

OILFIELDS OF THE  
WORLD

# OILFIELDS OF THE WORLD

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For S., J., N., C.

*Publishers' Addendum*

*This book was being printed during October, 1973, when the events took place which, within a few months, completely changed the structure of the international oil industry. The time-scale of the author's forecasts of likely developments has therefore been drastically shortened; but his principal conclusions are remarkably correct.*

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## PREFACE

**A**BOUT 260 billion barrels\* of crude oil have been produced from the world's oilfields in the period of 113 years that has elapsed since the drilling of Drake's first successful oil-well in 1859. In little more than a single century, therefore, mankind has dissipated with spendthrift lavishness much of the Earth's endowment of an irreplaceable mineral, for whose generation and accumulation many millions of years were needed.

To recover such a huge volume of liquid from depths of thousands of feet below ground level, often from locations situated in tropical forests or inhospitable deserts, has required the investment of immense amounts of capital, labour and—at least in recent years—the deployment of the most advanced technical skills. Yet, in the end, by far the largest proportion of the crude oil that has been obtained with so great an expenditure of effort has been converted into fuel of one sort or another and then destroyed by combustion. So attractive and convenient a source of flexible and easily transportable energy has oil proved to be, that it has always tended to displace the longer-established solid fuels wherever it has become available. World consumption of crude oil has in consequence roughly doubled with each decade that has elapsed since 1860, and there is as yet no sign of abatement in this remarkable rate of growth. Consumption in 1972 was 18·1 billion bbl, compared with only 3·8 billion bbl in 1950.

Until recently, there seemed little cause for more than superficial anxiety about the continuing availability of the supplies of crude oil which the world so lavishly destroyed each year in the course of releasing its energy content. In the past, the ratio between known oil reserves and annual consumption has generally grown in proportion to the exploration effort deployed—in a remarkable way, the greater the volume of oil that was consumed, the greater were the supplies proved to be still available. However, there is now a growing and disconcerting body of evidence to show that the end of this comfortable era is at last in sight. The new oilfields that are already needed if the huge forecast requirements of the future are to be met are proving increasingly difficult to find. On average, their discovery requires a more intense search, the use of increasingly sophisticated techniques, and the expenditure of more money per unit of production capacity than has generally been the case in the past. Furthermore, an increasing proportion of new oilfields is being discovered under the waters which cover the Continental Shelf—and progressively in deeper waters as the search moves outwards towards the slopes and rises of the continental margins. To drill a single well in an offshore area such as the North Sea may cost £2 million, while to develop a major oilfield there is likely to involve an expenditure of the order of

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\* Approximately 36,000 million tons.

£1000 per barrel/day of production capacity—or perhaps twenty times what it might cost in some oil-rich countries of the Middle East.

On the other hand, the continuing discussions between the international oil companies and the Middle East oil-exporting states have now made it clear that crude oil from that area, which provided one-third of world output in the early 1970's and will probably provide at least one-half by 1980, must inevitably become increasingly expensive, so that the major oil-importing developed regions—the United States, Western Europe and Japan—are likely to be faced with ever-increasing energy costs.

It is therefore perhaps timely to make an inventory of the known oilfields of the world and to attempt to arrive at a balanced picture of the actual and potential sources of oil supply. Of course, it is clearly impossible within the confines of a single volume to mention more than a small proportion of the roughly 30,000 “significant” oil accumulations that have been discovered. However, an attempt has been made to present the most important facts about the geology, geography and production history of most of the world's major oilfields, so that, with this background of the past and present reasonably firmly established, it may then be possible to consider future prospects with a clearer view.

E.N.T.

## ACKNOWLEDGEMENTS

A book which attempts to describe the oilfields of nearly 70 countries must inevitably draw on the work and publications of many authors, and to all of these I am therefore greatly indebted. Wherever possible, I have attempted to give due credit by citing the sources to which I have referred. The most important and numerous of these are the *Bulletin* and other publications of the American Association of Petroleum Geologists. I am also much indebted to the Association for permission to reproduce several diagrams, which are duly acknowledged. Other organizations which have kindly given permission for the reproduction of diagrams or illustrations include The British Petroleum Co Ltd, Institute of Petroleum Information Service, Petroleum Press Service, Niedersächsisches Landesamt für Bödenforschung, and the US Geological Survey. Dr H. V. Dunnington was kind enough to supply the excellent map of the Middle East oilfields.

