IC bureau of mines information circular 8203

THE PETROLEUM INDUSTRY OF IRAN

By L. Nahai and C. L. Kimbell

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

1963

THE PETROLEUM INDUSTRY OF IRAN

By L. Nahai and C. L. Kimbell

* * * * * * * * * * * * information circular 8203

UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

This publication has been cataloged as follows:

Nahai, Lotfollah

The petroleum industry of Iran, by L. Nahai and C. L. Kimbell. [Washington] U. S. Dept. of the Interior, Bureau of Mines [1963]

iv, 112 p. illus., 26 cm. (U. S. Bureau of Mines. Information circular 8203)

Bibliography: p. 106-108

1. Petroleum industry and trade—Iran. I. Kimbell, Charles L., joint author. (Series)

TN23.U71 no. 8203 622.06173

U. S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price $1.00

CONTENTS

CONTENTS (Con.)

ILLUSTRATIONS

Fig.

ILLUSTRATIONS (Con.)

TABLES

THE PETROLEUM INDUSTRY OF IRAN

by

L. Nahai [1] and C. L. Kimbell [2]

INTRODUCTION

Iran's petroleum industry is nearly 50 years old and the oldest in the Near East. According to published figures, Iran ranks third in production and reserves in the Near East. These reserves (including probable reserves) are estimated at 35 billion barrels and constitute about 11 percent of the world's total.

Iran is the sixth largest producer of crude petroleum in the world. The 1961 output of more than 430 million barrels was 5 percent of total world output for the year. In the same year, Iran ranked fourth among world petroleum exporters, providing 8.4 percent of total world exports.

Iran's crude and product exports meet part of the requirements of many countries in Europe, Asia, Oceania, and Africa. In 1960, about 12 percent of net crude imports of Western Europe was supplied by Iran. Shipments to Canada and Australia accounted for 17 percent and 14 percent, respectively, of the net imports of these countries. India obtained 57 percent of its net crude imports and Republic of South Africa almost all its crude imports from Iran. Although considerable crude oil moved from Iran to the United States, the quantity was insignificant in U.S. total net import. Major recipients of Iranian refined products in 1960 included the Republic of South Africa, the United Kingdom, India, and Pakistan.

The importance of the petroleum industry to Iran's domestic economy is well known. In 1961 it accounted for about 19 percent of the country's gross national product. The industry is the largest industrial employer, the largest source of foreign exchange (nearly 70 percent), and is estimated to contribute 25 percent to the total government revenue.

[1] Near East specialist, Division of Foreign Activities, Bureau of Mines, Washington, D.C.

[2] Foreign minerals specialist, Division of Foreign Activities, Bureau of Mines, Washington, D. C.

Work on manuscript completed January, 1963.

Iran's increasing energy requirements are being met by the industry. Petroleum products are available in all parts of Iran in ample supply and at reasonable prices. Virtually all mechanized transportation is powered by petroleum. In 1961 petroleum and natural gas supplied 94.6 percent of Iran's commercial and industrial energy needs.

Although petroleum and natural gas resources are the properties of the State, the Petroleum Act of 1957 provides for conclusion of agreements with foreign companies that meet necessary requirements to carry out petroleum operations. After passage of the Act, three companies concluded agreements with the Government of Iran, two of which successfully brought in commercial production in offshore areas. There are other districts that are also open for petroleum operation.

Iran is a member of the Economic Commission for Asia and the Far East (ECAFE), a United Nations' organization. As the largest petroleum producer among ECAFE regional nations, it is in a position to play a leading role in the petroleum activities of the organization. At the Second ECAFE petroleum symposium, Iran offered training opportunities for nationals of other ECAFE regional members and proposed "to make available its vast reserves of natural gas under favorable conditions and at a reasonable price to countries of the ECAFE region, particularly neighboring countries." Iran is also a member of the Organization of Petroleum Exporting Countries (OPEC). The technical experience that has come because of the early start of the industry in Iran and the legal knowledge gained by negotiating various types of operating agreements with producing companies should contribute to the deliberations of ECAFE and similar organizations.

Because of the competence of Iran in international petroleum problems, the importance of this industry to the domestic economy of Iran and free world oil supply, and the expected availability of additional petroleum districts of Iran for exploration by foreign capital, a brief treatment of the Iranian petroleum industry with historical developments might be useful to the U.S. Government and to private industry, especially because an overall treatment is not generally available. Furthermore, the report is part of a series by the Bureau of Mines, a series of analytical and statistical reports on the mineral resources of foreign countries. The report is based on published material and other information on the general geology and the general economic conditions of Iran.

DEVELOPMENT OF THE INDUSTRY

Petroleum development in Iran until nationalization of the industry in 1951 is essentially the story of over 40 years of operations of a single company, known as the Anglo-Persian Oil Company (APOC) until 1935 and the Anglo-Iranian Oil Company (AIOC) until 1954. This company was formed to exploit the concession granted to William Knox D'Arcy in 1901. Before the D'Arcy agreement, at least six concessions for exploitation of minerals, including

petroleum, were granted by the Iranian[3] Government, the first of these being the one granted in 1872 to Baron Julius de Reuter, a British national. However D'Arcy's concession was the only one that was followed through to successful production.

After the D'Arcy concession was approved, diverse Iranian, U.S., French, Dutch, and Russian firms at various times during 1916-46 negotiated for or were granted areas in the so-called five northern provinces that were excluded from the D'Arcy concession. For a variety of reasons, these concessions were cancelled or abandoned before any commercial production was achieved. The only geological work of any significance was done by Amiranian Oil Company (U.S.) in 1937-38 and Allgemeens Exploratie Maatschappij (Dutch) in 1939-44. Amiranian was a subsidiary of Seaboard Oil Company of Delaware.

D'Arcy Concession and APOC/AIOC Operations and Negotiations 1909-51

The principal terms of the D'Arcy concession and the evolution of the Anglo-Persian Oil Company are briefly discussed in Appendix L. The original agreement required the company to pay the Iranian Government "annually a sum equal to 16 percent of the net profits of any company or companies" that may be formed.

Perhaps the dominant feature of the relationships of APOC/AIOC and the Iranian Government during this period was the continuing attempt on the part of Iran to obtain a larger share of the profits to which it felt entitled. The government's efforts were naturally influenced by the degree of technological sophistication and know-how developed by Iran and by a feeling of relative strength, based both on internal conditions and prevailing international situations.

Three events subsequent to the signing of the D'Arcy concession may be regarded as turning points in the course of company-government relations. These are the Armitage-Smith Agreement of 1920, which played such an important part in the arguments concerning nationalization, the New Concession Agreement of 1933, and the Oil Nationalization Act, ratified on April 28, 1951. (The principle of nationalization was approved by Parliament on Mar. 21, 1951.)

Armitage-Smith Agreement

Two points covered in the D'Arcy concession agreement became controversial by 1919. First, AIOC[4] felt that the computation of royalties should be based only upon the net income of firms related directly to the D'Arcy concession and operating at least in part in Iran, while the Government

---

[3] Technically, the term "Persian Government" should be used for the government before 1935. For consistency, however, "Iranian Government" is used throughout this report.

[4] Officially, the company was known as Anglo-Persian Oil Company (APOC) until 1935, but for consistency, Anglo-Iranian Oil Company (AIOC) has been used in the balance of this report.

maintained that it should be based on the net income of all companies formed, including subsidiaries operating wholly outside of the country (40).[5]

Secondly, the company contended that the Government had failed to protect company property as specified in the agreement (tribesmen cut the Masjed-e Soleyman pipeline in 1915) and that it was therefore justified in withholding royalties due the Government as payment for damages incurred. The Government rejected this proposal, arguing that it was not liable for this damage which was essentially sabotage against the British beyond its control.

Sidney Armitage Smith represented the Iranian Government in its negotiations with the company, and an agreement was reached in December of 1920. Its principal provisions included the following:

1. The Iranian Government was to receive an annual royalty of 16 percent on net profits of AIOC and its subsidiaries, whether in Iran or not, except that the Government was not to receive royalty on profits of the AIOC and AIOC subsidiary tanker fleets moving Iranian (or other) oil. "Subsidiary companies" were defined as any company over which AIOC held control, by virtue of 50 percent of ownership or by virtue of being able to select over half of the board of directors.

2. Deductions allowable in the computation of net profits were specified in some detail.

3. A system of checking AIOC accounts (on which royalty payments were based) was explicitly stated.

4. In conjunction with the basic agreement a collateral agreement was signed under which AIOC agreed to pay £1 million as settlement of the dispute over royalty payments that had been withheld because of pipeline damages.

1933 Revision of the D'Arcy Concession

Under this agreement, the basis for computation of royalty was changed from 16 percent of net profits to 4 gold shillings per ton of petroleum consumed in or exported from Iran. In addition, the Government was also to receive a sum equal to 20 percent of the annual profit distributed to the account of ordinary stockholders of AIOC in excess of £671,250, regardless of whether the distribution was as dividends or accretions to the cash reserves of the company in excess of reserves on hand at the end of 1932 (40). Further financial details and other salient facts on this agreement are given in Appendix 2.

The 1933 agreement further specified that the concession was to remain in force until 1993, but the concession area was reduced to 100,000 square miles (selection of the boundaries of this area was left to AIOC). From 1933 to

[5]Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

nationalization in 1951, operations of the company grew, rather slowly in the early thirties but more dramatically shortly before and during World War II (except for 1940 and 1941). By 1950, the last full year of AIOC's operation, crude production attained an average of 664,000 barrels and throughput at the Abadan refinery averaged 526,000 barrels per day. The Abadan refinery also became one of the world's largest aviation gasoline producers.

Nationalization

Many factors led to the nationalization of AIOC holdings, and arguments on both sides have been fully covered in the petroleum press (34, 35). An unofficial translation (40) of the resolution pertaining to the nationalization of the oil industry, which was passed by the Iranian Majlis (Lower House) on March 15 and the Iranian Senate on March 20, says:

> "For the happiness and prosperity of the Iranian nation, and for the purpose of securing world peace, it is hereby resolved that the oil industry throughout all parts of the country, without exception, be nationalized, that is to say, all operations of exploration, extraction and exploitation shall be carried out by the Government."

Following the seizure of the industry in 1951, production and foreign marketing of crude oil and products, which had continued to rise markedly since the end of World War II, were severely curtailed, as will be shown. Iran received little income from the oil industry following nationalization and was forced to keep the installations on a care and maintenance basis. Moreover, much of the international market demand hitherto supplied by the Iranian oil industry was taken over by increased production in other Middle Eastern countries.

Post Nationalization--The Consortium Agreement Area

After prolonged negotiations, the Iranian Government on October 29, 1954, approved an agreement with Iranian Oil Participants, Ltd., an international consortium, in order to bring the Iranian oil industry back into large-scale production.

Iranian Oil Participants, Ltd., hereafter known simply as "The Consortium" originally had the following structure:

	Shares, percent
Anglo-Iranian Oil Company (now British Petroleum Company)	40
Bataafse Petroleum Maatschappij, N.V. (Royal Dutch-Shell group	14
Gulf Oil Corporation	8
Socony-Vacuum Oil Company, Inc. (now Socony Mobil Oil Company, Inc.)	8
Standard Oil Company (New Jersey)	8
Standard Oil Company of California	8
The Texas Company (now Texaco, Inc.)	8
Compagnie Française des Petroles	6

Subsequently (Apr. 29, 1955), one-eighth of the shares held by each of the original five U.S. firms were divided among the following nine U.S. firms:

American Independent Oil Company
Atlantic Refining Company
Hancock Oil Company (now merged with Signal Oil and Gas Company)
Pacific Western Oil Corporation (now Getty Oil Company)
Richfield Oil Corporation
San Jacinto Petroleum Corporation
Signal Oil and Gas Company
Standard Oil Company (Ohio)
Tidewater Associated Oil Company (now Tidewater Oil Company)

This redistribution left each of the original five U.S. participants with a 7 percent share of the Consortium and provided for a nine-way subdivision of the remaining 5 percent of U.S. ownership.

AIOC was reimbursed for its loss of properties under an agreement between the company and Iran which provided that after offsetting the £51 million due Iran against AIOC's claims, the Iranian Government was to pay a total of £25 million, interest free, to AIOC in 10 annual installments beginning in 1957. This payment was to be in the form of oil, turned over to AIOC or a subsidiary, and would not be subject to income tax.

Reimbursement to AIOC at this level took into account that additional payments were to be received by AIOC from Consortium companies. In compensation for the loss of 60 percent of its former holdings (the share given to other Consortium members), and, therefore, theoretically the loss of 60 percent of future revenues, the other Consortium members paid AIOC an initial sum of nearly $91 million (£32.4 million) and agreed to pay 10 cents a barrel on all exports until a total payment of $510 million was reached.

The Consortium operates in Iran on the basis of a fifty-fifty sharing of profits with the Iranian Government. To carry out operations in Iran, the Consortium founded two firms: Iraanse Aardolie Exploratie en Productie Maatschappij (Iranian Oil Exploration and Producing Company, or IOEPC), and Iraanse Aardolie Raffinage Maatschappij (Iranian Refining Company or IRC), both incorporated in The Netherlands and registered in Iran. The first is responsible for all exploration and production of crude, and the second is in charge of all refining operations. Crude oil and products for export are not actually owned by the Consortium subsidiaries. These firms, on behalf of their parent body, are not concessionaires but are simply producing and refining agents, acting for the Iranian Government in return for a fee (operating costs plus a profit) paid by the actual owner of all facilities, crude oil, and refinery products--the National Iranian Oil Co. (NIOC, see page 7). The output is sold by NIOC to the trading companies--the non-Iranian member firms of the Consortium or their designated subsidiaries or affiliates.

Since its institution, the Consortium has gradually increased crude production to levels exceeding the previously achieved maximum, although for technical and marketing reasons the refinery output has not yet reached the

previous record level. The Consortium has also discovered additional reserves of crude oil, both in extensions of former AIOC fields and in new fields, and has carried out a modernization and reequipment of the Abadan refinery. Government revenue from the oil industry reached the level of about $342.2 million (£122.2 million) in 1962.

Post Nationalization--Outside the Consortium Agreement Area

As Iran increased its know-how of the oil industry and with the passage of the new Petroleum Act (1957), the Iranian Government opened new areas for exploration and exploitation by non-Iranian firms, particularly favoring offers which provided for participation by NIOC.

An agreement with AGIP Mineraria, a subsidiary of Ente Nazionale Idrucarburi (ENI, the Italian State oil industry) was concluded in 1957. A company, Societe Iran-Italienne des Petroles (SIRIP, Iran-Italian Petroleum Company) was formed in which NIOC participated to the extent of 50 percent. The areas allotted to SIRIP are shown in figure 1. SIRIP discovered oil in its offshore area in 1960.

The next agreement was with Pan American Oil Company, the overseas subsidiary of Standard Oil Company of Indiana. In this case, Iran-Pan American Oil Company (IPAC) was the joint operation company formed, again with 50 percent NIOC participation and other provisions rather similar to the SIRIP agreement. After considerable exploratory expenditure, the company has made discoveries discussed in the section on Offshore Operations.

Perhaps the most important single feature of these two agreements is that through its 50 percent participation in each of the two companies (SIRIP and IPAC), the Iranian Government is entitled to receive 75 percent of net profits--50 percent by virtue of NIOC's half ownership, and an additional 25 percent in the form of a 50 percent income tax on the non-Iranian firms' incomes. However, the agreements also contained two important provisos: (1) Obligation of NIOC to meet half of the exploration expenditures once commercial oil discoveries were made, and (2) obligation of NIOC to meet half of all capital and operating expenses connected with developing fields and producing oil. The situation, therefore, is not analogous to the 50 percent profit sharing scheme under which the government has no capital invested in the industry.

A third agreement, similar to the SIRIP and IPAC arrangements was concluded in 1958 between NIOC and Sapphire Petroleums, Ltd., of Canada, leading to the creation of Iran-Canada Oil Company (IRCAN), but this firm was unable to meet the terms of the agreement, which was then cancelled.

Meanwhile, NIOC has been active on its own behalf, not only in the Naft-e Shah field and Kermanshah refinery, which it retained for its own operation when the bulk of former AIOC facilities were turned over to the Consortium, but also in the potentially important Qom fields area. In addition, NIOC is the sole distributor of refinery products other than lubricants in Iran and has assumed other important responsibilities described in the section on Role of Government.

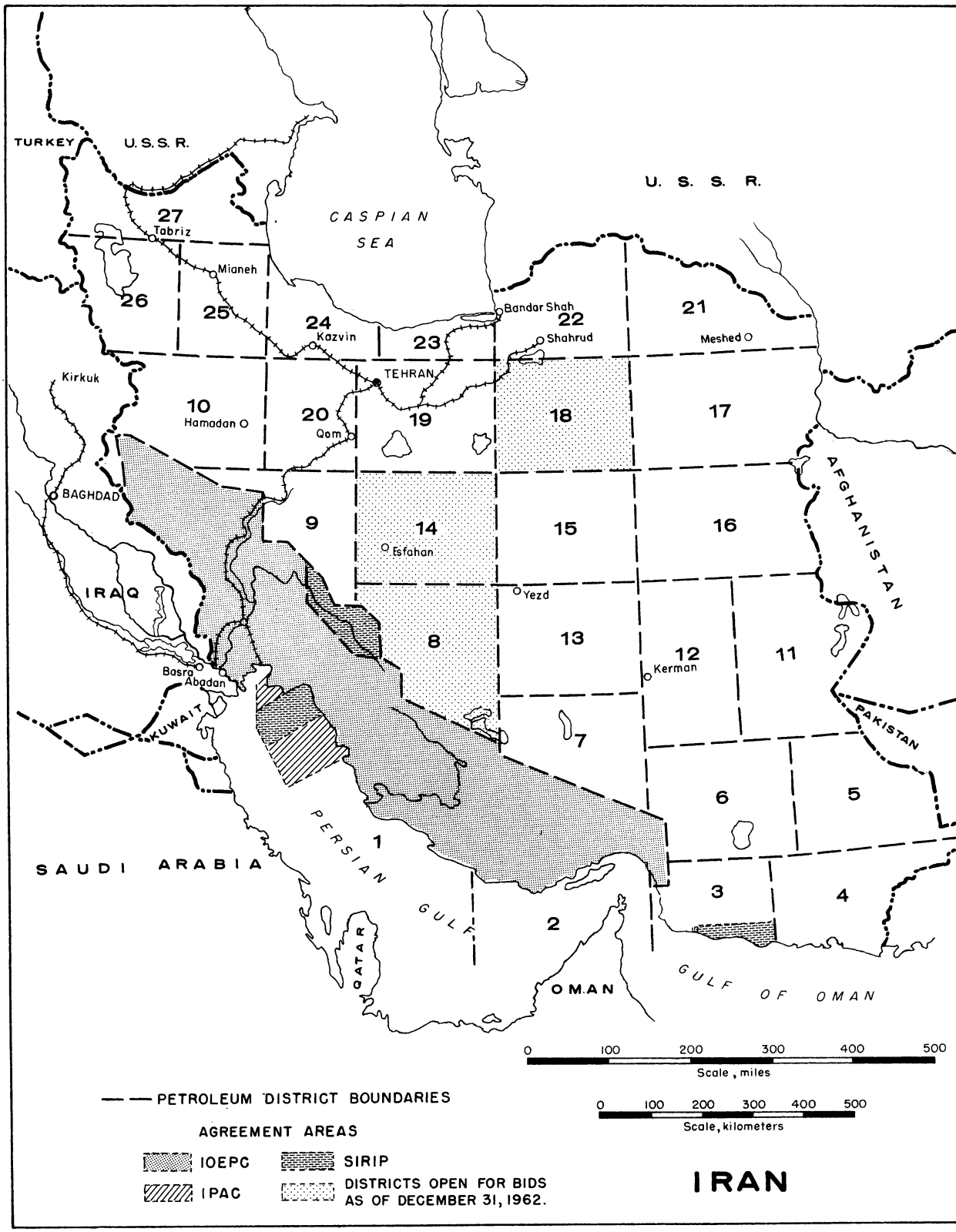


FIGURE 1. - Agreement Areas and Petroleum District Boundaries in Iran as of 1962 (29).

