBLICS

UNITED KINGDOM

YUGOSLAVIA

MIDDLE EAST

IRAQ

ISRAEL

JORDAN

LEBANON

NORTH AMERICA

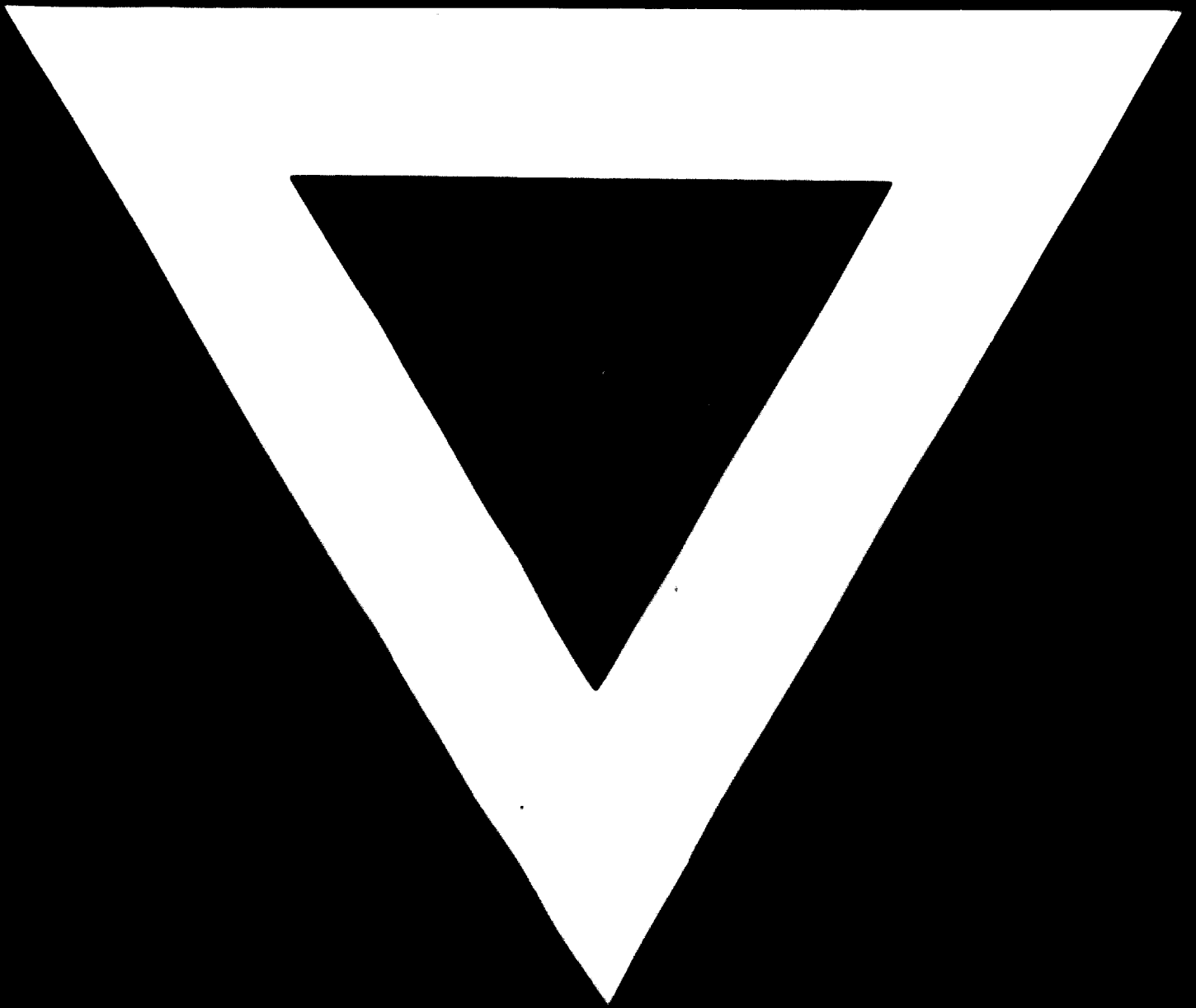
CANADA

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