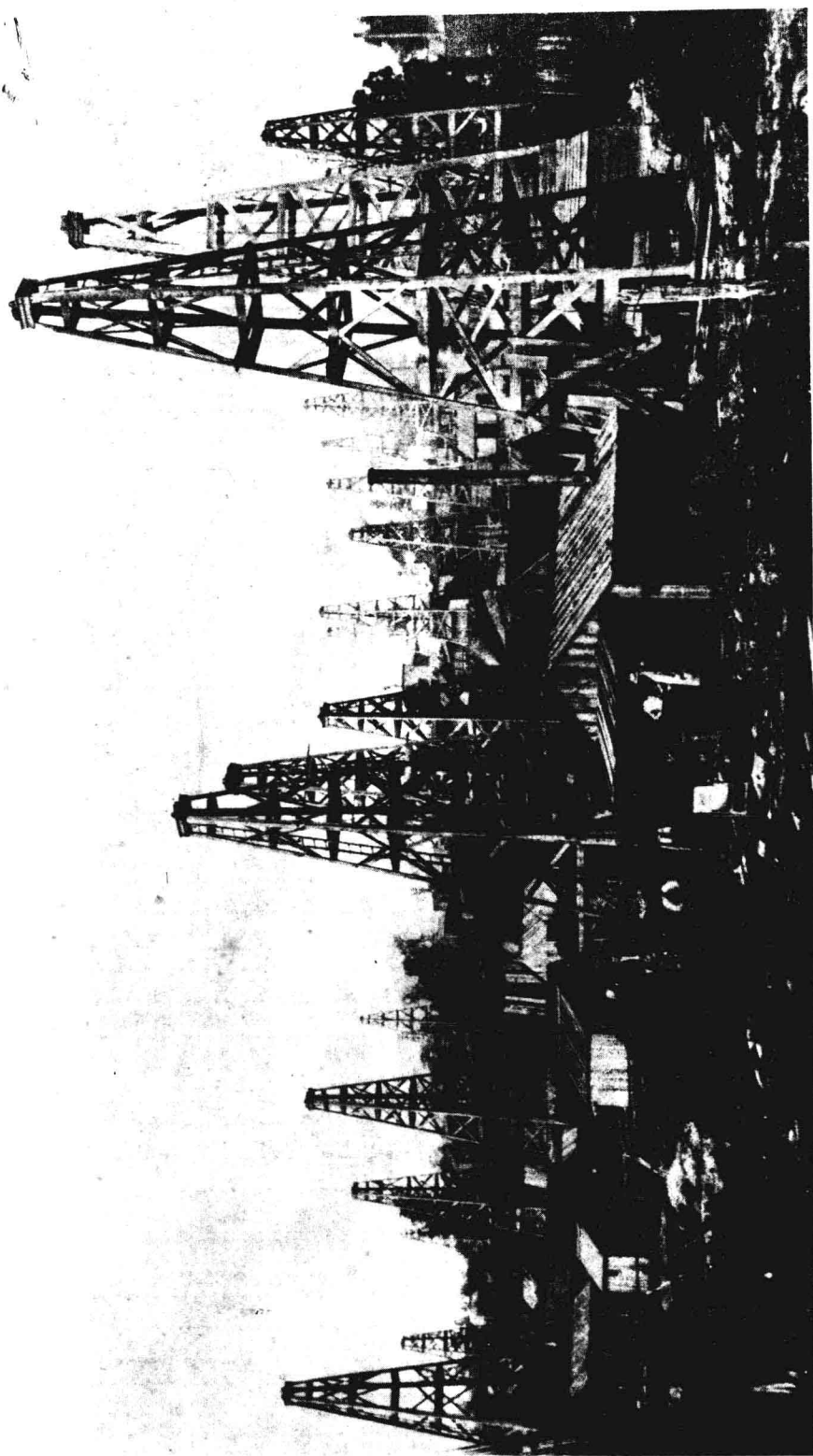
For statistical data I have consulted the best available published sources, and in particular the annual compilations of *World Oil*, Houston.

I must also record my thanks to Dr G. D. Hobson of the Royal School of Mines, London, for helpful comment and advice, to Miss L. M. Sandford for her invaluable assistance in all stages of the preparation of this work, and to my son John for his help with the diagrams.

E.N.T.