ROLE OF GOVERNMENT

Until the Oil Nationalization Act of April 28, 1951, the role of the Government was restricted almost exclusively to the granting of concessions and the collection of royalties and revenues accruing to the Government from activities of the AIOC in Iran. This last responsibility was given to a special office in the Ministry of Finance. The country did not have the organization or know-how to carry out petroleum exploration on its own, except for a modest program during 1948-51 by the Iran Oil Company (IOC, an affiliate of NIOC), and was not directly engaged in petroleum production, refining, or distribution. In the last decade the role of the Government in the Petroleum industry has become more significant and varied and includes other activities besides its traditional role of negotiating agreements.

The Government's main instrumentality in petroleum affairs is now the National Iranian Oil Company (NIOC) created by the Oil Nationalization Act of 1951. Mention should also be made of the Oil Exploration Department of the Ministry of Finance and of the Iran Oil Company. The Oil Exploration Department, established in 1948, was abolished in 1951 when its duties were taken over by NIOC. The Iran Oil Company performed exploration work for the Government as an independent organization from 1948 to 1951 when it was placed under NIOC's control as an affiliate organization.

NIOC was initially charged with the responsibility for operation of all nationalized facilities of AIOC, as well as administration of other petroleum activities. Unable to find foreign markets for crude oil and refinery products on a large scale, NIOC during 1951-54 had the dual task of producing at the level of domestic requirements and keeping much of the former AIOC facilities on a care and maintainence basis. Exploratory drilling during this period was curtailed.

The approval of the Consortium Agreement in late 1954 marked the beginning of a new pattern of Government and private industry operations, and since that time the NIOC has held a position of considerable importance in the Iranian oil industry although it produces only a small fraction of the country's petroleum output.

At the present time, NIOC's activities may be divided into the following major categories:

1. Ownership of all equipment classified as "fixed assets" now operated by the Consortium.

2. General administration of all oil and natural gas resources.

3. Exploration for and production of crude oil and production of refined products.

4. Distribution and marketing of essentially all petroleum products sold in Iran.

5. Operation of nonbasic services in the Consortium Agreement Area.

The organizational structure of NIOC effective as of November 1962, is shown in figure 2.

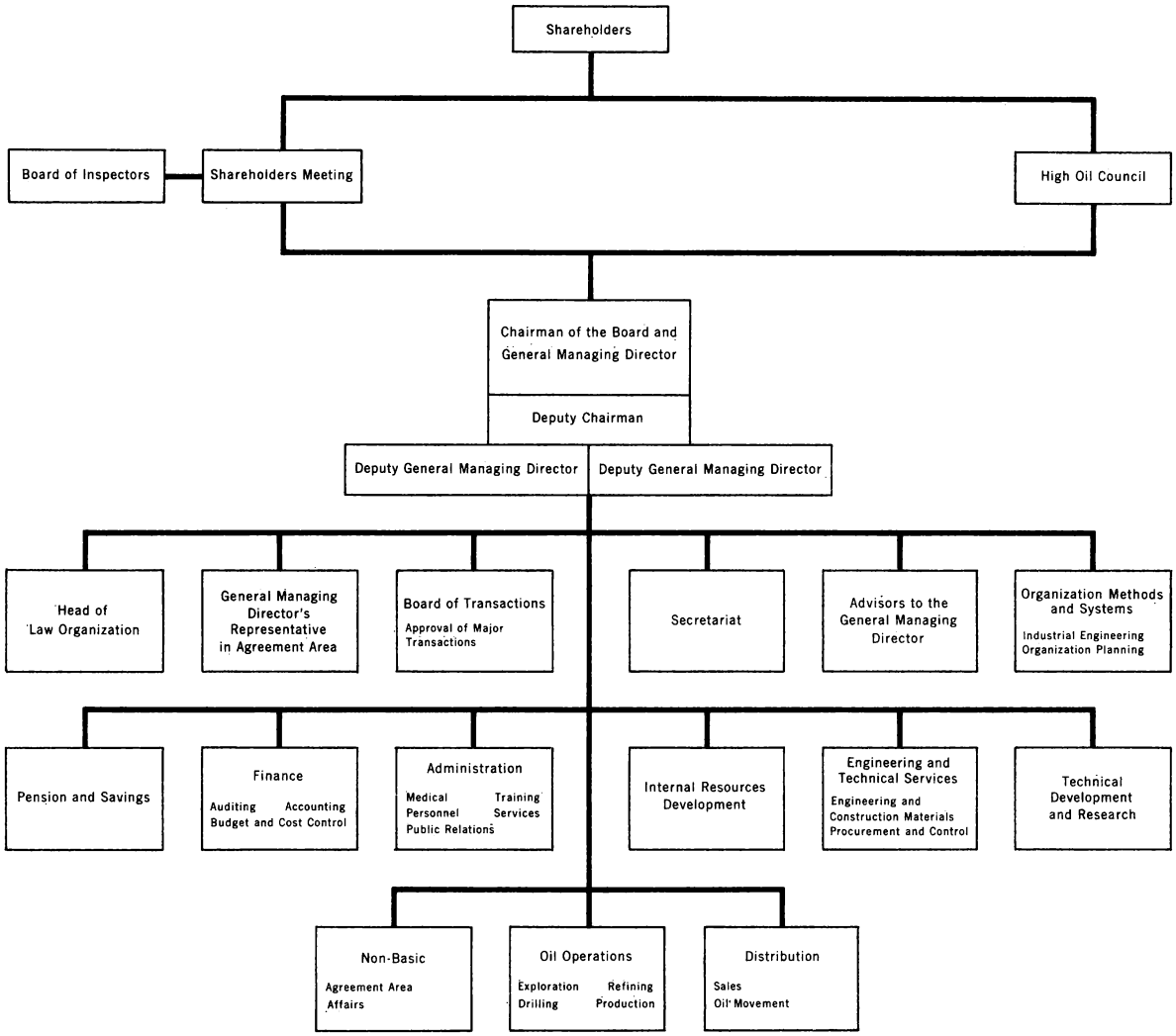


FIGURE 2. - Organization of National Iranian Oil Company as of November 1962.

Ownership by NIOC of fixed assets used by the Consortium in effect gives the Iranian Government a final voice in regulating the Consortium's activities. It assures adequate production at the Abadan refinery to meet domestic requirements.

Under its authority as general administrator of all oil and gas resources, NIOC determines the districts of Iran that are to be made available for exploration and development by private industry and areas to be retained in the National Reserves. NIOC is also responsible for negotiations with applicants for agreements within provisions of the Petroleum Act and is authorized to

represent the Iranian Government in partnership contracts with foreign and/or domestic interests. Stated payments, agreement fees, and other charges (except taxes and duties due from operators) are collected by NIOC.

NIOC is also actively engaged in oil exploration, production, and refining. (See sections on Petroleum and Natural Gas Fields and on Reserves for details on exploration; see sections on Crude Oil and Natural Gas Production and on Refinery Production for details on output of these commodities; and see the section on Refineries and Related Facilities for development activities.)

In summary, the agency has pursued a program of extensive geological and geophysical exploration in a number of regions of Iran and has conducted exploratory drilling programs in the Qom area and at several points in the northeast of the country. Drilling at Qom has proved the existence of two major oil-gas reservoirs, and the activities near Gorgan have resulted in discovery of gas, although they have not as yet indicated commercially produceable petroleum reserves.

NIOC has operated the Naft-e Shah field on the Iraq-Iran border since 1951 when it acquired the field by nationalization. Old wells there have been reworked, and new drilling has been carried out to insure a supply of crude to the field topping plant and to the Kermanshah refinery, which NIOC has also operated since nationalization.

As the sole distributor and wholesale outlet of petroleum products (other than lubricants) for the domestic market in Iran, NIOC has built a 2,670-kilometer products pipeline system and owns a fleet of road tank trucks and a number of storage depots throughout Iran. (Details on the company's functions in these fields may be found in the section on Transportation and Distribution of Petroleum Products for Domestic Consumption and on Consumption.)

Operation and regulation of so-called nonbasic services and facilities for the Consortium and other foreign companies also fall within NIOC's jurisdiction. These comprise housing, welfare and medical services, commissaries, training and education, public utilities, public transport and road maintenance, and property security. Responsibility for these services was delegated to NIOC under the Consortium agreement. Hospitals and medical services were transferred in 1957, housing at Abadan in 1958, and final transfer of all remaining services occurred in 1960-61.

The significance of the nonbasic services was pointed out in an August, 1962, press interview by Mr. Bagher Mostofi, member of the Board of Directors of NIOC in charge of nonbasic services. He stated that 40 percent of the petroleum industry employees in the Consortium area came under the jurisdiction of nonbasic services. In 1961 nonbasic services had 392 construction plans on which 4,320 million rials (75 rials equals approximately US$1) had been spent. In the last 2 years, 1,150 houses were built and more than 1,000 additional houses were under construction. A total of 2,162 kilometers of road must be maintained. Sums expended on school buildings construction exceed 200 million, and annual medical expenses amount to 550 million rials.

NIOC also has not neglected establishment of research facilities. In cooperation with the Institut Français du Petrole of France, it established in 1960 a center for research in petroleum and petrochemistry. Although the primary purpose of the center is to train Iranian engineers to do fundamental research in these fields, it is also equipped to solve operating problems of the industry. In the center's first 2 years of operations, refinery studies seem to have been emphasized, specifically isomerization studies aimed at production of products more suited to world demand patterns (33).

Building of another research installation, the Petroleum Engineering Laboratory Facility at Rey, near Tehran, was started in April of 1961, and was nearly completed in late 1962 (6). Physical facilities, including 14 laboratories, 10 offices, a library, conference room, and core storehouses, are divided into four main operating sections: Core and Reservoir Analysis, Reservoir Fluid Analysis, Mud and Cement Analysis, and Chemical Analysis. The research installation is equipped with the latest internationally accepted equipment for the various operations required in reservoir studies and will thereby permit the NIOC to perform studies that it heretofore was unable to carry out on its own.

PETROLEUM LAW

Petroleum, bitumen, and natural gas resources are the property of the State, "the surface owner having no right other than receiving the value of his land of which he may be dispossessed under the principle of eminent domain (38)." These resources are controlled and administered under the Petroleum Act of 1957. This law defines the general principles under which an agreement may be made and describes varieties of relationships between the State and a company. One important feature is that once an agreement is made it must be ratified by the Legislature, thereby the agreement becoming an Act of Parliament.

NIOC is responsible for administering the law. It is authorized to negotiate and conclude agreements with any person, whether Iranian or foreign, who has the necessary technical and financial competence, provided the foreign operator is a national of a country that permits Iranians to carry out similar operations.

The law defines three types of operators authorized to conduct and manage petroleum operations: "Person," "Mixed Organization," and "Joint Structure." "Person" means "any natural or juridical person" but not including NIOC and its subsidiaries. "Mixed Organization" means "any juridical person which is owned in part by any person and in part by NIOC." "Joint Structure" means "any operating structure which is created jointly" by the NIOC and one or more persons "without a separate juridical personality resulting from such combinations." "Mixed Organizations" or "Joint Structures" in which NIOC participation exceeds 50 percent have certain advantages over operators holding agreements in which NIOC has between 30 and 50 percent interest or no interest at all (under the law, if NIOC participates in a "Mixed Organization" or "Joint Structure," it must have at least 30 percent interest).

According to provisions of the law, NIOC has divided the territory of Iran, including the continental shelf but exclusive of the Consortium area, into 27 districts, each with 80,000 square kilometers maximum area (see fig. 1). At its discretion, NIOC declares any district or part thereof open for petroleum operation. It must ensure, however, that at least one-third of the total exploitable area including the continental shelf is conserved as National Reserves. NIOC may alter the boundaries of the districts or revise its decision whether they are open for exploration, but at least 3 months prior notice must be given and the decision must not adversely affect any agreements already executed.

The area that may be granted to a company in each district depends on the degree of NIOC participation. In any case, no operator may engage in petroleum activities in more than five districts at one time. Where the ownership interest of the NIOC is 50 percent or more the "Mixed Organization" or "Joint Structure" may hold not more than 16,000 square kilometers in any one district at any one time. This area is reduced to 9,000 square kilometers for "Mixed Organizations" or "Joint Structures" with less than 50 percent NIOC interest. The total area that may be held by a nonparticipation operator in one district at one time may not be more than 6,500 square kilometers.

Similarly, with NIOC participation of more than 50 percent, no cash bonus is required, whereas, in the other two cases referred to previously, a cash bonus must be paid, the amount being determined by NIOC in accordance with the circumstances of the case.

An annual rental to be determined by NIOC, compatible with extent and characteristics of the particular area, must be paid by all operators, a part of it as a lump sum upon conclusion of the agreement. Up to a certain income tax liability, the rental paid annually and annual installments on account of the rental may be included as a portion of the operating cost. When a company goes into partnership with NIOC, NIOC may agree that, instead of rental payment, the company may meet all the exploration expenses up to the discovery of petroleum in commercial quantities; in such cases NIOC sets a minimum expenditure.

With respect to each district declared open, NIOC invites offers on the basis of Specimen Agreement Form and necessary specifications of the district, and will select from proposals the one that it regards most advantageous to the country.

The original period of an agreement may not in respect of each area exceed 25 years from the date of commencement of commercial production, and may be renewed for no more than three terms of 5 years each. Upon expiry or termination of an agreement, all fixed assets erected or installed in connection with the agreement become the property of NIOC. The law stipulates the maximum number of years within which drilling must start (4 years in cases where NIOC interest in a "Mixed Organization" or "Joint Structure" amounts to 50 percent or more and 5 years in other cases); it also requires that one-half of the area entrusted to any operator must be returned to NIOC (on one or on several occasions) within 10 years from the date of each agreement. If an

operator fails to achieve commercial production in any agreement area within 12 years, that area must be returned to NIOC.

Items that the operator is entitled to include in operating costs in computing its tax liability are laid down in each individual agreement. Examples of allowances in addition to those established by Article 36 of the Income Tax Act of 1956 are rental payment, fixed asset charge, a reasonable annual proportion of cast bonus, cost of drilling nonproductive wells, and expenditures made related to drilling, deepening, or completing wells.

Materials required for conducting petroleum operations may be imported without custom duties, but material for personnel consumption is subject to custom duties and other taxes generally applicable at the time of importation. No taxes are imposed on exports of petroleum by an operator nor on dividends paid by an operator from income arising as a result of its operations. Every operator is subject to an income tax on its net income in accordance with prevailing income tax laws. Article 36 of the Iranian Income Tax of 1956 guarantees that the oil companies will not be subject to discriminatory taxation.

NIOC may require any operator to deliver to it a portion of such petroleum as may be required for Iranian internal consumption at cost plus a reasonable operating fee. Further, in the case of agreements in which NIOC does not have an interest of 50 percent or more, NIOC may require the operator to supply up to one-eighth of the total production to the government, the value of which, at the current posted price, shall be deducted from the operator's tax liability.

A force majeure article provides automatic extension of the agreement for the duration of the force majeure occurrence, provided this does not exceed 1 year. Differences that cannot be resolved through procedures established in the individual agreements shall be referred to conciliation or arbitration.

In addition to agreements for exploration and exploitation as just outlined, the law provides for the negotiation of and establishment of agreements with any class of operator for the refining, transportation, and sale of petroleum abroad. Such agreements may be made for a period initially not to exceed 40 years and renewable for no more than three terms of 5 years each.

Although this summary gives many important features of the law, it cannot serve as a substitute for the full text of the law that presumably may be obtained from NIOC.

ROLE IN THE NATIONAL ECONOMY

Monetary Income

For nearly three decades after oil production started in Iran, revenues from the industry were not an important factor in the overall economy of the country. Payments by AIOC during 1910-32, before renegotiation of the royalty basis, totaled about £12.5 million sterling, an average of about only £543,000

annually. Even in terms of the modest budget of Iran during these years, the country's annual receipts from the petroleum industry were not significant.

Beginning in 1933, receipts increased, but much of the oil revenue was prescribed for special purposes that had little effect on the general national economy. Starting in the early 1940's, however, petroleum income was used more for meeting general budgetary expenditures, and this situation prevailed until nationalization of the industry in 1951.

During the period of nationalization (August 1951 to September 1954), the income from foreign sales was negligible. The government-controlled industry was unable to find either foreign markets or tanker facilities and was forced to curtail production to about the level of domestic consumption, which was a small percentage of normal output.

With the resumption of oil production in significant quantities in 1954, oil revenues have become vitally important in Iran's economy and will remain so in the forseeable future. Iran's expanded economy, higher standard of living, and rising industrialization necessitate development expenditures that can be financed principally through oil revenues.

Contributions of the Consortium to the Iranian economy since 1954 are shown in table 1. The relationship of these payments to Iran's gross national product, total foreign exchange earnings, and Government expenditures for 1960-62 were:

Consortium disbursements	1960	1961	1962
In million pounds, sterling	132.4	141.3	[1] 153.4
In million U.S. dollars	370.8	395.6	429.5
As a percentage of gross national product[2]	9.9%	8.7%	([3])
As a percentage of total foreign exchange earnings	48.6%	45.0%	([3])
As a percentage of estimated Government expenditure (approximate)[4]	40.0%	39.0%	44.0%

[1] Includes approximately £3.5 million in settlement of claims for previous years.

[2] Based on estimates of gross national product as follows: 1960, US$4,190 million; 1961, US$4,555 million. Various other estimates of the GNP have been reported.

[3] Not available.

[4] Includes general treasury budget, Plan Organization budget, NIOC budget, and special extra-budgetary expenses. The percentages are cited merely as a measure of magnitude, realizing that these disbursements do not all accrue to the Government (see table 1).

The net profits, and tax and royalty payments of AIOC during its operation (table 2), are of interest. Tables 1 and 2 are not strictly comparable because data comparable to "Other Payments" by the Consortium are not available from AIOC for 1910-51. The column "Royalty Payments to Iran" in table 2 correspond only to "Payments Under the Oil Agreement" listed in the Consortium. Moreover, "Net Profits of AIOC" (table 2) include income from the company's operations outside of Iran.

TABLE 1. - Consortium disbursements in Iran, 1954-62, in pounds sterling (19)

	[1] 1954	1955	1956	1957	1958	1959	1960	1961	1962
Payments to the Iranian Government under the Oil Agreement Stated Payments:									
Cash	684,930	4,532,115	13,131,069	19,628,580	23,282,612	25,763,624	28,521,000	30,601,000	34,384,000
Petroleum products (value received in lieu of cash)	173,365	4,820,867	2,177,928	1,722,556	1,635,468	252,885	-	-	-
Subtotal	858,295	9,352,982	15,308,997	21,351,136	24,918,080	26,016,509	28,521,000	30,601,000	34,384,000
Income tax:									
Trading companies	([2])	([2])	37,772,363	([2])	([2])	([2])	70,993,000	70,897,000	81,692,000
Operating companies	([2])	([2])	1,241,454	([2])	([2])	([2])	2,280,000	2,406,000	2,701,000
Subtotal	[3] 2,677,450	[4] 22,101,250	39,013,817	54,687,214	63,421,274	67,728,663	73,273,000	73,303,000	84,393,000
Total	[3] 3,535,745	[4] 31,454,232	54,322,814	76,038,350	88,339,354	93,745,172	101,794,000	103,904,000	118,777,000
Other payments (Consortium estimate):									
Import duties and taxes	([2])	516,984	772,000	([2])	700,000	900,000	1,025,000	575,000	510,000
Wages and salaries	([2])	15,621,813	17,903,000	([2])	19,750,000	20,670,000	19,688,000	28,200,000	28,292,500
Consortium contributions to Workers Social Insurance Organization	([2])	849,019	1,485,000	([2])	1,660,000	1,780,000	1,680,000	1,854,000	1,528,000
Payments to Iranian contractors and for purchases in Iran	([2])	4,217,982	2,552,000	([2])	5,380,000	6,340,000	8,251,000	6,794,000	4,775,000
Other[5]	([2])	1,235,017	-	([2])	-	-	-	-	-
Total	([2])	22,440,815	22,712,000	([2])	27,490,000	29,690,000	30,644,000	37,423,000	34,595,500
Grand total	([2])	53,895,047	77,034,814	([2])	115,829,354	123,435,172	132,438,000	141,327,000	153,372,500

[1] For the period from October 29 to December 31 only.
[2] Not available.
[3] Includes advance of 500,000 to Government of Iran on Dec. 21, 1954.
[4] Payment due for 1955 less 500,000 advanced to Government of Iran on Dec. 21, 1954.
[5] Includes 819,168 (taxes on salaries and wages) and 415,849 (overseas staff cash drawings) both in 1955. These data not reported in other years.

TABLE 2. - Net profits of the Anglo-Iranian Oil Company, company tax payments to United Kingdom and royalty payments to Iran, 1910-51, in thousand pounds sterling (2, 3, 4)

Year	Net profit[1]	United Kingdom taxes[2]	Royalty payments to Iran[3]
1910-32.....	51,870	7,700	12,498
1933.....	2,644	305	1,812
1934.....	3,183	512	2,190
1935.....	3,519	409	2,221
1936.....	6,123	911	2,580
1937.....	7,455	1,652	3,545
1938.....	6,109	1,157	3,307
1939.....	2,986	1,956	[4]4,271
1940.....	2,842	2,975	[4]4,000
1941.....	3,292	2,921	[4]4,000
1942.....	7,790	4,918	[4]4,000
1943.....	5,639	2,799	[4]4,000
1944.....	5,677	2,756	4,464
1945.....	5,792	2,806	5,624
1946.....	9,625	2,980	7,132
1947.....	18,565	15,267	7,104
1948.....	24,065	28,310	[5]9,172
1949.....	18,444	20,094	[5]13,489
1950.....	33,759	26,742	[5]16,032
1951.....	24,843	27,374	8,326
Total.....	244,222	154,544	119,767

[1] Includes profits of AIOC subsidiaries and installations not in Iran (see text, page 15).

[2] Includes company income tax (all years), corporation profits tax (in all years reported, 1919-25 and 1948-51), and National Defense contribution (1937-42). Described as "Provision for taxes" in 1940-46 and therefore may not equal tax actually paid in those years. Definitely excludes recoverable taxation on shareholders dividends in years 1942-51 and probably excludes such taxation in years 1910-47 were applicable.

[3] The data are as reported by various published sources other than company annual reports except for 1936-38 and 1948-51. For other years, differences in royalty allocations shown in company annual reports and the above data were apparently adjusted annually from funds held in reserve for such contingencies but not specifically identified for this purpose.

[4] In 1940, AIOC paid an idemnity of £1,500,000 to the Iranian Government for 1939 and guaranteed a minimum of £4,000,000 annually for 1940 and 1941 to compensate for losses resulting from the company's inability to move sufficient crude and products during the war years. This £4,000,000 guarantee was subsequently extended to 1942 and 1943. Without the guarantee, royalty payments would have been £2,770,814; £2,786,104; £2,025,304; £3,427,933, and £3,617,917, for the years 1939-43, respectively.

[5] Had the supplemental agreement of 1949 been ratified, these payments would have been increased to £18,667,000, £22,890,000, and £30,000,000 (approximate) in 1948, 1949, and 1950, respectively.

Consortium reports indicate that all "Oil Agreement" payments shown in table 1 consist of money derived from non-Iranian sources, and that in addition, between 69 and 96 percent of "other payments" listed in table 1 for the years 1956-61 were also foreign-derived funds. The funds are largely foreign derived because the Consortium has no major sources of income within Iran and by far the greater share of its revenue is obtained from abroad by exporting and marketing Iranian crude and oil products in foreign countries.

The financial contributions of other segments of the Iranian oil industry as yet bear no comparison to those of the Consortium. Contributions by operators other than the Consortium have been limited to a US$25 million cash bonus paid by Pan American Petroleum Corporation. Some foreign exchange earnings are credited to NIOC; such income consists of proceeds from export sales of crude and products. However, as can be seen in table 3, NIOC has shown an operating deficit for the years listed. This is primarily because of the low cost at which NIOC makes petroleum products available in all parts of Iran.

TABLE 3. - Summary of NIOC Income[1] and Expenditures, 1957-59, in thousands of rials[2] (29)

	1957	1958	1959
Income:			
Domestic sales, refinery products	3,314,059	4,473,322	5,309,322
Export sales, crude oil and products	40,885	50,279	30,740
Other sources	73,151	113,717	81,781
Total	3,428,095	4,637,318	5,421,843
Expenditure:			
Exploration costs	344,663	647,039	680,897
Production of products for indigeneous consumption	1,181,528	1,272,348	1,532,803
Production of crude and products for export	2,322,953	2,074,087	2,433,872
Transportation	35,579	43,411	25,911
Administration, internal distribution, training, and welfare	722,018	964,293	1,184,840
Miscellaneous	78,697	199,000	352,854
Total	4,685,438	5,200,178	6,211,177

[1] Excludes NIOC share of stated payments from the Consortium to the Iranian Government.

[2] For the period 1957-59, rials may be converted approximately at the rate of 75 to US$1.

The Government's direct income from the oil industry, the so-called stated payments and income taxes, are distributed to three Government agencies, the Plan Organization, the Ministry of Finance, and NIOC. The distribution of this income for 1957-59 was as follows:

Year	Distribution, percent		
	Plan Organization	Ministry of Finance	NIOC
1957.....	50.2	[1] 33.9	15.9
1958.....	45.6	[2] 42.8	11.6
1959.....	49.5	41.4	9.1

[1] Includes 8.4 percent originally paid to NIOC but transferred from that organization to the Ministry of Finance.

[2] Includes 5.6 percent originally paid to NIOC but transferred from that organization to the Ministry of Finance.

The Plan Organization is the Government agency concerned with the execution of successive 7-year development plans, the first of which was adopted in 1949. Originally budgeted at 21 billion rials (US$656 million at the rate of exchange in 1949), 37 percent of the first plan was to be financed by oil revenues. Actual expenditures fell short of the target because of the near stoppage of the oil industry in 1951. The second 7-year plan covering the period from September 1955 to September 1962 proposed the expenditure of 84 billion rials (US$1.1 billion) in its revised form as it appeared in mid-1956. Actual expenditure was $1.119 billion, of which $811.9 million, or about 73 percent, came from oil revenues. About 55 percent of the oil revenues is allocated to the third 7-year plan in its first year.

The Ministry of Finance's share of the oil industry revenue is used to supplement budgetary receipts.

Money received by NIOC is spent to cover the cost of administering its production and distribution activities, as well as the cost of operations and drilling in areas that NIOC is exploring independently, and to finance construction of pipelines, new distribution facilities, and new equipment for the Naft-e Shah oilfield and the Kermanshah refinery. Moreover, once oil is discovered in areas that NIOC holds in partnership with foreign companies, NIOC becomes liable for meeting its share of the discovery costs.

Other Benefits

In addition to direct revenue, Iran benefits from the oil industry in a number of other ways. Expenditures by foreign oil companies for their operation in Iran indirectly contribute to the economy and add to the total foreign exchange earnings. As will be shown in the section on Consumption, the industry saves Iran foreign exchange that would be needed if domestic petroleum supplies were not available for the country's expanding needs. Availability of petroleum products in all parts of the country in ample quantities and at reasonable prices has been a stimulant to the country's economic growth.

The oil industry is an important employer (see tables 4 and 5). It ranks as Iran's largest industrial employer, employing nearly one-third of industrial labor force. Almost 60,000 employees of the industry and their dependents, totaling perhaps one-quarter million people, enjoy housing, medical

services, public utilities, and other amenities that compare favorably with those offered by other industries. Wages and salaries paid by the oil industry have been notably higher than prevailing rates in other fields of employment. However, there were deficiencies in housing in the post World War II period.

TABLE 4. - Employment in the Iranian oil industry[1] 1939-60 (19, 28, 29)

Year	Iranian	Non-Iranian	Not specified[2]	Total[3]
1939.....	15,060	2,723	([4])	17,783
1940.....	13,380	2,273	([4])	15,653
1941.....	10,986	2,079	([4])	13,065
1942.....	11,654	1,803	([4])	13,457
1943.....	16,389	2,864	([4])	19,253
1944.....	16,485	3,380	([4])	19,865
1945.....	21,781	4,030	12,143	37,954
1946.....	24,889	4,520	12,461	41,870
1947.....	28,221	4,228	11,065	43,514
1948.....	29,917	4,306	12,189	46,412
1949.....	32,011	4,477	16,410	52,898
1950.....	([4])	([4])	([4])	([4])
1951.....	50,662	4,271	12,951	67,884
1952-54.....	([4])	([4])	([4])	([4])
1955.....	48,799	280	8,921	[5]58,000
1956.....	[6]52,668	[6]453	10,026	63,147
1957.....	[7]47,940	[7]0	15,363	63,303
1958.....	56,611	693	4,724	62,028
1959.....	56,616	908	4,295	61,819
1960.....	([4])	([4])	([4])	[8]58,894

[1] Data for 1939-49 and 1951 include only employees of the Anglo-Iranian Oil Company; 1955-59 include the Consortium, NIOC, SIRIP, IPAC, IRCAN, and contract labor of the Consortium where applicable.

[2] Includes contract labor of undesignated nationality but presumably almost entirely Iranian nationals in all years, estimate of total NIOC employment in 1955, NIOC staff in 1956-57, and Consortium staff in 1957.

[3] Total of listed figures only. Data for 1939-44 are known to be low because of the lack of information on contract labor.

[4] Not available.

[5] Includes 51,945 employees of the Consortium and an estimate of 6,055 employees of NIOC.

[6] Does not include staff of NIOC, which are not reported by nationality in this year; these employees are included under "not specified."

[7] Excludes staff of Consortium and NIOC, which are not reported by nationality in this year; these employees are included under "not specified."

[8] Includes Consortium employees as of December and NIOC employees as of November.

TABLE 5. - Personnel of the Iranian oil industry by company and categories of work, 1955-61[1] (18, 28, 29)

	1955	1956	1957	1958	1959	1960	1961
Consortium:							
Labor.....	42,900	40,391	39,985	40,053	36,758	35,197	23,907
Iranian staff.....	5,899	5,080	5,859	5,356	4,887		
Non-Iranian staff.	280	453		603	713	727	635
Total.....	49,079	45,924	45,844	46,012	42,358	35,924	24,542
NIOC:							
Labor.....	[2]6,055	7,197	7,955	8,424	11,226	13,729	([3])
Iranian staff.....		2,113	2,448	2,778	3,353	4,275	([3])
Non-Iranian staff.				90	68		
Total.....	[2]6,055	9,310	10,403	11,292	14,647	18,004	([3])
Others[4].....	2,866	7,913	7,056	4,724	4,814	4,966	([3])
Grand total....	[2]58,000	63,147	63,303	62,033	61,819	58,894	([3])

[1] Figures refer to the following months: 1955, September; 1956-59, Dec. 31; 1960, November for NIOC and December for Consortium; 1961, December (Consortium only).
[2] Estimated.
[3] Not available.
[4] Includes Consortium contractors (1955-60), and employees of SIRIP, IPAC and IRCAN (1959-60).

Various education, training, and apprenticeship programs, instituted in the past and still continuing, have also benefited Iran because some of the engineers and skilled workers have left the oil industry to seek employment elsewhere, thus bringing their skills to other parts of the country.

Development of the southwestern part of the country and the island of Abadan resulted mainly from the oil industry. Growth of port facilities in this area was also stimulated by the industry.

These indirect benefits continue to operate in the economy and to grow because Iranian contractors and suppliers increasingly will provide many of the services and goods that the oil industry needs and that in the past were obtained abroad.

A development of potential significance is the greater utilization of natural gas unavoidably produced with oil. A modest start has been made by using natural gas as raw material for a chemical fertilizer plant at Shiraz. Utilization of natural gas for making polyvinyl chloride and other petrochemicals has received serious consideration. Undoubtedly, a fuller utilization of natural gas, both as fuel and as a chemical raw material, will be realized in the near future.

On a more modest scale, the oil industry supplies a market for sulfur and barite produced in the country.

PETROLEUM GEOLOGY

Published geological literature on Iran is rather extensive but scattered. With the exception of detailed regional work done in connection with petroleum exploration in southwest Iran, much of the presently available information was obtained by individuals working in disconnected areas at different times and does not include large-scale geological surface and tectonic mapping under an organized service. Geological surveys in connection with petroleum exploration outside the Consortium area have greatly increased since 1948, as a result of field work both by IOC, and by other oil companies that have obtained operating agreements with the NIOC. Areal geologic data available through 1957 were incorporated in the first complete geological map of Iran, compiled at a scale of 1:1,000,000 and published by IOC in December of 1959 at a scale of 1:2,500,000. In 1962, with United Nations assistance, the Iranian Government started organizing a national Geological Survey with planned operational scope extending beyond exploration for mineral and fuel resources.

Regional Structure

Geographically and geologically, Iran may be subdivided into three areas (see fig. 3):

1. The Zagros Mountains and the foothills and plains on their southwestern flank.

2. The Central Plateau.

3. The Alborz Mountains and the foothills and plains on their northern flank.

Zagros Mountains--Persian Gulf Area

The Zagros Mountains and the highly folded southwestern foothills constitute the southern limit of the Alpine orogenic belt in Iran. Through Middle Tertiary time, the entire area was part of a geosynclinal basin extending from eastern Turkey to northern Iraq and eastern Syria through the Persian Gulf, Kuwait, and eastern Saudi Arabia to the Arabian shield. The basin contains a very thick sequence of Paleozoic, Mesozoic, and Tertiary sediments that are now highly folded along the northeast margin of the geosynclinal area as a result of tectonic activity extending from late Mesozoic to late Tertiary time. On the basis of structure, de Böckh, Lees, and Richardson (7) subdivide the geosyncline into three regions: The foreland, the folded and sheared zone, and the zone of nappes.

The foreland, which encompasses the prolific fields of Kuwait and Saudi Arabia, is typified by gentle warping and folding; broad domelike anticlines with dips of less than 10°. The area of the foreland on the Iranian land mass is restricted to the extreme southwestern corner of the country in the vicinity of Abadan. Within Iran, no production has been obtained from the foreland but it appears that the first wells drilled by IPAC in its offshore concession were located near the center of the Persian Gulf in an effort to strike a producing formation in a structure of the foreland type.

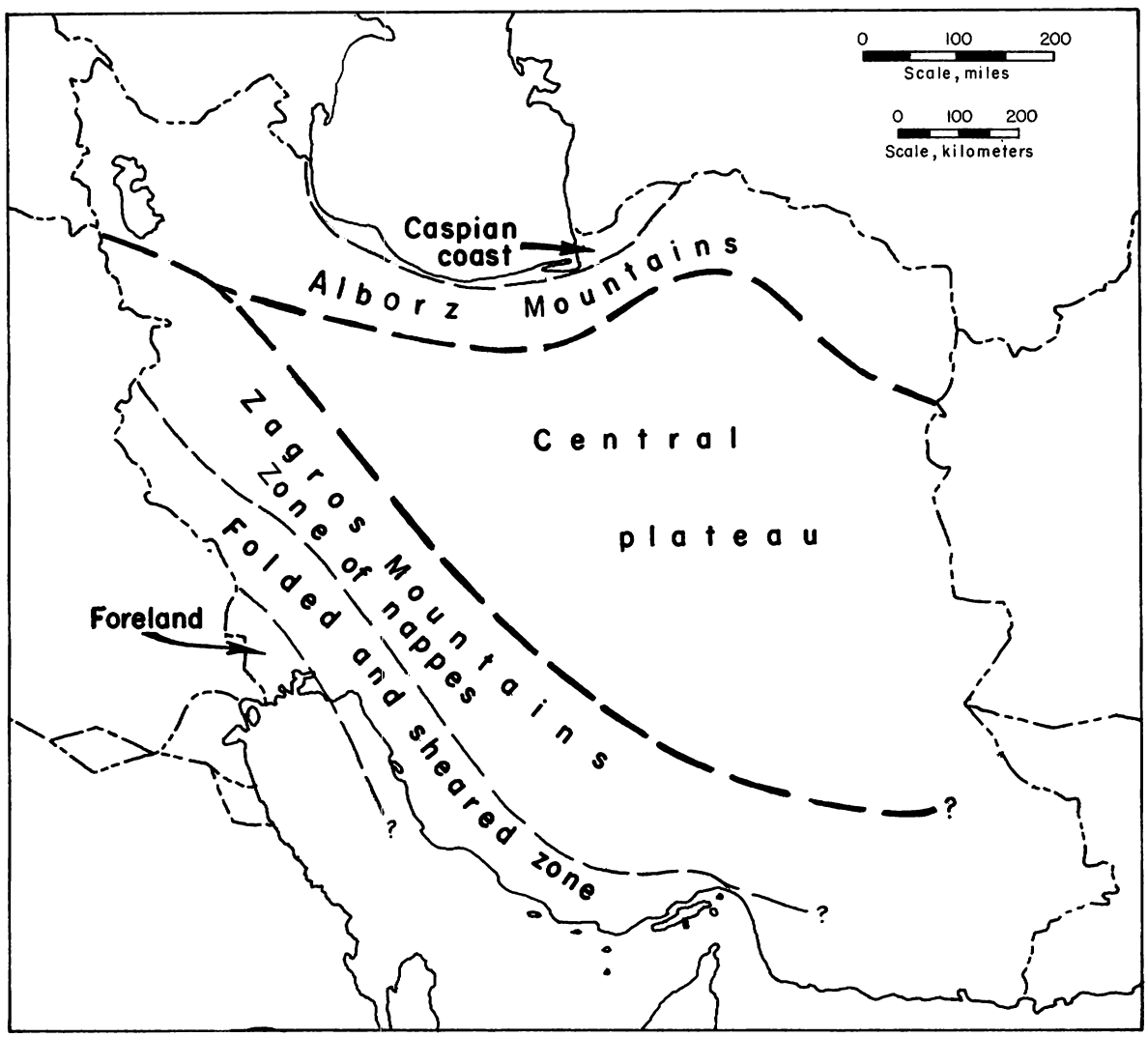


FIGURE 3. - Major Geologic Regions of Iran.