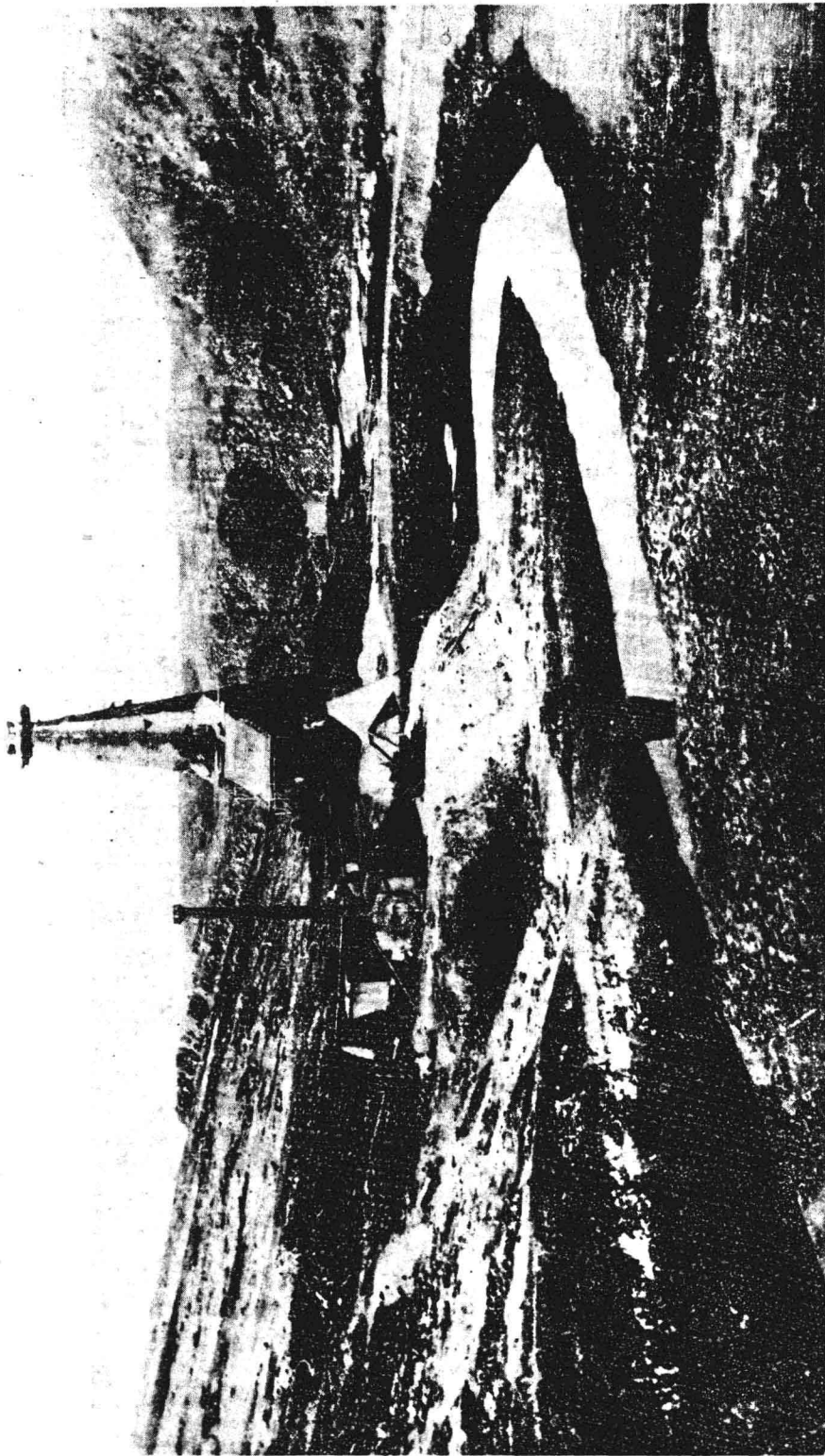
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**A typical Pennsylvania oilfield scene in 1889, ten years after the completion of Drake's first oil-well. The derricks were of wood, and the method of drilling was by percussion tools. (Source: Institute of Petroleum Information Service.)**





The first oil-well successfully drilled in Iran—the D'Arcy well at Chia Surkh, 1902-5.  
(Source: Petroleum Information Bureau.)



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## CHAPTER 1

# History and Uses of Petroleum

### 1. PETROLEUM IN HISTORY

#### (i) The Early Years

THE fluid mineral petroleum ("rock oil") is an extraordinary and unique substance. In its origin, it may have been related in some degree to the origin of life itself, both on the Earth and perhaps also in other parts of the universe. In its application, it has provided an enormous amount of cheap and ubiquitous energy, the most fundamental requirement of our civilization. It is, furthermore, a chemical raw material from which a huge range of products can be obtained—even including proteins for human nourishment.