The folded and sheared zone of the Zagros Mountain area includes the area occupied by the Zagros foothills, which is the location of all but one of the major developed Iranian petroleum and natural gas fields in the Consortium area. The subsurface geology of the Ahvaz field, the one exception, is also similar to other fields, although it is in a topographically flat area.

No production has been derived from the zone of nappes and that part of the Zagros Mountains that fall within the folded and sheared zone of the geosyncline.

Central Plateau

The Central Plateau comprises the vast area of central Iran including the southern and eastern slopes of the Alborz and Zagros Mountains, respectively, and extending southward to the coastal mountains of Persian Gulf and Gulf of Oman. It differs from the southwestern areas in several respects, both structurally and lithologically. The role of this region in the structural history of Iran is still controversial. De Böckh, Lees, and Richardson (7) discussed it under the title "median mass," but they did not imply a stable, undeformed region. Considerable evidence of mobility can be seen; anticlines, synclines, and major block-type faults are present within this area, but the sharply asymetrical structures and the thrust faults of the Zagros region are not developed. As of 1961, two fields, Sarajeh and Alborz, both in the vicinity of Qom, have been proven as potential commercial producers within this region.

Alborz Mountains and Caspian Coast

These mountains, the northern limb of Alpine folding in Iran, possess structural characteristics somewhat similar to those of the Zagros Mountains. The geology of the mountains themselves has attracted little attention for petroleum exploration. North of the mountains along the Caspian coast, exploratory efforts were carried out before World War II, and, in 1959, NIOC recorded a gas strike of some proportions near Gorgan, indicating the presence of at least some natural gas reserves.

General Stratigraphy

The general stratigraphic sequences found in the known petroleum areas of Iran are given in table 6, correlated to the best of present knowledge. However, the correlations indicated between the area south of the Zagros Mountains and other areas are subject to question in some cases. Units of significance to the oil industry as reservoir rocks are the Asmari limestone-dolomite of the southwestern fields and its approximate equivalent the Oligocene-Miocene marine formation at Qom, the Middle Cretaceous (see footnote to fig. 4) at Lali, and the Lower Cretaceous limestone and sandstone and an Upper Jurassic limestone of the offshore area.

Asmari Limestone

The principal producing horizon of Iran is the Oligocene-Miocene Asmari limestone-dolomite. On an average, this unit is about 1,000 feet thick within the fields area, the thickness ranging within the fields themselves from 250 feet at Naft-e Shah (NIOC) to about 1,500 feet at Gach Saran. All production is derived from anticlinal entrapments. No well has produced significant quantities of oil unless a reasonably developed fracture system is penetrated because the typical unfractured Asmari limestone-dolomite is relatively compact with only a modest total pore space (porosity) finely divided.

TABLE 6. - Generalized columnar sections of oil-producing areas in Iran (11, 12, 15, 21)

Era	Period	Epoch		Southwestern fields and offshore areas	Qom area	Caspian area
Cenozoic	Quaternary	Pleistocene		Largely alluvium and gravel, occasional marine units near coast.	Continental alluvium, playa lake deposits, salt beds, and mud flats.	Gorgan loess.
						Brackish and fresh water beds.
						Marine marls and sands.
	Tertiary	Pliocene		Upper Bakhtiari: Conglomerates, cherts, silts, and marls.	Upper Red Formation: Conglomerates and gravels with much volcanic debris, sandstones, and thin gypsum beds.	Marine marls, clays, sandstones, and conglomerates.
				Lower Bakhtiari and Upper Fars: Fresh water marls, silts, sandstones, and conglomerates, missing in places near the mountains.		Continental conglomerates, and fresh water sands.
		Miocene	Upper		Gypsiferous marls, sandstones, and conglomerates.	Marls, sandstones, and calcareous and sandy shellbeds.
			Middle	Middle Fars: Evaporites, red beds, and thin limestones.	Marls and sandstones; rarely conglomerates.	Clays, marls, and shellbeds.
				Lower Fars: Limestones with interbedded evaporites.		
				Cap Rock: Massive evaporite unit.		Gypsum.
			Lower	Asmari limestone: Massive limestones with interbedded evaporites and marls.		Section missing due to erosion
		Oligocene	Upper		Marine formation: Limestone with localized evaporite units.	
			Middle	Gypsum beds, marls, and limestones		
			Lower		Lower Red formation: Shales, gypsiferous marls, sandstones, and volcanic flows and pyroclastics.	
					Basal conglomerate.	
		Eocene	Upper	Predominantly limestones: Glauconitic in the southwestern areas; interbedded with marls and bituminous shales to the north and northeast.	Volcanics with calcareous intercalations.	
			Middle	Gypsum unit.		
			Lower	Marls and limestones.	Salt beds and siltstones.	
		Paleocene			Section missing due to erosion	
Mesozoic	Cretaceous	Upper		Marls.	Various marls and limestones.	Chalky limestones with zones of chert sandstones and basalt flows.
				Marls, limestones, flysch, and conglomerates.		
				Marls, and reef limestone.		
		Middle[1]		Massive limestone.		
		Lower		Limestones and polybituminous neritic or bathyal shales.	Section missing	Metamorphics, age not positively determined.
	Jurassic	Upper[1]		Massive limestone in some areas and polybituminous, calcareous shale elsewhere.	Limestone found in outcrop near Kermanshah may be present or absent in subsurface.	
		Lower[1]		Massive limestone.		
	Triassic			Massive limestones, partly dolomitic, with shale, sandstone, and gypsum members.	Quartzites and sandstones of Alborz Mountains may be present in subsurface.	
Premesozoic				Sediments of Cambrian to Permian age, Paleozoic and Precambrian on, metamorphics	Unreported.	

[1] The Cretaceous Period is divided into three parts instead of two as in the United States. On the other hand, the Jurassic Period is divided into two parts instead of three as in the United States.

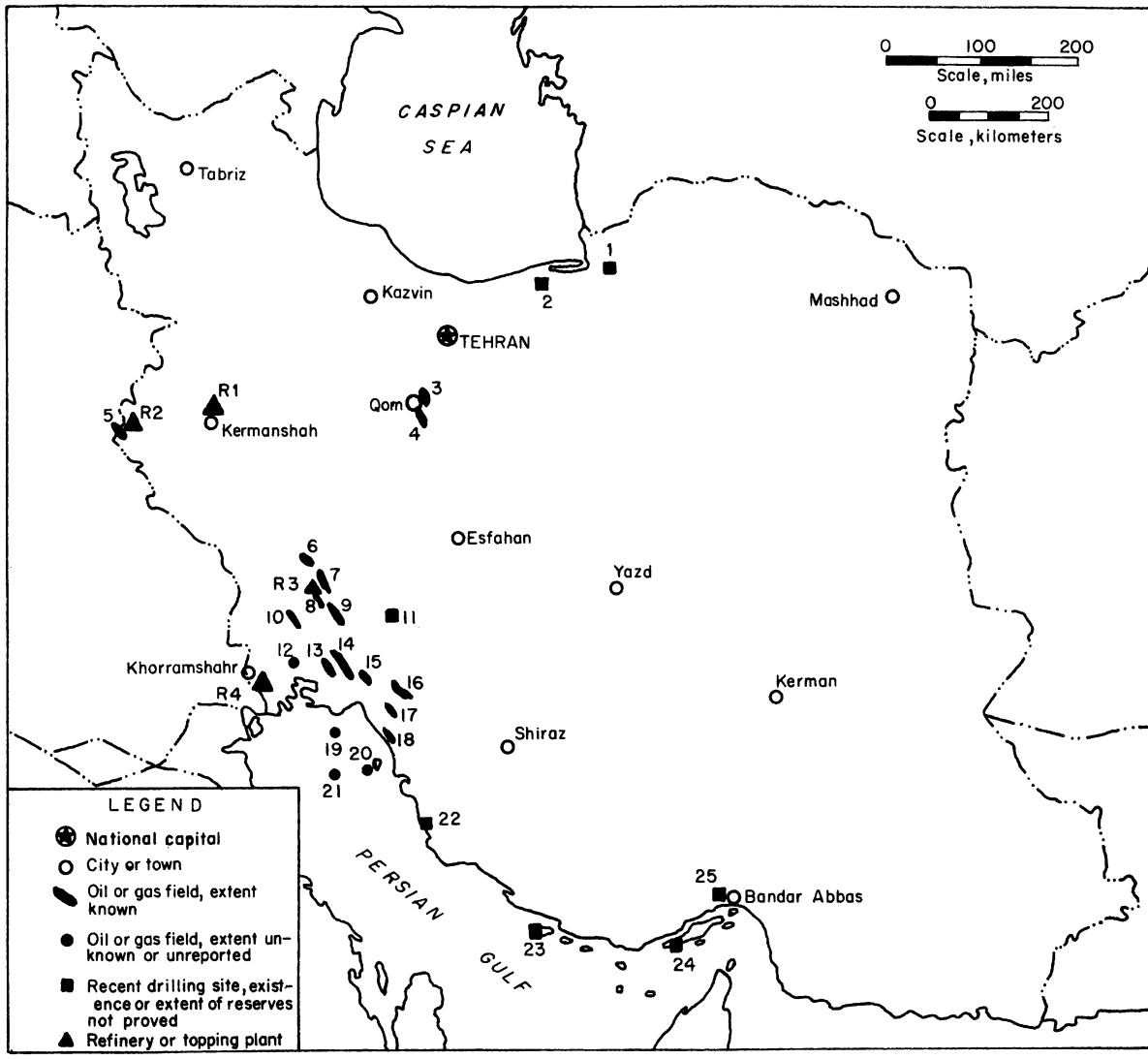


FIGURE 4. - Developed Oil and Gas Fields, Major Prospects, and Refineries in Iran, 1962.

Fields and prospects:

1–Gorgan
2–Sari
3–Alborz
4–Sarajeh
5–Naft-e Shah
6–Lali
7–Masjed-e Soleyman
8–Naft-e Safid
9–Haft Gel
10–Ahvaz
11–Kuh-e Sequtah
12–Mansuri
13–Khalafabad
14–Agha Jari
15–Pazanum
16–Gach Saran
17–Bibi Hakimeh
18–Binak
19–Bahregansar (SIRIP),
20–Kharg Island (Consortium), and Darius (IPAC)
21–Cyrus (IPAC)
22–Mand
23–Sheykh Shu'eyb
24–Qeshm Island
25–Bandar Abbas (Suru)

Refineries:

R1–Kermanshah
R2–Naft-e Shah topping plant
R3–Masjed-e Soleyman topping plant
R4–Abadan

Because of the association of fractures with prolific production, it was assumed for many years that fractures actually served as reservoirs. More thorough study of the reservoir rocks, however, revealed that, as elsewhere, the oil is situated in pores in the limestone, and that the fractures simply act as channels for the rapid migration and egress of oil once the reservoir is tapped. The source rocks generally have a very low flow capacity, but the well-developed fracture system permits a rapid "bleeding" from the limestone.

The fracture system is so efficient as a migration route for the oil that virtually unrestricted reservoir connection has been proven over distances of 32 kilometers or more. Lees (23) notes that because of this situation, a well spacing interval of 3.2 kilometers (2 miles) or more may be used in obtaining uniform withdrawal of oil without producing local disturbances of gas/oil and/or oil/water interfaces.

Because of the importance of the fractures to sound reservoir engineering practice, these fractures have been studied extensively through cuttings, cores, and various well logs from the fields and through examination of Asmari outcrops in the Zagros Mountains. Detailed discussion of the physical characteristics of the Asmari reservoirs are given by Anderson (1). He indicates that in these reservoirs, unlike in many elsewhere, the gas-oil ratio did not increase with time as production continued. As oil is withdrawn from the reservoirs, pressure generally declines and gas comes out from the solution with oil. A portion of this gas migrates into the gas cap of the structure while the balance remains in place in a so-called gassing zone where it furnishes the drive to force oil out of the pores in the reservoir rock and into the fissures.

Recent drilling by IPAC in the offshore area showed the Asmari limestone-dolomite to contain small quantities of 10° API oil in the Darius No. 1 well and gas in the Cyrus No. 2 well.

Lower Fars Cap Rock Anhydrite

The Lower Fars formation, which includes the cap rock for Asmari reservoirs, consists of anhydrites, marls, numerous thin limestones, and rock salt. Its thickness in the oil-producing areas of southwest Iran varies considerably as a result of (1) irregular initial deposition, (2) subsequent tectonic activities, and (3) erosion. The unit as a whole is highly competent--plastic in nature. It has, therefore, been generally an effective seal for the Asmari reservoir rock.

The basal segment of the Lower Fars formation, known as the Cap Rock anhydrite, is overlain by interbedded marls, thin limestones, some thin oil shales, salt units, and other thin anhydrites that, taken together, are designated as stage I of the Lower Fars formation. The Cap Rock anhydrite seems to be present throughout the fields area, but the overlying units of stage I are reduced or altogether absent in many areas (23). Thicknesses of stage I, however, may reach 15,000 feet down the flanks of the productive anticlines.

Stage II of the Lower Fars formation, red and gray marls, anhydrite, and locally some salt, overlies stage I and is quite uniform in thickness, ranging from 500 to 700 feet except where eroded away. State III, the uppermost unit of the Lower Fars formation consists of numerous shell-containing limestones interbedded with anhydrite and gray marls but contains no salt.

Oligocene-Miocene Marine Formation

The production obtained by NIOC from the Qom area is derived from a reservoir of roughly equivalent age to the Asmari limestone-dolomite of the southwestern fields. Paleontological evidence indicates that these two rock units are lateral facies in an unseparated basin. However, the Oligocene-Miocene marine formation at Qom differs from the Asmari formation of the southwestern fields by prevalence of marls and sandstones over limestones and the presence of volcanic material at Qom. The Asmari is, however, predominantly limestone and shows no evidence of volcanic activity.

The Oligocene-Miocene sequence at Qom consists chiefly of limestone, sandy marls and alternating marls and limestones about 4,000 feet thick. It is underlain by the Lower Red formation of Oligocene age, which consists of red and greenish silty shales, gypsiferous marls, sandstones, anhydrite layers, volcanic flows, and pyroclastics, and overlain by the Upper Red Formation of Miocene-Pliocene age, which is essentially a terrestrial unit. Data on the cap rock sealing the Qom area reservoir are not available, but presumably it is a Miocene anhydrite unit.

Eocene Reservoir and Cap Rock

The total thickness of Eocene beds in the area of the southwestern fields varies from 400 to 1,000 feet. Northeast and southwest of the field's area, the Eocene section thickens considerably.

The Eocene section has proved productive only at Masjed-e Soleyman where a thin limestone, capped by an Eocene marl unit, has yielded modest quantities of oil. Apparently the distribution of suitable marl cap rocks is irregular and discontinuous. The location of the reservoir in the total Eocene section is not reported.

Cretaceous Reservoirs

The Middle Cretaceous limestone has proved to be a commercially productive zone at Lali among the older Consortium fields. Recent drilling by the Consortium as well as SIRIP and IPAC has shown the Cretaceous formations to be oil bearing at Bibi Hakimeh, Binak, and Gach Saran in the Consortium agreement area and in the offshore areas drilled by SIRIP and IPAC. The SIRIP wells struck oil both in the Asmari and the Middle Cretaceous Bangestan limestones. Two pay zones have been reported in the IPAC Cyrus No. 2 well. The upper one is equivalent to the Middle Cretaceous Burgan formation of Kuwait, while the lower, identified as the Lower Cretaceous Khami limestone, is tentatively correlated with the Ratawi pay zone of the Kuwait Neutral Zone. This well was deepened into the Upper Jurassic Khami limestone where it blew out after

striking high-pressure oil. Darius No 1 well of IPAC has oil only in the Ratawi zone.

At Lali, the reservoir has long been termed simply "The Middle Cretaceous"; in the SIRIP field the name "Bangestan formation" has been applied to the reservoir. It appears that these units are equivalent lateral facies, if not the same formation. Taken together, the Lower and Middle Cretaceous units range from 3,000 to 5,000 feet thick, but not all of this thickness is productive.

PETROLEUM AND NATURAL GAS FIELDS

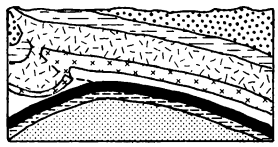
All the Iranian petroleum and natural gas fields that have a production history of world significance are in southwest Iran, within the Consortium Agreement area (see fig. 4 for location). These include the Agha Jari, Gach Saran, Haft Gel, Masjed-e Soleyman, Lali, and Naft-e Safid fields, and the Pazanun natural gas condensate field (not yet a significant commercial producer). The Naft-e Shah field of NIOC, west of Kermanshah on the Iran-Iraq border, is the only producing field outside of the Consortium Agreement area with an extended production history, and its output has been modest compared to that of the prolific Consortium fields. All these fields were discovered by 1938.

After nearly two decades in which no new discoveries were reported, NIOC drilling activities in the Qom area found a petroleum reservoir in 1956 on a structure named Alborz (not to be confused with the Alborz range), and shortly afterwards on the Sarajeh structure. Consortium exploratory drilling discovered the Ahvaz field in 1958, Binak in 1959, Bibi Hakimeh in 1961, and Khalafabad, Kharg Island, and Mansuri in 1962 (fig. 5). The Ahvaz reservoir has been proved to be a significant addition to Consortium reserves; the potentials of the Binak, Bibi Hakimeh, Khalafabad, Kharg Island, and Mansuri fields are not yet fully known but drilling in these areas continues.

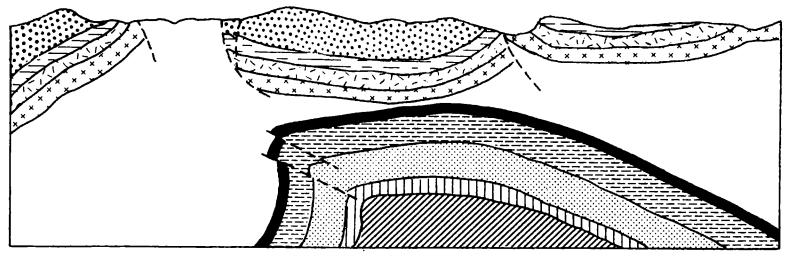
After several unsuccessful wells in offshore concessions during 1959 and early 1960, SIRIP and IPAC found oil in commercial quantities in 1960 and 1961, respectively. By the end of 1962, SIRIP had four wells completed with an aggregate production potential of 20,000 barrels per day and was drilling a wildcat well, Tanb No. 1. IPAC had completed five producers, three near Kharg Island (one rated at 35,000 barrels per day and two more with an unreported potential), and two farther offshore, one rated at 6,000 and the other at 14,000 barrels per day.

Other areas with promising structural features have been or are being drilled in the vicinity of Gorgan and Sari near the Caspian Sea, and on Qeshm Island in the Persian Gulf. Some of the holes have found oil or gas, but the existence of commercial reserves in these areas has not yet been proved.

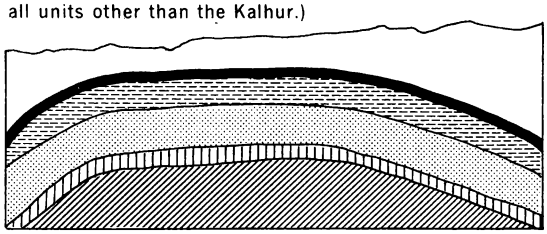
Exploratory drilling activities at several other locations have been terminated on the basis of one or more unsuccessful tests since 1954. Included among these are Consortium-area wildcats at Mand on the Persian Gulf Coast south of Bushire, Sheykh Shu'eyb Island in the Persian Gulf, and Bandar Abbas



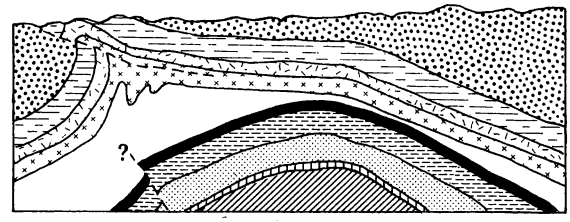
NAFT-E SHAH (Note: Subdivisions of the Lower Fars may differ somewhat from those used in other cross sections. The reservoir rock here is termed the Kalhur limestone. The rock unit below the Kalhur comprises all units other than the Kalhur.)



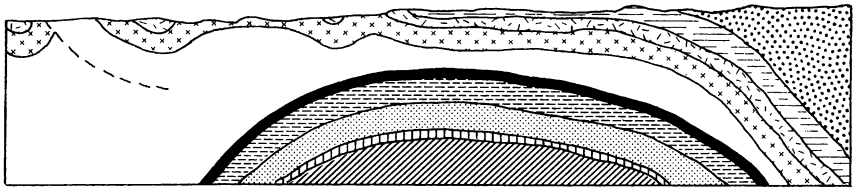
LALI



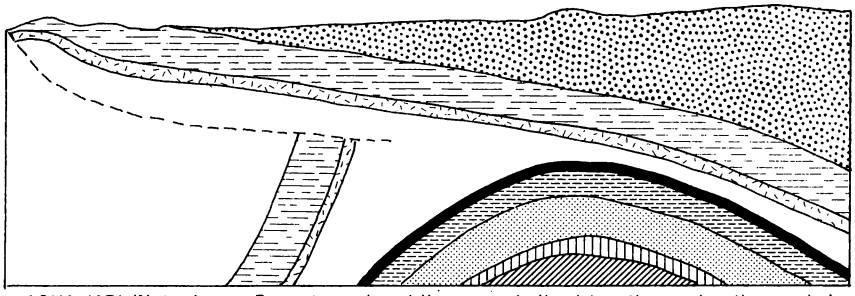
MASJED-E SOLEYMAN (Note: All stages of Lower Fars are symbolized together using the symbol for stage I.)



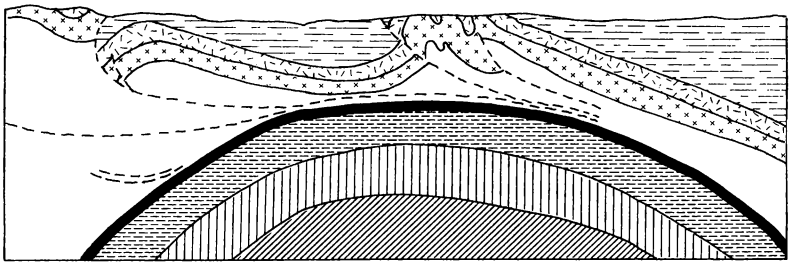
NAFT-E SAFID



HAFT GEL



AGHA JARI (Note: Lower Fars stages I and II are symbolized together, using the symbol for the former.)



GACH SARAN (Note: Apparently no Oligocene is present other than the lower Asmari. Eocene beds are symbolized together with upper Cretaceous using the symbol for the latter.)

GEOLOGICAL SYMBOLS

- Upper Fars and Bakhtiari
- Middle Fars
- Lower Fars, stage III
- Lower Fars, stage II
- Lower Fars, stage I
- Cap rock
- Asmari or equivalent
- Eocene-lower Oligocene
- Upper Cretaceous
- Middle Cretaceous and older
- Fault

FIGURE 5. - Geological Cross Sections of Some Iranian Oil Fields. Thickness of certain rock units has been exaggerated in some places so they could be plotted. (Modified from Petroleum Times (36).)

near the Straits of Hormuz and the SIRIP wildcat on Kuh-e Sequtah structure in the Zagros Mountains northeast of the Consortium area. These sites are shown in figure 5.

The Consortium Agreement Area

The first commercial petroleum production in Iran was from the Masjed-e Soleyman field, one of seven major fields now developed within the area allocated to the Consortium under the 1954 Agreement. This field was discovered in 1908 and first exploited in 1911. The chronology of development of the fields in this area, together with their present relative importance is summarized in table 7.

TABLE 7. - Chronology of development of Consortium oil fields in Iran

Field	Discovery date	Date of first commercial production	Rank as an oil producer among Consortium fields	
			Cumulatively since discovery	In 1962
Masjed-e Soleyman..	1908	1911	3	4
Haft Gel.....	1928	1928	2	3
Gach Saran.....	1928	1940	4	2
Naft-e Safid.....	1935	1945	5	6
Pazanun.....	1937	1943	Not producing[1]	Not producing[1]
Agha Jari.....	1937	1945	1	1
Lali.....	1938	1948	6	7
Ahvaz.....	1958	1959	7	5

[1] Pazanun was not considered an oilfield until 1960 or 1961; it produced gas condensate and natural gas during mid-World War II; output not equatable to crude oil.

Some details of geology and other specific information regarding these fields and other promising Consortium-area prospects is given by field or area in the sections that follow. Cross sections of several Consortium Agreement area fields are compared in figure 5; characteristics of the fields appear in table 8; drilling activities are given in table 9; and annual production data are recorded in table 11 (under crude production).

Masjed-e Soleyman

The reservoir at Masjed-e Soleyman is in a broad, flat-topped, asymmetric anticline with maximum dimensions of about 29 kilometers by 6.5 kilometers. The northeast flank of the anticline dips 20° to 30°; the southwest flank commonly dips 40° to 50° and in one place is almost vertical (36). At its structural culmination, the Asmari formation is only 600 feet below the surface, and throughout the entire structure this unit's average thickness is about 1,000 feet. Beneath the Asmari formation are about 2,000 feet of Eocene and Upper Cretaceous marls and marly limestones overlying the Middle Cretaceous limestone unit that is productive at the Lali field. A modest production from Eocene limestones is reported at Masjed-e Soleyman, but the underlying Upper Cretaceous units have been unproductive and the Middle Cretaceous beds, though containing oil (as shown in cores recovered), yielded only water when tested.

TABLE 8. - Characteristics of Iranian oil fields

Field or part of field	Reservoir	Porosity, percent	API gravity of oil, degrees	Reservoir thickness, feet	Depth to producing formation, feet	Topographic elevation: Minimum, feet (from sea level)	Topographic elevation: Maximum, feet (from sea level)	Original gas/oil interface level, feet (plus or minus from sea level)	Original oil/water interface level, feet (plus or minus from sea level)	Elevation of highest structural culmination, feet (plus or minus from sea level)
Masjed-e Soleyman.....	Asmari-Eocene....	5.6	38.8	1,000	640- 3,000	+800	+1,900	None	-2,200	+200
Lali:										
Northeast flank.....	Asmari.....	4.6	38.8	1,200	4,000- 7,000	+500	+1,400	-4,300	-5,400	-3,000
	Middle Cretaceous	4.0		+1,700	7,300- 9,000			(1)	-8,020	-6,500
Southwest flank.....	Asmari.....	4.6		1,200	4,000- 7,000			-4,300	-6,500	-3,000
	Middle Cretaceous	4.0		+1,700	7,300- 9,000			(1)	-8,020	-6,500
Haft-Gel:										
Northwest dome.....	Asmari.....	7.4	37.5-38.5	900	1,900- 4,000	+800	+1,500	-2,200	-3,087	-850
Central dome.....	do.....							-1,015		
Southwest dome.....	do.....							1,065		
Naft-e Safid:										
Northeast flank.....	do.....	7.0	35.5	900	3,000- 6,000	+300	+1,400	+4,442	(1)	-2,330
Southwest flank.....	do.....								-5,560	
Pazanun.....	do.....	(2)	±35.0	(1)	5,400-?	+900	+1,700	(2)	(1)	-4,500
Agha Jari:										
Northwest dome.....	do.....	7.6	34.4	+1,000	4,900- 9,800	+340	+1,340	(1)	(1)	-4,000
Southwest dome.....	do.....							-4,610		
Location not specified	Bangestan.....	(2)	(2)	+2,800	[3]8,800-10,900			(2)	(2)	[3]-8,468
Gach Saran.....	Asmari.....	7.7	31.8	1,550	2,800- 6,150	+2,100	+2,500	-725	[3]-7,875	-200
	Bangestan.....	(2)	(2)	(2)	[3]6,100					
Ahvaz.....	Asmari (lower)...	(2)	30.0	±600	7,850 minimum	+100	+150	(2)	(2)	-7,747
	Bangestan.....	(2)	22-24.5	(2)	10,470 minimum			(2)	(2)	-10,370
Bibi Hakimeh.....	Asmari.....	(2)	(2)	(2)	3,350 minimum	(2)	(2)	(2)	(2)	[3]-3,347
	Bangestan.....	(2)	(2)	(2)	6,200 minimum	(2)	(2)	(2)	(2)	[3]-6,206
Binak.....	Asmari.....	(2)	27.5	(2)	5,900 minimum	(2)	(2)	(2)	(2)	-5,840
	Bangestan.....	(2)	31.0	(1)	10,900 minimum	(2)	(2)	(2)	(2)	-10,822
Khalafabad.....	Asmari.....	(2)	30.0	(2)	8,930 minimum	30	110	(2)	(2)	-8,900
Naft-e Shah.....	do.....	±13.0	41.5	250	2,400- 3,010	(4)	(4)	[5]-2,110	[5]-2,720	(2)
IPAC Darius.....	do.....	(2)	10.0	±300	[3]5,700	[6]None	[6]None	None	(2)	(2)
	Ratawi.....	(2)	31.0	+1,000	[3]9,400			(2)	(2)	(2)
IPAC Cyrus.....	Asmari.....	(2)	(7)	±300	[3]2,000	[6]None	[6]None	[8]None	[8]None	(2)
	Burgan.....	(2)	(2)	(2)	[3]7,000			(2)	(2)	(2)
	Ratawi.....	(2)		+1,000	[3]9,700					

[1] Unknown.
[2] Not reported.
[3] Approximate.
[4] Average elevation, +570.
[5] 1962 level.
[6] Offshore fields, actual topographic elevation is unreported distance below sea level.
[7] Discovery well struck only gas; no oil present.
[8] No oil; only gas was struck in this reservoir. Level of gas/water interface is not reported.

TABLE 9. - Drilling activities, Consortium fields, 1955-61 (18)

Field	Year	Number of wells at yearend			Wells drilled during the year					Approximate production, barrels per day
		Total	Producing	Shut-in	Producing	Observation	Dry	Total new wells	Workovers completed	
Agha Jari.....	1955	32	16	3	0	0	0	0	(1)	15,100
	1956	34	21	1	2	0	0	2	0	17,700
	1957	37	21	1	3	0	0	3	3	21,600
	1958	44	28	2	6	0	1	7	1	18,000
	1959	48	30	3	3	1	0	4	0	20,000
	1960	51	32	(1)	2	1	0	3	1	21,000
	1961	52	33	(1)	1	0	0	1	4	21,400
Ahvaz.....	1955	4	0	0	0		0	0		0
	1956	4	0	0	0		0	0		0
	1957	5	0	0	0		1	1		0
	1958	6	0	0	0	0	0	0	0	0
	1959	7	1	0	1		0	1		2,800
	1960	7	1	0	0		0	0		6,000
	1961	10	2	1	2		0	2		3,500
Gach Saran.....	1955	13	1	3	0	0	0	0	(1)	100
	1956	13	2	2	0	0	0	0	0	6,400
	1957	14	4	0	0	1	0	1	0	12,100
	1958	18	4	4	2	0	1	3	5	14,800
	1959	24	10	3	5	0	0	5	0	5,900
	1960	30	10	(1)	4	2	0	6	1	11,000
	1961	38	12	(1)	6	0	1	7	1	21,100
Haft Gel.....	1955		9	11					(1)	4,400
	1956		17	3					10	5,000
	1957		20	0					0	6,000
	1958	48	20	0	0	0	0	0	0	7,200
	1959		20	0					0	7,500
	1960		20	0					0	8,100
	1961		19	0					5	6,500
Lali.....	1955		1	4					(1)	5,300
	1956		1	4					0	7,100
	1957		3	2					4	3,500
	1958	15	4	1	0	0	0	0	1	4,400
	1959		5	0					0	3,000
	1960		4	0					0	3,200
	1961		4	0					0	2,800
Masjed-e Soleyman...	1955		14	(1)					(1)	2,300
	1956		16	11					0	2,400
	1957		17	(1)					1	3,400
	1958	257	23	(1)	0	0	0	0	10	2,100
	1959		25	6					2	2,500
	1960		27	(1)					12	2,200
	1961		28	(1)					15	1,200
Naft-e Safid.....	1955	24	4	(1)	0	0		0	(1)	1,700
	1956	24	8	5	1	0		1	0	2,600
	1957	27	12	(1)	2	1		3	0	3,600
	1958	28	14	3	1	0	0	1	1	4,300
	1959	29	17	(1)	1	0		1	1	3,200
	1960	29	15	(1)	0	0		0	7	2,700
	1961	29	15	(1)	0	0		0	5	2,200
Pazanun.....	1955	4			0		0	0	0	
	1956	4			0		0	0	0	
	1957	4			0		0	0	0	
	1958	4	0	(1)	0	0	0	0	0	0
	1959	4			0		0	0	0	
	1960	5			0		1	1	2	
	1961	6			1		0	1	1	

[1] Data not available.

According to Lees (23), when production started, the "reservoir was full of oil to its crest maximum . . . but at an early stage a gas cap commenced to form and has gradually expanded until now the oil zone is confined to a narrow annulus around the anticline." Lees also states that when production started there was an "oil column" of 2,200 feet, this being presumably the vertical distance between the Asmari culmination and the oil/water interface. The economically productive zone is restricted on the plunging northwest end of the structure by lower than average porosity and poorly developed fissure systems.

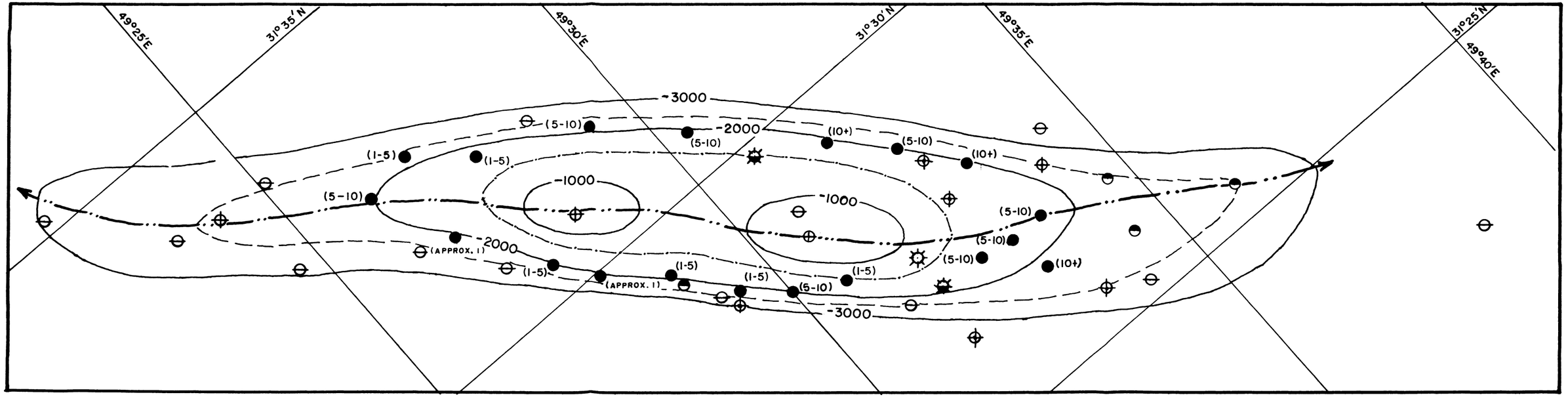
The oil/water interface is at virtually the same elevation at all points where it appears on the structure, intersecting Eocene beds in the anticline's center area and Oligocene-Miocene Asmari beds in a ringlike zone about the central core. Although the oil/gas interface has been driven down by the formation of the gas cap, the oil/water interface level has varied but little during the productive history of the field, a condition which is unusual in view of its proximity to outcropping Asmari beds. This lack of appreciable water drive has resulted in a reduction of reservoir pressure as production has continued, and gas lifts are used on some wells on the northeast flank.

Gas from the gas cap, as well as dissolved gas, are produced for use as fuel in the field area, and residues, originally only those recovered from the Abadan refinery but more recently those recovered from the field topping plant, have been reinjected into the gas cap. This leads to the re-production of these reinjected products together with new crude oil. Recent data on the share of total output consisting of identifiable reinjected residues are not available, but in view of the increased rate of reinjection, it is very likely higher than 5.5 percent reported by Graham, Hetherington, Old, and Tuman (14) for 1951.

At the time that Masjed-e Soleyman was first exploited, the characteristics of the Iranian fields were not well known; as a result early development of the field was haphazard compared to that of other Iranian fields. In 1961, only 28 of the 257 wells drilled on the structure were operational. However, the extra drill holes have provided an opportunity for detailed study of reservoir behavior because they have been used as observation wells. Field engineering experience gained from studies of Masjed-e Soleyman reservoir has been of considerable value in planning development of the newer fields.

Haft Gel

This field, about 55 kilometers south-southeast of Masjed-e Soleyman, lies along an anticlinal trend extending at least 130 kilometers, oriented roughly parallel to the Masjed-e Soleyman structure. The Haft Gel structure is an anticline about a sinuous axis with three subsidiary domes--northwest, central, and southeast (fig. 6). The overall structure measures about 32 kilometers long and from 2.4 to 4.8 kilometers in width. It is less asymmetrical and more rounded on top than the Masjed-e Soleyman reservoir. Two of the three domes have structural culminations at about the same level--about 850 feet subsea; the third is at about 2,200 feet subsea.