The history of petroleum and its relationship to mankind goes back to the dawn of history. The early civilizations that developed in the great river valleys of Mesopotamia used the asphalt obtained from hand-dug pits as building cements, for ornamental purposes, and to caulk their boats. The legend of the Flood described in Genesis and in the epic poem of Gilgames records only one among the many inundations of the low-lying river lands of Mesopotamia, to survive which a well-caulked Ark was certainly desirable.

The Elamites, Chaldeans, Akkadians and Sumerians are all known to have mined shallow deposits of oil-derived asphalt ("pitch") in the course of their history, and in the annals of Tukulti Ninouria the town of Hit on the Euphrates is mentioned as a prolific source of this material. The ancient name of Hit was *Ihi* or *Ihidakira*, meaning "bitumen spring", and its asphalt deposits formed perhaps the first known example of a "commercial" petroleum accumulation\*. The asphalt derived from Hit, which is still locally used for road-making, boat construction and as a building cement, was also exported in ancient times across the desert to Egypt, where it was used extensively in the preservation of mummies

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\* The term "commercial" as applied to petroleum is discussed on p. 34

and in ornamental work. Nile boats were caulked with it—the three-months old Moses was cradled in bulrushes “daubed with pitch”. The tribute paid to Thotmes III at Karnak included a material imported from Mesopotamia, which was probably asphalt from Hit.

In ancient Egypt, petroleum oils derived from seepages were used medicinally (“Syrian oil” or “green oil”) and there are many recorded references to “liquid fire”, which support the theory that the Egyptians originally migrated southwestwards from the Caucasus, where the flames issuing so strangely from the ground in the Baku area were later accorded a religious significance in the Zoroastrian tradition. Indeed, some form of temple was continuously in existence near the Baku “eternal fires” from ancient times right up to the beginning of this century.

Even today, the air traveller crossing the oilfield regions of the Middle East by night is vividly reminded of Old Testament allusions by the flames (as of “a leaping fiery furnace”) which pierce the darkness; while the traditional fate of Sodom and Gomorrah may well be linked with the oil seepages that are still to be found around the southern borders of the Dead Sea.\*

In Iran, archaeological remains in Khuzistan show that asphalt was commonly used for bonding and jewel-setting during the Sumerian epoch, i.e. about 4000 BC, while the word “naphtha” has probably been derived from the Iranian verbal root *nab*, to be moist.

After the fall of the Tower of Babel (in the construction of which “oil out of the flinty rock” is reported to have been used as a cement) and the destruction of Babylon in about 600 BC, the general use of asphalt for building purposes decreased, since the Greeks and Romans built in quarried stone.

Petroleum oils derived from seepages were used, however, in Roman times for medicinal purposes and in religious rites, while asphalt was always in demand for ship-building and repair.

After the decline of Rome, the knowledge of the properties of petroleum passed to the Arabs, who developed the first distilling process for obtaining inflammable products for military purposes. The famous “Greek Fire” included “Medean oil” from Northern Persia in its composition.† During this period, the heavier constituents of petroleum

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\* It is interesting in this context to note that in Dr. Johnson's dictionary (1755) “asphaltos” is described as follows: “A solid brittle, black, bituminous, inflammable substance, resembling pitch, and chiefly found swimming on the surface of the Lacus Asphaltites, or Dead Sea, where anciently stood the cities of Sodom and Gomorrah. It is cast up from time to time, in the nature of liquid pitch from the earth at the bottom of this sea; and, being thrown upon the water, swims like other fat bodies, and condenses gradually by the heat of the sun, and the salt that is in it . . .”

† “Greek fire” was used as a “secret weapon” by the Byzantines against the Muslims in the 7th and 8th centuries, and later by the Saracens against St Louis, and by the Knights of St John against the invading Turks at Malta. It consisted essentially of porous pots filled with paraffin and ignited by gunpowder and fuses. It is interesting to note that Herodotus (viii, 52) records a much earlier use of petroleum as a weapon of war during the siege of Athens in 480 BC, when the Persians used incendiary arrows wrapped in oil-soaked tow.

that were needed as medicaments were commonly obtained from the wrappings of disinterred Egyptian mummies.

With the Renaissance, a number of sources of shallow crude oil and asphalt were discovered in Europe, and subsequently also in the new-found Americas. Raleigh used Trinidad "pitche" for repairing his ships, and samples of various petroleum oils were brought to Europe by travellers from distant lands. Late in the 17th Century, sufficient oil was actually produced by the distillation of oil-shale (whose nature is discussed on pp. 356) to light the streets of Modena in Italy, and in 1725 Peter the Great issued various ordinances regulating the carriage of oil from Baku by boat up the Volga, showing that there was already a lively demand for petroleum at that time, principally for use as an unguent and fuel.

Rock asphalt was extensively mined in Europe from the impregnated limestone deposits at Neuchatel, Seyssel, Val de Travers and Ragusa, when the demand arose for new road-building materials after the close of the Napoleonic Wars.

Paraffin wax was first obtained on a commercial basis from shale oil at about the same time, and was subsequently extensively used in the manufacture of candles. The increasing demand for liquid fuel for lighting purposes led to the rapid development of the oil-shale industry, notably in Scotland, where it prospered and developed until recent times, when the competition provided by imported low-cost crude oils made it no longer economic.

In the New World, shallow seepages of oil and gas were plentiful, as is indicated by the occurrence of many place names such as "Burning Springs". Small quantities of crude oil were traditionally marketed for their medicinal properties, but the first truly commercial application of a petroleum product in the western world was the use of natural gas from a shallow well at Fredonia in New York State in 1820. (Many centuries earlier, in the time of the Shu Han dynasty in China—221-263 AD—there are records of natural gas from shallow wells being transported locally through bamboo pipes for use as a fuel). The Fredonia gas was distributed by small-bore lead pipe to nearby consumers, including the leading local hotel, and when General Lafayette arrived at Fredonia in the middle of the night, he was welcomed by the light of gas lamps and a gas-cooked barbecue was served in his honour.

For all these early applications, only small amounts of petroleum were available, obtained from shallow pits and surface seepages, both in the New World and the Old. In August, 1859, however, the first true *oil-well* was drilled by a percussion rig in Pennsylvania. At that time, and in that area, such wells were customarily drilled to obtain brine, which was used to produce solid salt by evaporation, and traces of oil had often been noted on the surface of the water recovered. This first well, drilled by the celebrated "Colonel" Drake, produced only a small volume of

oil—about 25 b/d—from a depth of 69 ft, but its success was to precipitate world-wide changes. Energy had previously been provided by human and animal muscle-power and by the combustion of solid fuels (wood, peat, coal, etc.) which could only be collected with considerable effort, and had to be laboriously transported to the point where the energy was needed. Liquid or gaseous petroleum, on the other hand, could provide an “instant” source of easily-transportable energy which might, when passed through pipelines, be consumed far from the point of production. It was a much more concentrated and flexible form of fuel than any that had previously been available.

Within a year of the successful completion of Drake’s well, 175 further oil-wells had been drilled in the same area. The search for petroleum spread rapidly to other parts of North America and also to other countries—Russia, Romania, Poland, and the then Netherlands East Indies. A new industrial era had begun, the age of oil, in the course of which the world was to change profoundly.

#### (ii) Since 1859

The fact that oil was first discovered in Pennsylvania so close to its immediate markets, coupled with a favourable fiscal system which has always encouraged exploration, resulted in a very rapid rate of oil industry growth in the United States, where for many years more oil was produced than in any other country. Thus, during the first century of the industry’s existence, nearly 1½ million oil-wells were drilled in the United States, and these produced in aggregate nearly half the total volume of crude oil produced in the whole world over this period. In fact, the US proportion of annual world oil output was usually not less than 60% and sometimes more than 70% in most of the years from 1860 to 1946. (However, since then the proportion has fallen with each succeeding year—it was less than 20% in 1971—and although more than three-quarters of all the wells drilled anywhere in the non-Communist world are still drilled in the USA\*, the average production per well is now less than in any other oil-producing country†).

Outside the USA, pre-revolutionary Russia was initially predominant, due mainly to the huge individual outputs of a relatively small number of Baku wells. Subsequently, the Russian oil industry declined, until after sustaining the ravages of two wars, its focus shifted eastwards from the old oilfields of the Caucasus to the newer oil areas of Ural-Emba and Western Siberia, and production then rapidly rose again to make the USSR once more the world’s second largest oil producer. In the 1920’s, Mexico, briefly, and subsequently Venezuela, in turn occupied this position. Mexican production, based on a relatively few enormously productive wells drilled along the prolific limestone reef known as the

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\* 26,224 wells out of a total of 34,083 in 1971, i.e. 76%. † See Table 108, p. 363.