● OIL WELL
⊛ GAS/OIL OBSERVATION
⊛ GAS WELL (CLOSED IN)
◒ OIL WATER OBSERVATION
⊕ ABANDONED ABOVE ASMARI
⊕ ABANDONED
⊖ WATER OBSERVATION

NUMBERS IN PARENTHESES INDICATE APPROXIMATE PRODUCTION POTENTIAL OF WELLS, IN 1,000 BBL PER DAY

0 1 2 3 4 5 6 7 8
Scale, kilometers

0 1 2 3 4 5
Scale, miles

ANTICLINAL AXIS
CONTOUR
OIL/WATER INTERFACE
OIL/GAS INTERFACE

FIGURE 6. - Structural Contour Map of Haft Gel Oil Field.

(Face p. 34)

Unlike conditions at Masjed-e Soleyman, the oil/water interface at Haft Gel has risen with production. While the rate of rise has not been sufficient to maintain reservoir pressures at original levels, the water drive at this field was rated by Graham, Hetherington, Old, and Tuman (14) in 1955 as the most effective in those Iranian fields whose reservoir mechanics are known.

The Asmari limestone here averages 900 feet thick. It is underlain by 1,150 feet of Eocene and Upper Cretaceous strata beneath which is a great thickness of Middle Cretaceous strata that is not productive at Haft Gel, although, as at Masjed-e Soleyman, it contains considerable oil in pores.

Maximum rate of production of Haft Gel field was about 200,000 barrels per day in the latter World War II years and is currently about 133,000 barrels per day. The production potential of all wells averages about 7,000 barrels per day, varying from 1,000 to 15,000 barrels per day in individual cases. All production of Haft Gel is delivered to the Abadan refinery. The average API gravity of stabilized crude at atmospheric pressure ranges from 37.5 to 38.5.

Fissuring in the Asmari limestone, which is a fundamental factor in productivity of wells and reservoir behavior, is well developed. The gas-oil ratio has remained practically constant at about 400 cubic feet per barrel indicating that only solution gas has been produced with the oil. The original oil/water interface level was 3,087 feet subsea, and the original reservoir pressure was 2,092 psig.

Haft Gel crude is stabilized in two production units: Nos. 3 and 4, the latter with six stages. The No. 4 unit replaced the No. 1 with five stages commissioned in 1929 in the southeast end of the field and No. 2 commissioned in 1934 serving the area of the central dome. The No. 3 unit, in the area between the Nos. 1 and 2, was commissioned in 1936. Wellhead separators are operating at 350-400 psig.

Gach Saran

The Gach Saran field, including the recently proved Lishtar extension to the northwest, is over 60 kilometers long (fig. 7). The main area of the field, without the Lishtar extension, occupies an area more than 40 kilometers long and 6 to 10 kilometers wide. This main area has two domes, each with a small gas cap. The principal dome, highly elongate, is in the center, and a smaller, more oval dome is subparallel to and off the northeast corner of the principal dome. The Lishtar extension was at one time regarded as a separate anticline. However, drilling in 1959-61 proved it to be a major extension, probably another dome separated in its upper reaches from Gach Saran's main dome by a saddle, but linked with that structure above the oil/water interface of both.

Fissure systems at Gach Saran are not as well developed as in other Asmari fields, particularly in the upper part of the formation. This poor development may be partly compensated for by differences in porosity from other fields. Average porosity at Gach Saran is only slightly greater than

that of Haft Gel and Agha Jari, and, according to Slinger and Crichton (41), there is a greater proportion of large-radius pores in the Gach Saran reservoir.

The "oil column" (vertical distance between oil/gas and oil/water interfaces) at Gach Saran is the largest recorded to date in Iran, 7,150 feet. This great height and the nature of the porosity rank this reservoir as the most capacious in Iran (40). Average well production in 1962 was about 27,000 barrels per day; well No. 35 is capable of producing 80,000 barrels per day. In 1958, the oil/water interface was 7,943 feet subsea, about 10,300 feet below the surface, while the gas/oil interface level varied from 790 feet subsea under the northwest dome to more than 2,758 feet subsea under the southeast dome. On January 1, 1962, oil/water and gas/oil interface levels were 7,700 and 890 feet subsea, respectively. Solution gas aided by water influx is the principal producing mechanism.

Reportedly drilling activities in 1960-62 have proved the mid-Cretaceous Bangestan formation to be oil bearing at Gach Saran (20). In addition, the lower Cretaceous-Jurassic Khami formation, which was reached at 10,246 feet, contains gas underlain by sulfurous water.

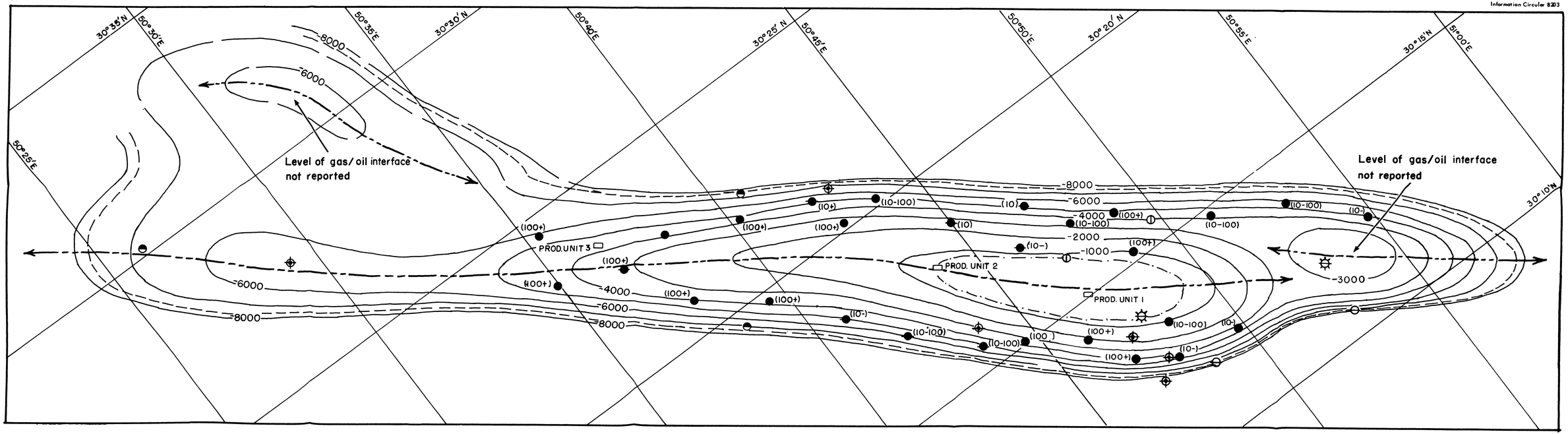
The Gach Saran field, discovered in 1928, was not put in production until 1940 because of its remote location and rugged terrain and the availability of crude from Haft Gel and other fields. Production rate in 1940 was 8,500 barrels per day and increased only to 52,000 barrels per day in 1950. Accelerated development started in 1960, and with commissioning of a second production unit in December 1959 (figs. 8 and 9) and completion of the new Kharg terminal in 1960, production rate is currently 250,000 barrels per day of which 60,000 is dispatched to the Abadan refinery. Another production unit was scheduled for completion in January 1963 (fig. 10), at which time a total production capacity of 540,000 barrels per day will be available. Some data on the three production units are shown in table 10; No. 1 unit supplies gas to Shiraz pipeline.

Gach Saran crude is heavier than crude produced at the Consortium fields except for Ahvaz; even the Masjed-e Soleyman mixed crude and plant residues are lighter. Inlet crude to the production unit is 31.8° API (average for winter and summer); stripped crude is 31.3° API. The Gach Saran crude has also 0.025 percent by weight sulfur, which is reduced to 0.007 maximum.

Naft-e Safid

This field lies just northwest of the Haft Gel field, along the same fold axis as the latter, although lines along the crestal maxima of these two fields are en echelon. Naft-e Safid's reservoir is separated from Haft Gel's by a saddle that lies only slightly below the oil/water interface of Naft-e Safid but considerably below the oil/water interface of Haft Gel.

The field is about 27 kilometers long and reaches a maximum width of about 4 kilometers, but as a result of a large gas cap only a peripheral zone of the field is capable of oil production. The reservoir is an asymmetric



- OIL WELL
- OIL WELL (CLOSED IN)
- GAS WELL (CLOSED IN)
- OIL/WATER OBSERVATION
- WATER OBSERVATION
- ABANDONED ABOVE ASMARI
- WELL DRILLING, JUNE 1962

NUMBERS IN PARENTHESES INDICATE APPROXIMATE PRODUCTION POTENTIAL OF WELLS, IN 1,000 BBL PER DAY

0 2 4 6 8 10 12 14 16
Scale, kilometers

0 2 4 6 8 10
Scale, miles

- ANTICLINAL AXIS
- CONTOUR
- OIL/WATER INTERFACE
- OIL/GAS INTERFACE

FIGURE 7. - Structural Contour Map of Gach Saran Oil Field.

(Face p. 36)

FIGURE 8. - General View of Production Unit No. 2 at Gach Saran.

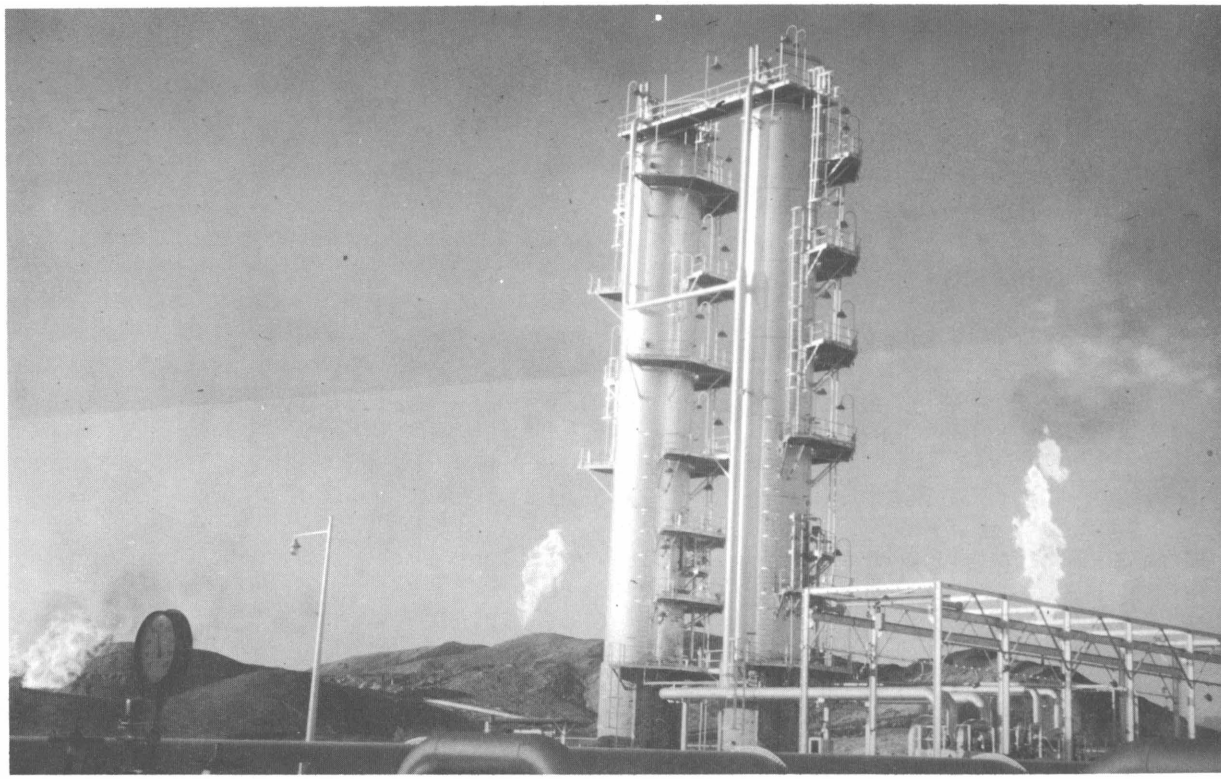


FIGURE 9. - H_2S Stripper, Gach Saran Production Unit No. 2.

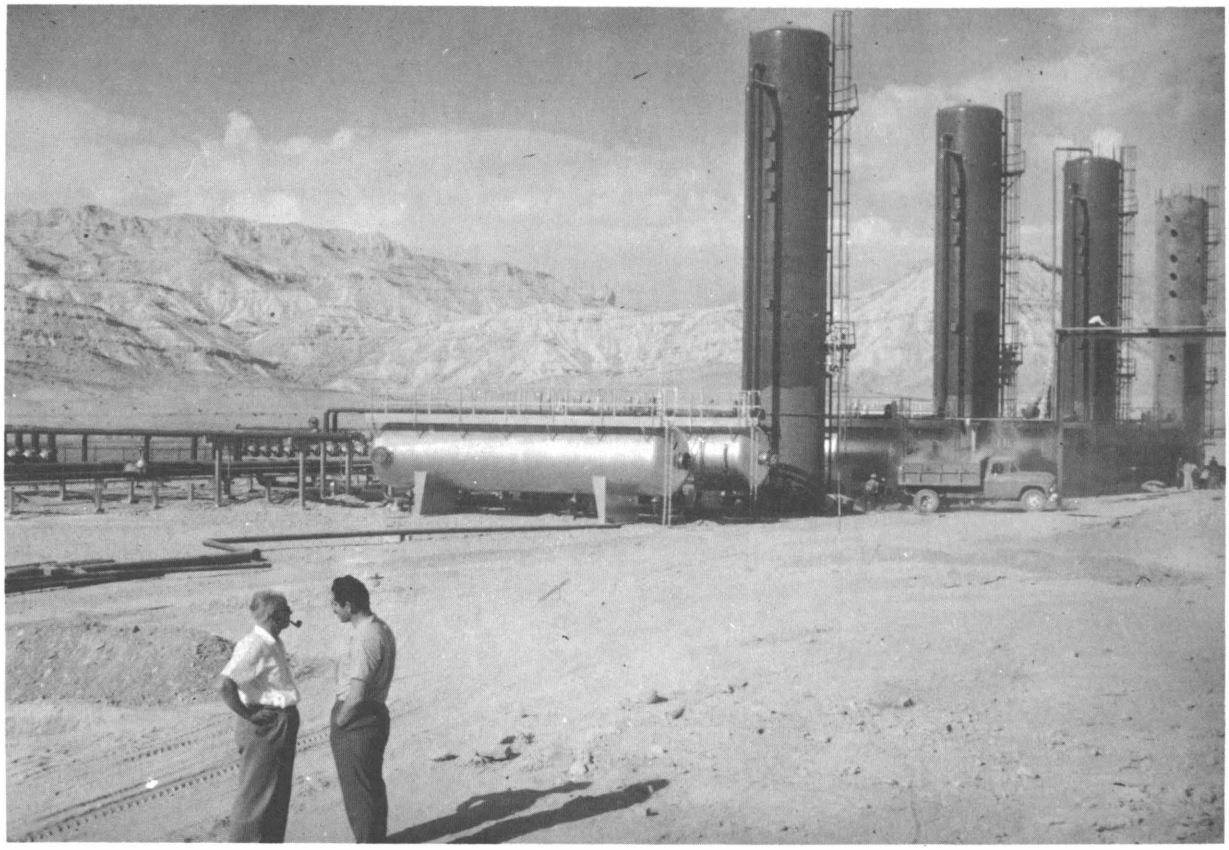


FIGURE 10. - Production Unit No. 3, Gach Saran, Under Construction.

anticline; the southwest flank dips more steeply than the northwest and displays some evidence of faulting. Two structural culminations exist, the most northerly one being slightly over 100 feet lower than the southern. The gas cap, 2,000 feet high, completely fills both domes and is continuous across the saddle separating them. It is underlain by an oil zone approximately 1,000 feet thick.

The Naft-e Safid reservoir is poorly fractured, compared to other southwestern Iranian fields. Because of this, wells are closer, and maintaining uniform oil/water and oil/gas interface levels during production requires greater care. A weak water drive is evident at Naft-e Safid, and its weakness is attributed (14) to the fact that the larger production from adjacent Haft Gel is drawing from the same aquifer.

Agha Jari

This field, now the largest producer in Iran both on an annual and cumulative basis, is situated at the southeastern edge of the foothills area, nearly 100 kilometers southeast of Haft Gel. It lies along an anticlinal axis parallel to and about 50 kilometers away from the axis occupied by Haft Gel and Naft-e Safid. Outstep wells drilled in 1959-61 have proven the reservoir to extend over 45 kilometers along the anticlinal axis, and within the area so far developed, attains a maximum width of about 5 kilometers.

TABLE 10. - Production units of Gach Saran field, 1962

Production unit number	Date of commission	Capacity, barrels per day	Number of stages	Comments
1	June 1940	150,000	7	First stage at wellhead operating at 600 psig; second stage in flank separators at 330 psig; final four stages in a central unit operating at 120, 50, 20, and about 5 psig. Of the 150,000 barrels per day capacity 60,000 barrels are sent to Abadan and 90,000 barrels to Kharg. Sulfur in crude for Kharg is reduce to 0.007 pct maximum by weight.
2 (Dasht-e Balout)	December 1959	190,000	5	First stage at wellhead, final 4 stages in a central unit at separation pressures of 600, 170, 80, 30, and about 5 psig.
3	January 1963	200,000	4	National Tank Company vessels are used throughout. H_2S is stripped in 2 columns, each with a capacity of 90,000 barrels per day.

The structure is a sharply asymmetrical anticline, dipping about 30° NE and becoming, if not exceeding, vertical not far to the southwest of the culmination. The surface geology here, unlike at many of the other southwestern fields, roughly corresponds to subsurface geology, except that the Fars units overlying the reservoir have been thrust faulted, while the Asmari reservoir and underlying sediments apparently were only sharply folded.

At Agha Jari two domes are separated by a slight saddle (fig. 11). Each has a small gas cap. In 1962 the oil/gas interface was at 5,300 feet subsea; the oil/water level was at approximately 8,800 feet subsea, giving an oil column of about 3,500 feet. Well pressure at 6,400 feet is 3,160 psig.

Available information indicates that the fracturing in Agha Jari is better developed, on the whole, than in any other southwestern field, but variations exist across the structure. Wells on the sharply folded southwest flank have generally proved more productive, presumably because the more intense deformation there has better fractured the incompetent Asmari.

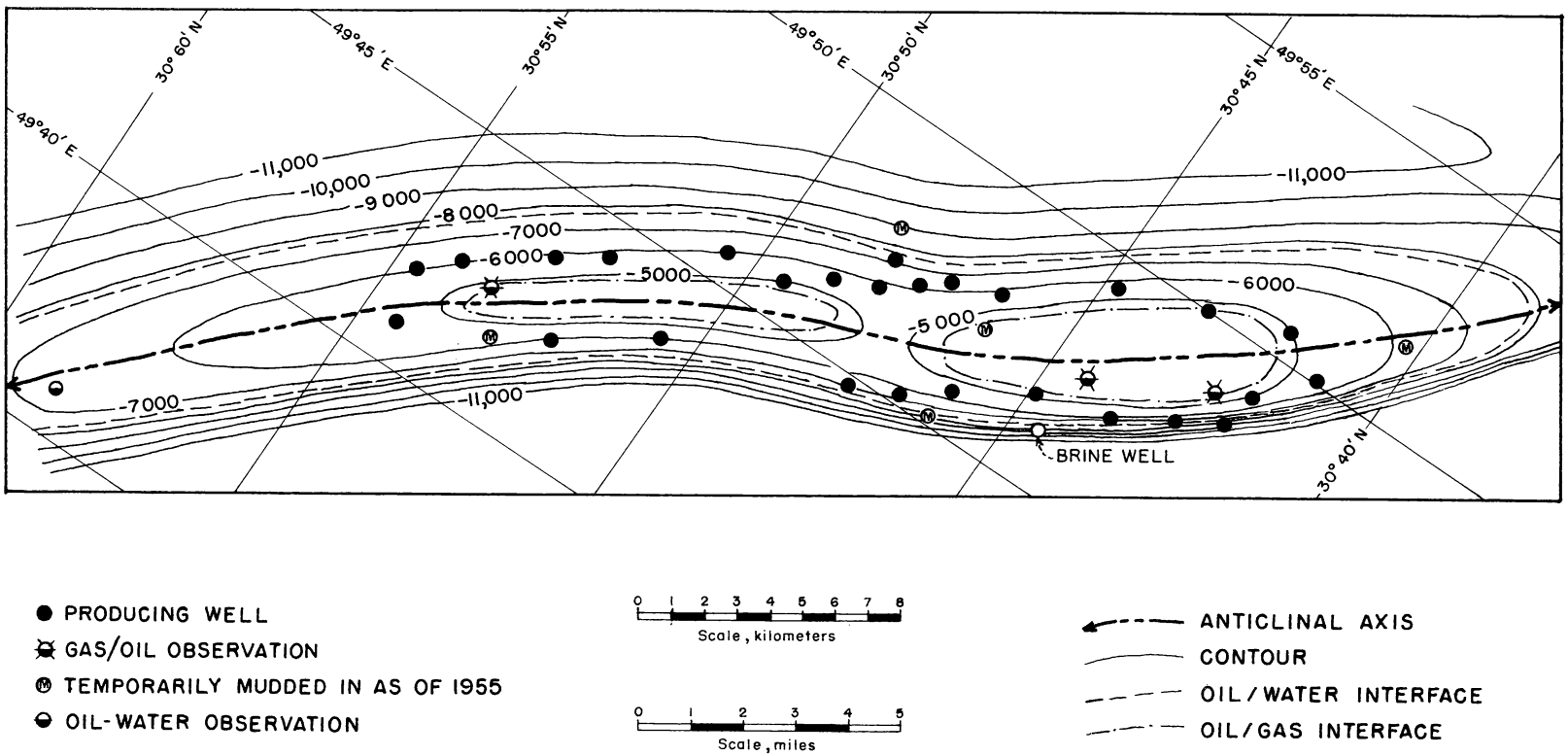


FIGURE 11. - Structural Contour Map of Agha Jari Oil Field.

Agha Jari is mainly a gas drive field. Pressure drop associated with production is relatively low. Presumably gas released from solution as crude is produced nearly balances the total gas withdrawal. Pressure data obtained during 1951-54, when there was no production, indicated that water drive in Agha Jari reservoir, if any, is feeble (14).

Commercial production from Agha Jari field started in 1944. Present production capacity is 1 million barrels per day and 1962 production was 890,000 barrels per day from 37 wells. Crude is 34° API.

Proceeding on the surface of the Agha field from northwest to southeast, there are production units No. 5, No. 3 at Do-Bandi (fig. 12), Flow Tank Unit at Mian Kuh, production unit No. 1 at Sar-i Band and No. 2 at Maidan-e Jafar. No. 3 has a capacity of 220,000 barrels per day and No. 5, 250,000, of which 70,000 is currently utilized. Eight wells are connected to No. 3 and three to No. 5. In No. 3, pressure is reduced in 7 stages from 500 to 8 psig as follows: 500, 200, 98, 48, 24, 11, and 8. Gas obtained from the first stage is sent to Abadan at the rate of 70 to 80 million cubic feet per day. Crude, after separation from gas, is pumped to Bandar Mashur, the pumps boosting pressure from 8 to 900 psig.

Lali

The Lali field, about 40 kilometers north of Masjed-e Soleyman, lies along a continuation of the anticlinal trend occupied by Masjed-e Soleyman, but is slightly offset to the northeast. In addition to a significant Asmari reservoir, this field has an underlying Middle Cretaceous reservoir of significant proportions. The Asmari proved area measured 26.4 by 6.4 kilometers at

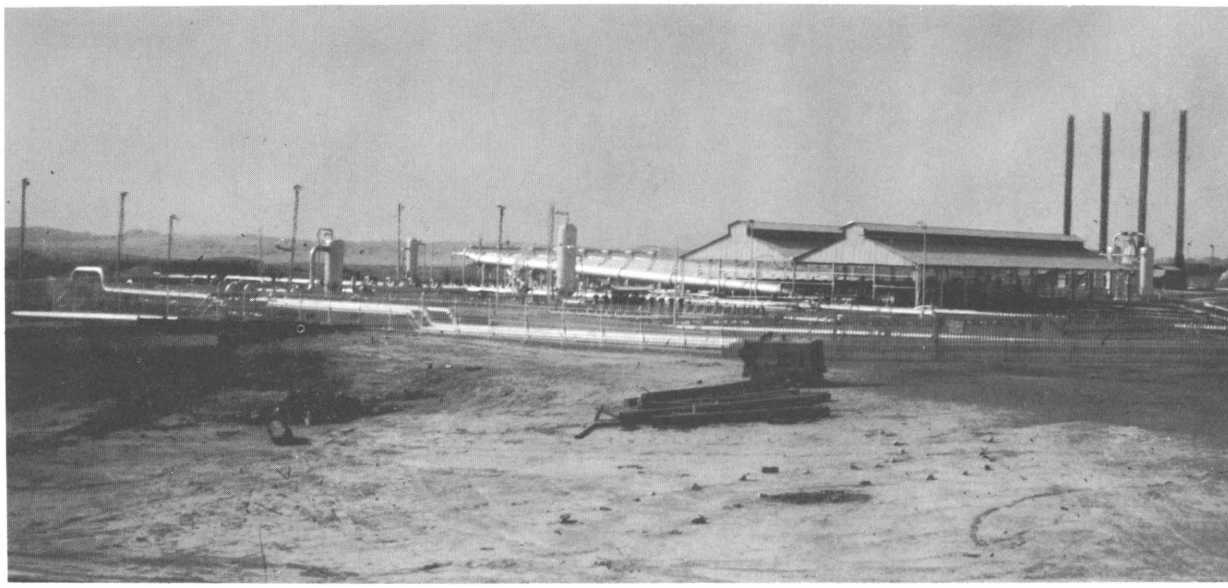


FIGURE 12. - Production Unit No. 3 at Agha Jari.

the original oil-water interface, and the Cretaceous reservoir was 15.2 by 4.0 kilometers. The Lali structure is a slightly overturned anticline with two culminations. The northeast flank of the broad dome dips away gradually for a considerable distance, while the dip of southwest flank is gradual near the culmination, but then falls away sharply with some overturning. Thus, the crestal and axial planes of the structure are widely divergent.

The reservoir mechanics of Lali structure are incompletely known. Graham, Hetherington, Old, and Tuman (14) report that it is probable that the Asmari reservoir in reality consists of two separate productive zones, each with separate gas/oil and oil/water interfaces. Even less is known of the Cretaceous reservoir because most of the wells have been drilled only to the Asmari. However, the Cretaceous reservoir is probably the better of the Lali productive zones (14). Calculations based on pressure gradients recorded before, during, and after shutdown of most wells in 1951 imply that the oil/water interfaces in both the Asmari and Cretaceous reservoirs have moved up considerably, and, thus, an active water drive is present.

Ahvaz

Now undergoing development, the Ahvaz field is situated on an Asmari anticlinal axis over 70 kilometers southwest of the Naft-e Safid - Haft Gel trend. The proven area of the field extends at least 27 kilometers along the northwest-southeast trending structure, and indications are that the reservoir extends both north and south of its present defined limits. The small number of wells drilled to date have not defined clearly the width of the field, but in all probability it is not less than 3 kilometers. Reservoir characteristics have not been reported in detail, but high pressures are prevalent and a significant gas cap seems to be present. The field's status as a major future source of petroleum seems assured on the basis of the production level of the discovery well (Ahvaz No. 6), which is rated at 33,000-37,000 barrels per day, and by the completion of Ahvaz No. 8, a successful 27-kilometer northwesterly outstep from the discovery well.

Pazanun

This field, long regarded as a significant potential producer of natural gas and condensate (condensate value: 1.8 gallons per 1,000 cubic feet) and operated briefly during World War II for such production, was shown to contain at least limited quantities of oil by a new well drilled in 1961. To date six wells have been drilled, of which only one has reached the oil zone; consequently, the extent of the reservoir has not been fully determined. However, Consortium reports indicate that the discovery oil well was not as promising as had been expected. It appears that further development here is not immediately planned.

The Pazanun field lies along the same structural trend as the Agha Jari field and its axis is situated slightly east of the crestal axis of that field. Available information indicates a length of at least 26 kilometers and a maximum width of not less than 6 kilometers for the gas cap. The gas cap reportedly measures at least 1,500 feet vertically; and its culmination may be as much as 2,000 feet from the oil/water interface.

According to Lees (23), the Pazanun and Agha Jari crestal maxima are about the same elevation. Lees also explains the much larger gas cap at the Pazanun field by the probably greater thickness (and consequent better sealing character) of the Lower Fars unit at this field, citing the poor development of gas seeps at Pazanun as evidence.

Undeveloped Proved Structures

In addition to the fields mentioned above, five recent discoveries have been reported within the Consortium area, all somewhat removed from existing producers. In July 1959, an exploratory well at Binak, 35 kilometers south-southeast of Gach Saran was brought in with a production potential reported by various sources to be between 4,000 and 20,000 barrels per day of 29° API gravity oil. This well proved a Middle Cretaceous (Bangestan?) reservoir and apparently indicated presence of oil and/or gas in the Asmari unit. Total depth of the test well was 10,822 feet.

In mid-1961, an exploratory well at Bibi Hakimeh, between Gach Saran and the Persian Gulf, was brought in at about 3,500 barrels per day. This well penetrated a gas cap in the Asmari unit at a depth of 3,347 feet and found oil in the Middle Cretaceous Bangestan limestone at a depth of 6,206 feet; it was completed at 6,748 feet in the Bangestan. A second well was drilled in 1962. Apparently, fluid connection exists between Asmari and Bangestan limestones.

In May 1962, the Consortium proved the existence of a reservoir in the Khalafabad anticline that lies across the Agha Jari-Bandar Mashur pipeline route near the mile 19 manifold northwest of Bandar Mashur. The wildcat well, about 16 kilometers southwest of Umidieh, was plugged back and completed as an Asmari producer after being drilled to Eocene marls at a total depth of 10,786 feet. This deeply buried structure apparently lies along the southwestward prolongation of the Ahvaz trend and is the first successful completion in the Consortium area to be positioned on the basis of geophysical evidence alone, there being no reflection of subsurface geology on the ground in this area. The first well here has given evidence of a significant pool in the Asmari limestone, and further tests of deeper horizons are planned.

Consortium drilling at Kharg Island in late 1962 confirmed the discovery made by IPAC in its Darius No. 1 drilling program and proved a field of considerable size. The Consortium's well apparently is not as prolific as the IPAC discovery well.

In November 1962, a Consortium wildcat on the Mansuri anticline struck oil in the Asmari limestone, and the well was being deepened to test the Bangestan limestone.

Other Areas

The Qeshm Island well, the first to be drilled here by the Consortium but the fourth attempt in the area, is situated on the Salakh anticlinal structure. This well was spudded in late 1961, but its present status is not known.

At the end of 1961, the Consortium reported that it had started preparations for exploratory drilling at two other sites, one at Mushtaq, about 80 kilometers northwest of Ahvaz, and the other at Kuh-e Bushgan, 176 kilometers southeast of Gach Saran (19).

Exploratory drilling in several other areas has not met with success and has been terminated. Two wells at Mand on the Persian Gulf south of Bushire, one drilled by AIOC and the second drilled to 13,541 feet in 1959-60 by the Consortium, failed to strike oil. The Sheykh Shu'eyb (or Lavan) Island well drilled in 1961 reached a depth of 10,446 feet and penetrated to lower Triassic formations without finding any trace of oil or natural gas and was abandoned. The cost of this test was reported to be £682,000 (US$1,909,600).

The Bandar Abbas test well, known as Suru No. 1 is the deepest well drilled to date in Iran. This well, which penetrated a small accumulation of gas between 10,880 and 11,760 feet, was terminated at 14,865 feet in Lower Jurassic sediments and was evaluated as essentially nonproductive. The cost of the well was £1,406,000 (US$3,936,800) according to Consortium reports.

National Iranian Oil Company Fields

NIOC now wholly controls three proven petroleum fields: The Naft-e Shah field, originally developed by AIOC, and two structures in the Qom area, entirely explored and developed by NIOC. Naft-e Shah has been in production since 1935 and under NIOC's direct control since 1951. Commercial production from the Alborz structure at Qom started in 1962; production at Sarajeh has not yet started.

Naft-e Shah field

This small field is situated on the Iran-Iraq border, roughly half of it lying on each side of the border. The Iraqi part is known as the Naft Khaneh or Khaniqin field. Naft-e Shah is situated in the southwestern foothills of the Zagros Mountains, roughly 400 kilometers northwest of Lali, the nearest Consortium field. The reservoir, 12.8 kilometers long and 2 kilometers wide, consists of the upper 250 feet of Asmari formation--here known as the Kalhor limestone. It is underlain by 500 feet of essentially unproductive Asmari anhydrite, with minor zones of thin limestone, marls, and salt. The slightly asymmetrical anticlinal reservoir structure is reflected in surface geology, although at the surface the structure is offset almost 1 kilometer to the southwest of the Asmari culmination as a result of thrust faulting in the overlying Fars formations. A gas cap is present over the producing zone, which lies about 3,000 feet below surface, and a water drive is evident.

Anglo-Iranian Oil Company drilled six wells at Naft-e Shah, and NIOC later drilled three wells. Of these, NIOC now considers three to be producers (9). These wells are each rated as producing 3,000-5,000 barrels per day, and presumably they may now be operated at or near capacity (until 1959-60, they were restricted by pipeline capacity and throughput level of NIOC refineries).

Qom Area

By early 1961, the Qom area on the central plateau, about 120 kilometers south-southwest of Tehran, was finally proven to possess appreciable petroleum reserves and important quantities of natural gas. All exploration efforts in the Qom area have been contracted for or actually performed by Iranian Government oil organizations, including government seismic equipment in operation shown in figure 13. The spectacular blowout of the Alborz No. 5 well in August of 1956 on the larger of the two known structures in the Qom vicinity attracted worldwide attention to the area and suggested the presence of large quantities of petroleum. This well, after flowing wild at an estimated rate of 80,000-100,000 barrels of 38° API crude per day for nearly 3 months, bridged itself in November 1956 and has remained closed in since.

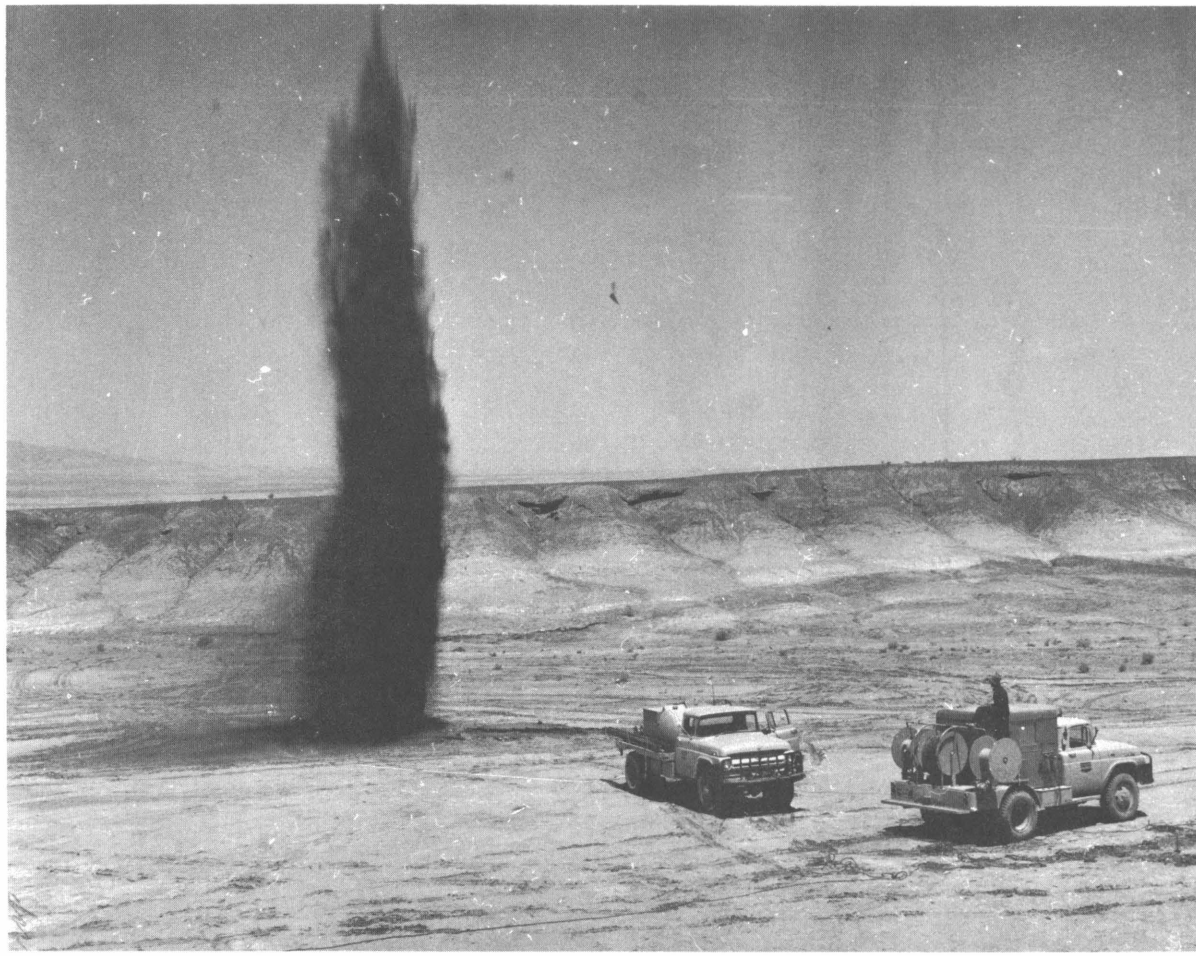


FIGURE 13. - NIOC Exploration Operations in Central Iran.
(Courtesy of NIOC.)