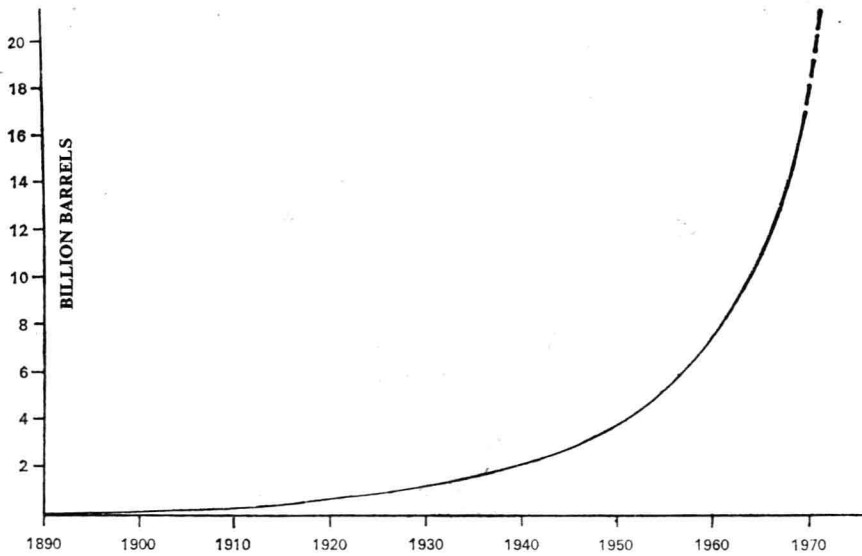
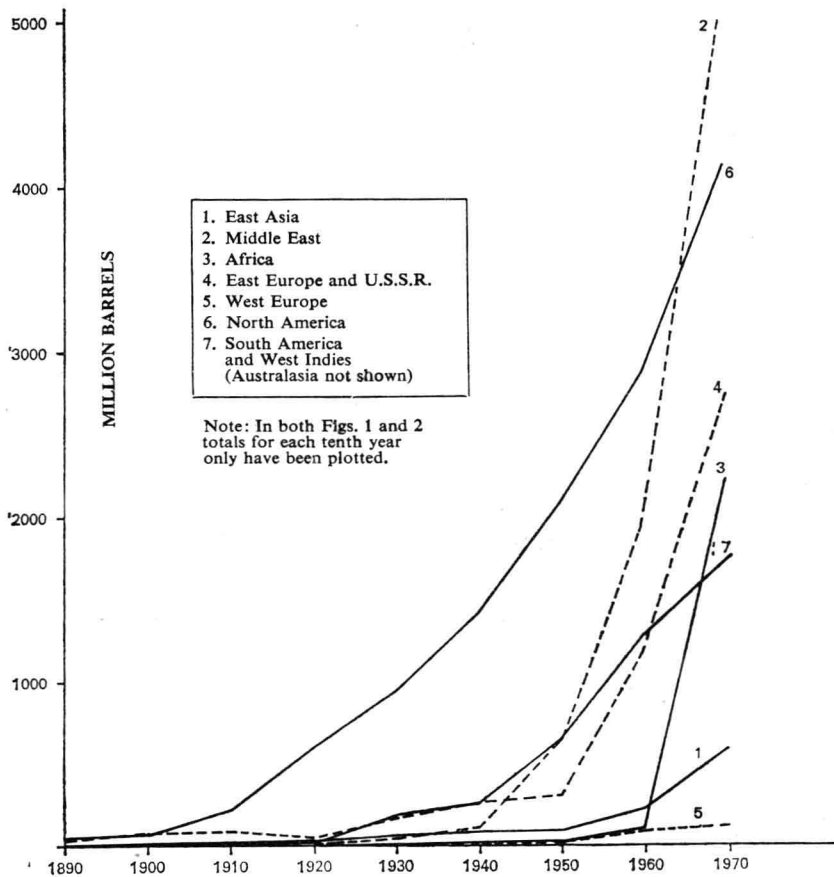


Fig. 1. WORLD ANNUAL OIL OUTPUT 1890-1970



Note: In both Figs. 1 and 2 totals for each tenth year only have been plotted.

Fig. 2. GROWTH OF OIL PRODUCTION FROM MAJOR AREAS



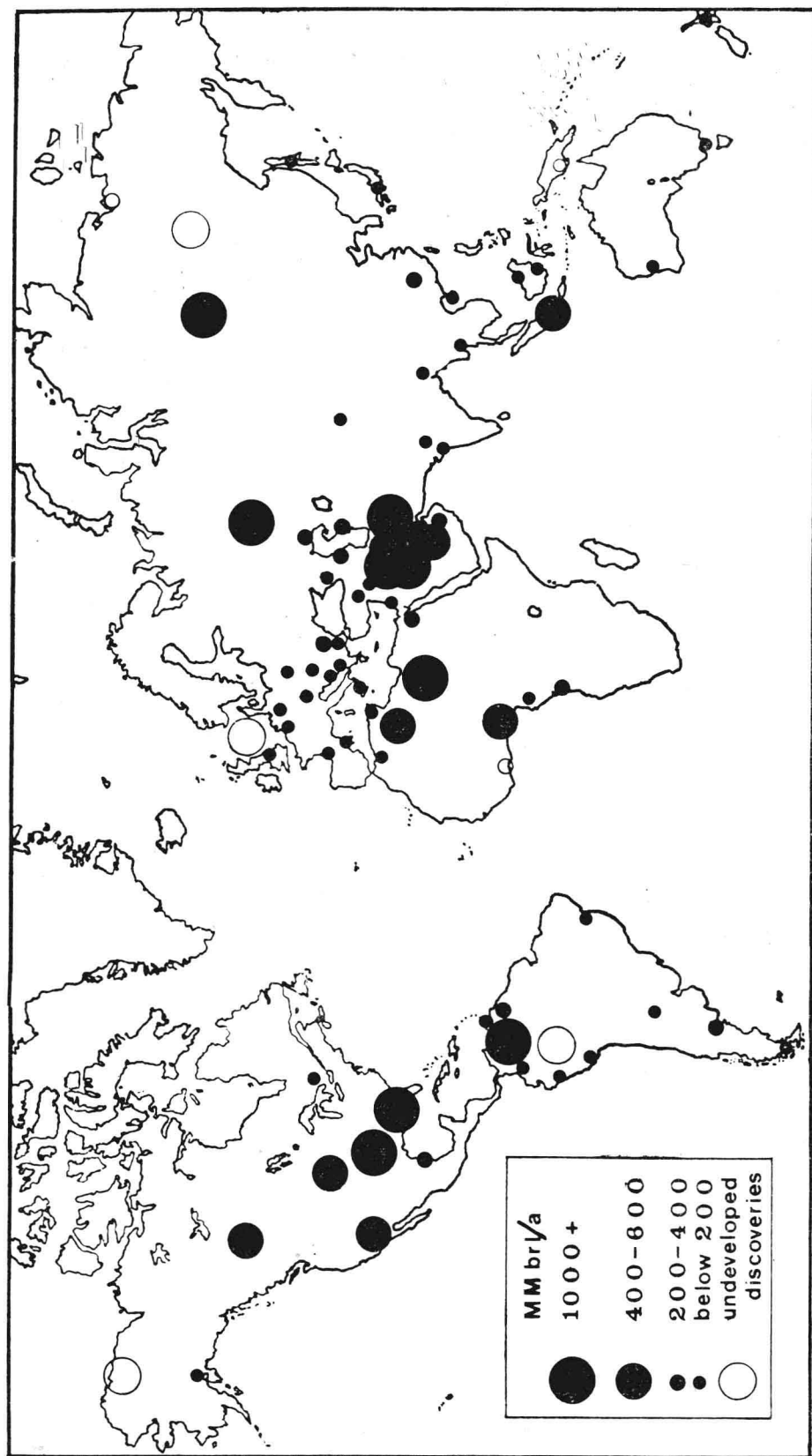


Fig. 3. MAP ILLUSTRATING RELATIVE IMPORTANCE OF WORLD OIL-PRODUCING AREAS

"Golden Lane", soared for a few years but fell rapidly as these wells were exhausted and their outputs turned to salt-water; in spite of increased exploration in recent years, Mexico now ranks only 17th among the oil-producing nations of the world.

Venezuela was for many years after 1930 the world's greatest oil exporting state. Production reached a peak in 1964, much of the output being sent to the United States and western Europe. Since then, however, unfavourable tax and labour legislation has tended to discourage exploration and fresh capital investment, so that oil production has increased only very slowly over the last few years. (As a result, both Saudi Arabia and Iran moved ahead of Venezuela as oil producers during 1971.)

Several countries whose oilfields were developed early in the history of the industry still continue to be substantial producers, as for example, Romania and Germany, in Europe; Indonesia and Brunei, in Asia; Trinidad in the Caribbean; and Argentina, Brazil and Colombia in South America. However, their outputs are now small compared with those of the newer oil-producing states of the Middle East, which have shown the most rapid and impressive increases of petroleum production in recent years. This has been partly due to the geology of their oilfields, which are generally very large structures with thick and highly permeable reservoir beds, and partly also—at least in the first stages of their development—to the unitary nature of the concessions, which made very rapid production increases possible when transport facilities and markets became available.

Oil was found in Iran as long ago as 1908, in Iraq in 1927, and in Saudi Arabia in 1938; but it was not until after the end of the last war that the remarkable expansion of the Middle East oil industry really began. Today, the belt of oilfields lying between Turkey and Oman produces more than a third of the world's total oil output, and is still capable of considerable further development.

The post-war years have also seen the rapid emergence of North and West Africa as important oil-producing areas. In North Africa, large new accumulations of oil and gas have been discovered and developed in Algeria, Libya, and recently also in Egypt; while in Nigeria development has also been remarkably rapid, in spite of the dislocation caused by the Biafran war.

If world annual crude oil output is plotted against time on a scale designed to smooth-out short-term fluctuations, a remarkably consistent growth curve is obtained (Fig 1), reflecting an output which has rather more than doubled in each succeeding decade, equivalent to an average rate of growth of about 7.1 % p.a. compound throughout the history of the industry.

As crude oil and natural gas became increasingly available, they everywhere displaced the less convenient and less efficient solid fuels as

sources of energy. Thus, whereas in 1900 crude oil provided only 3.8% and natural gas 1.5% of world primary energy\* consumption, by 1970 the respective proportions had risen to 40.1% (oil) and 18.1% (gas) (Table 1). The total petroleum-derived proportion had therefore multiplied by a factor of nearly 11 since the start of the century.

TABLE 1  
CHANGES IN THE CONSUMPTION STRUCTURE OF WORLD FUEL AND  
ENERGY SOURCES DURING THE 20th CENTURY (% of Total)

	1900	1920	1940	1960	1965	1970
Coal/Lignite	94.2	86.7	74.6	52.1	43.2	36.0
Oil	3.8	9.5	17.9	31.2	36.7	40.1
Natural Gas	1.5	1.9	4.6	14.6	17.8	18.1
Hydraulic power and, from 1960 onwards, atomic power	0.5	2.0	2.9	2.1	2.2	5.8
Total	100	100	100	100	100	100

(additions vary due to rounding-off)

Sources: F. Baade and UN Statistical Yearbook "World Energy Supplies", 1962-1965.  
CEC estimate for 1970 (see p. 346).

By 1971, commercial oil production was being obtained from 64 countries and totalled 17.5 B bbl—roughly 125 times the output in 1900 (Table 2). (Provisional figures for 1972 show a further overall increase in world output of 4% to about 18.1 B bbl). However, it is interesting to note that, since man-made frontiers have little relationship to the geological factors which control the size and productivity of individual oilfields, more than 85% of the total output comes from only 11 countries (Tables 3, 4).

TABLE 2  
GROWTH OF WORLD OIL OUTPUT 1890-1972  
(MM bbl)

	East Asia	Austral- asia	Middle East	Africa	E. Europe & USSR	West Europe	North America	South America, W. Indies	World
1890	0.2	—	—	—	25.6	0.1	46.6	—	72.5
1900	6.0	—	—	—	69.9	0.3	64.5	0.3	141.0
1910	20.1	—	—	—	88.4	1.1	213.5	1.4	324.5
1920	29.1	—	12.2	1.0	44.8	0.6	600.2	7.1	695.0
1930	56.9	—	46.8	2.0	172.2	1.8	939.1	189.5	1408.3
1940	81.7	—	102.7	6.5	269.2	10.9	1405.8	268.8	2145.6
1950	87.7	—	640.9	16.7	307.0	19.6	2075.1	644.1	3791.1
1960	227.3	—	1923.3	105.3	1189.7	98.8	2863.6	1266.5	7674.4
1970	589.3	65.2	5154.1	2208.4	2717.8	114.7	4112.1	1729.9	16691.5
1971	607.0	114.3	5929.3	2065.0	2852.4	107.5	4116.8	1689.1	17481.4
1972†	777.8	119.8	6453.4	1968.7	2990.6	100.5	4174.8	1577.0	18102.6

† Estimated

\* Defined on p. 342.