Chronology of exploration and result of drilling in this area is as follows:

1936..... Oil seep is reported.

1937..... Two 1,500-foot wells drilled.

1951-56..... Alborz wells Nos. 1, 2, 3, 4, and 4-A drilled. Of these, well No. 3 penetrated traces of oil but high well pressures were recorded.

1956..... Alborz No. 5 brought in.

1956-57..... Alborz Nos. 6 and 7 drilled; these wells failed to reach reservoir.

1960 (July)..... Alborz No. 8 brought in as a production well; 20,000 barrels of oil mixed with 70,000 barrels of salt water when fully open, but because of technical difficulties was later abandoned.

1961-62..... Alborz Nos. 9, 10, and 11 successfully brought in, and were undergoing production tests in mid-1962.

The Alborz structure is an asymmetric anticline. For purposes of geological description, it has been divided into two portions, East and West Alborz. On the surface, the West Alborz has an axis trending N 60° W. The south flank dips 40° to 90°, but the northern flank is gently dipping (15° to 30°). The asymmetry in the East Alborz is reversed (5). The reservoir rock at Alborz is an Oligocene-Miocene lateral equivalent of the Asmari at 8,000 to 9,000-foot depths. Reserve estimates have not been made.

Partly as a result of failure in the Alborz structure during 1956-57, NIOC initiated a drilling program on the Sarajeh anticline, the second of the two principal structures in the Qom area. This program yielded successful results almost immediately, and, by July 1, 1961, a total of six wells had been or were being drilled on this structure. The pay zone here, a limestone roughly equivalent to but not identical with the Asmari at a depth of about 8,500 feet, is reportedly 500 feet thick. NIOC officials estimate reserves of Sarajeh as 70 million barrels of light oil, and 1,000 billion cubic feet of gas. Gas condensate produced here is rated at 45° API.

The Sarajeh structure is a nearly symmetrical anticline trending roughly east to west, but the axis turns slightly to the north at its western end, a change in direction attributed to faults located along the plunging western end of the feature. At the surface, rock units dip as much as 40° along the flanks, but the dip of the reservoir rocks reportedly do not exceed 25° (5).

In May 1961, a well was spudded in at Yort-e Shah, about 90 kilometers southeast of Tehran and 58 kilometers from Sarajeh structure. This well was drilled to 3,906 feet; at this depth drilling was reportedly suspended with no apparent success.

Offshore Operations

After rather disappointing initial drilling efforts, the offshore areas of SIRIP and IPAC by the end of 1961 seemingly were proven to have significant production potential. A total of nine wells have been drilled, four by SIRIP and five by IPAC, and most recent reports indicate that six of these, all of SIRIP's and two of IPAC's are commercial producers. The locations of these wells are shown generally in figure 4 and in detail in figure 14.

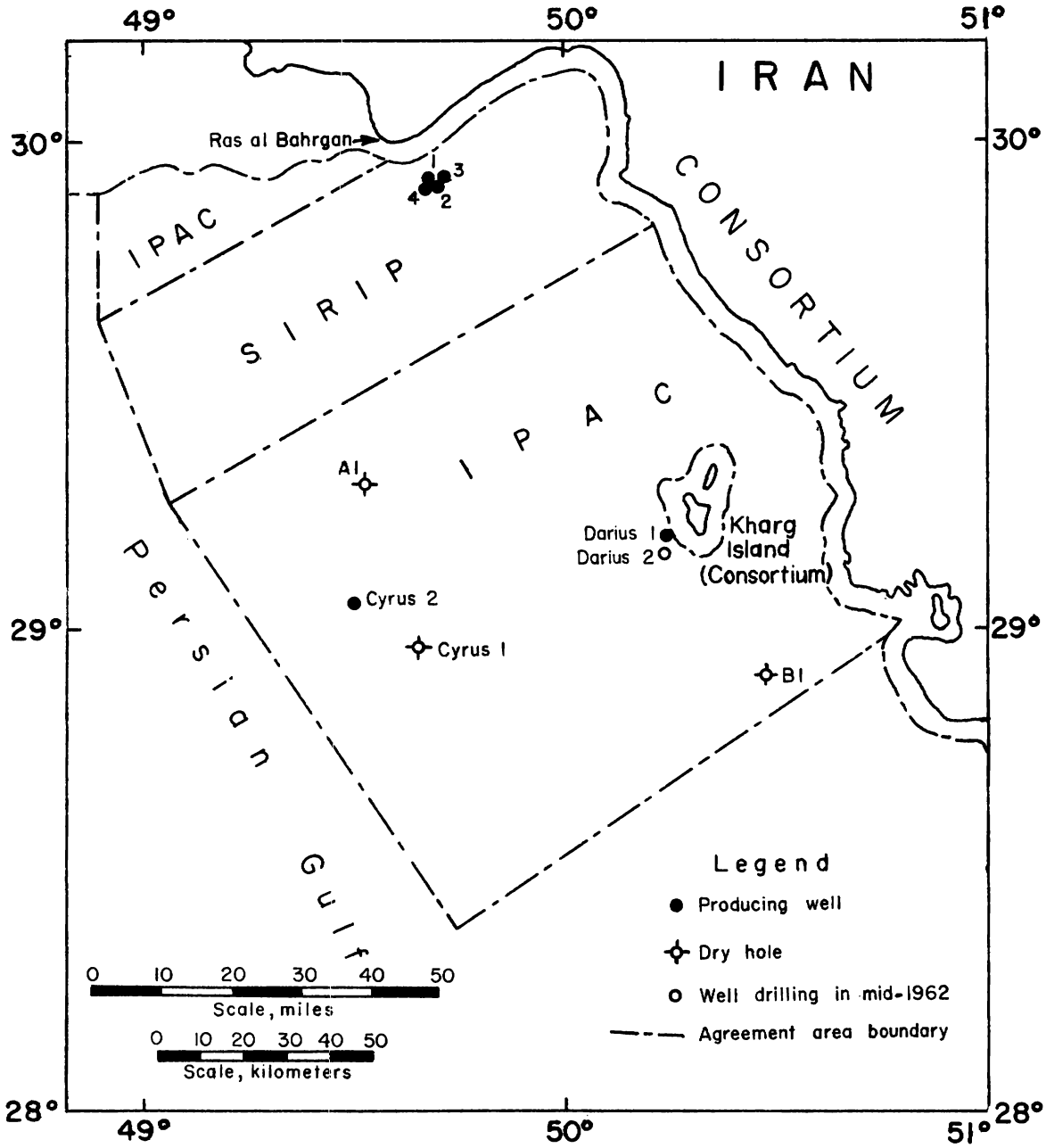


FIGURE 14. - Detailed Map of Offshore Well Locations, Iran, 1962.

Total production capacity of the four SIRIP wells is estimated at about 20,000 barrels per day of 32° to 34° API gravity crude. Three of these wells were drilled from a single platform located 12 kilometers from the shore, in line with the foreland of Ras al Bahrgan (fig. 15), and the fourth from another platform 2.5 kilometers southwest of the first. Capacity of the first well drilled from the above platform in the Bahregansar field is 3,500 to 5,000 barrels per day.

The first of the IPAC wells, drilled from a moveable platform (fig. 16) near the extreme outer edge of the concession (close to the median line of the Persian Gulf), reached its planned depth in late 1960, and after testing of oil shows was regarded as a failure. Likewise, the second IPAC well spudded in May 1960 about 33.5 kilometers south of Kharg Island and about 48 kilometers off the coast of Bushire, was abandoned as noncommercial, in spite of oil shows, in March of 1960 after testing to 12,497 feet.

IPAC's discovery well, Darius No. 1 was brought in from a mobile platform near Kharg Island in November 1961. It struck oil in the Lower Cretaceous at 11,000 feet and flowed at the rate of about 35,000 barrels per day of 29° API gravity oil containing some sulfur. The capacity of the well for most efficient production is reportedly in the range of 20,000 to 25,000 barrels per day.

IPAC's fourth well, Cyrus No. 2, located about 72 kilometers southwest of Kharg Island blew out on January 15, 1962, after striking high pressure gas at about 10,706 feet. A blowout preventer on the platform had failed to function properly, but within 1 week a crew equipped with gas masks boarded the then-abandoned barge and repaired the blowout preventer before serious damage occurred. About 6,000 barrels per day was produced from the Lower Cretaceous Khami, which may be the equivalent of the Ratawi formation of the Kuwait Neutral Zone Wafra field. Cyrus No. 2 was being deepened to test the Upper Jurassic Khami formation when the blowout occurred. Another well, Cyrus No. 2-A, was drilled from this same platform and was completed as a 14,000-barrel-per-day producer from the Burgan limestone.

IPAC's Darius No. 2 was spudded in shortly after successful completion of Darius No. 1. It is situated about 3.3 kilometers southwest of the discovery well and in water too deep to permit drilling from a fixed platform. This well, together with Darius No. 3, were completed as producers by the end of 1962, but their output potential is unreported.

Initially IPAC drilled as near the center of the Gulf as possible because of indications that the series of folds that provide the reservoir structures for the prolific Consortium fields on the Iranian mainland were not paralleled by similar structures under the Gulf, and that, instead, the Gulf area was characterized by a single gently sloping anticline (similar to those of Saudi Arabia and Kuwait) with its axis near the center of the Gulf. Discovery of oil in Cyrus No. 2 would seem to support this idea. The structural relationship between this well and Darius No. 1, the discovery well, remains to be worked out.

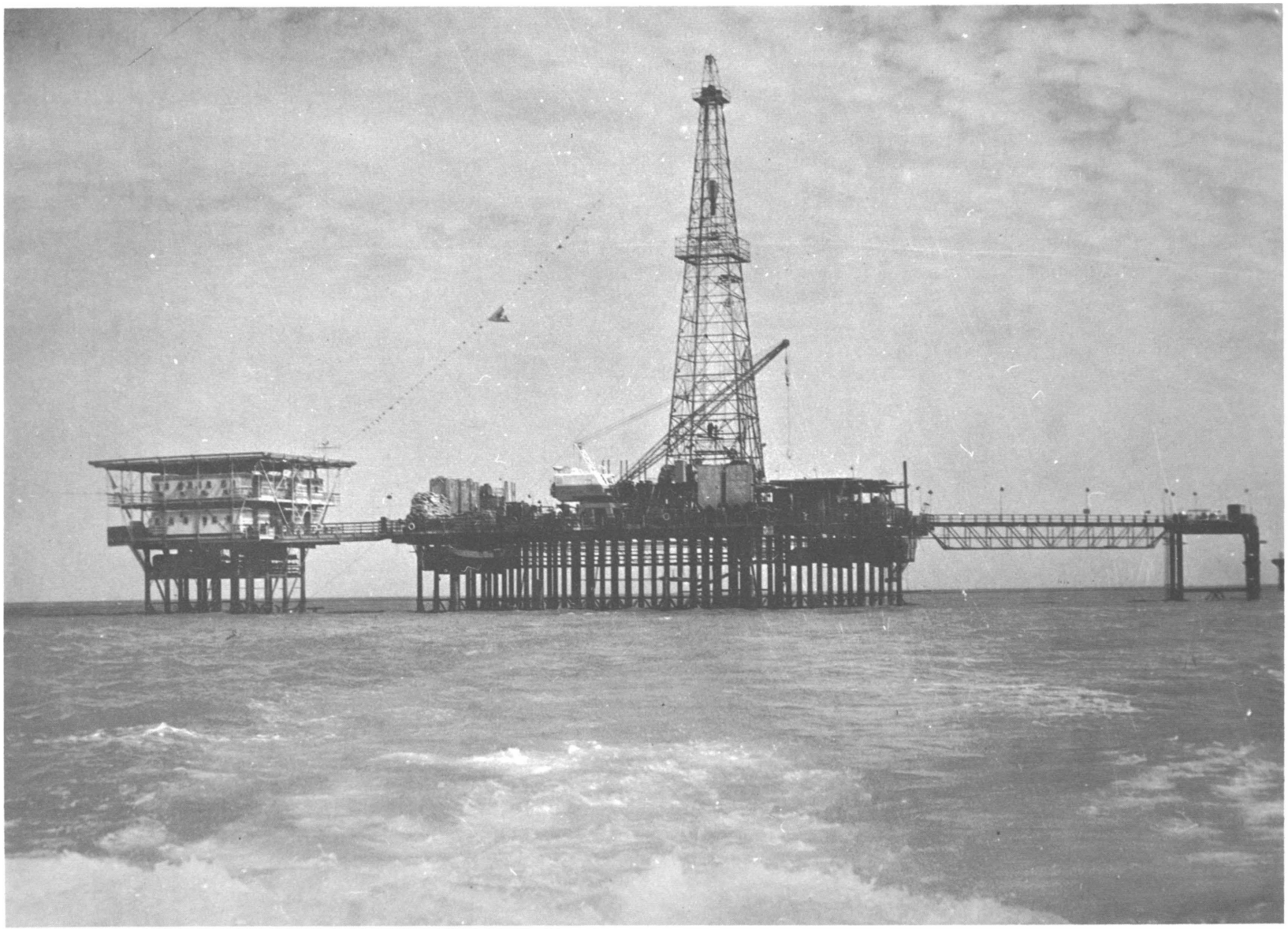


FIGURE 15. - SIRIP's Drilling Barge in the Persian Gulf.
(Courtesy of NIOC.)

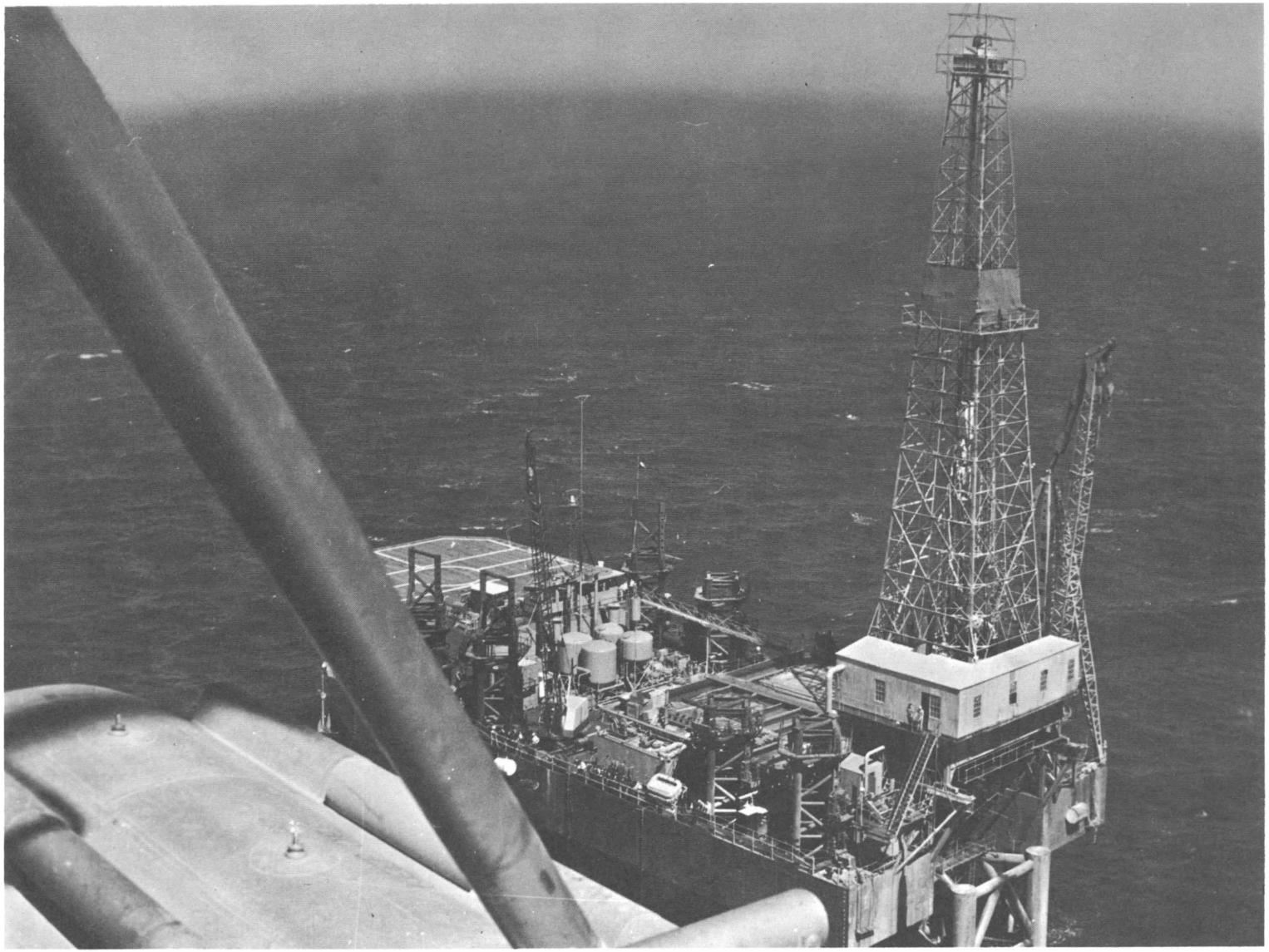


FIGURE 16. - The Iran-Pan American Drilling Barge in the Persian Gulf.
(Courtesy of NIOC.)

Caspian Sea Area

By mid-1962, a total of six wells had been drilled by NIOC to undetermined stratigraphic horizons at two different locations between the Alborz Mountains and the Caspian Sea. Five of the wells are located about 38 kilometers from Gorgan. One of these, Gorgan No. 3, struck high pressure gas on July 7, 1960, at 6,852 feet in Upper Tertiary sediments and yielded an estimated 100 million cubic feet of gas per day until capped 6 days later (32). Wells No. 4 and 5, the last reaching 4,620 feet, were unproductive and operations were halted in early 1961. No full appraisal of the Gorgan reservoir has been made. However, initial NIOC reports described the reserves as "important," and a map published in NIOC's Newsletter of January 31, 1962, shows an "oilfield" in this area (32).

A single well drilled by a light stratigraphic rig in the vicinity of Sari (36° 34' N; 53° 04' E), about 280 kilometers east-northeast of Tehran was abandoned at a depth of more than 1,100 feet (the capacity of the rig) in April of 1961. At that time, heavier equipment reportedly was to be moved in to deepen the hole, but through early 1963, activities had not yet been resumed.

Zagros Mountains

After two years of preliminary exploratory activity, SIRIP spudded in its first well in the Zagros Mountain agreement area on October 31, 1960. This well, drilled with an air-cooled equipment because of water shortage, was situated on a small anticlinal structure, Kuh-e Sequtah, about 240 kilometers by road south-southwest of Esfahan. Drilling was suspended at 12,083 feet shortly after July 1961; the well had not shown any indications of commercial quantities of petroleum. Evidently, information derived from this well indicated a lack of potential in the area, and SIRIP has apparently halted all work on this tract. There has been no indication that the Kuh-e Rig structure in the same area, mentioned at one time as a possible second site, will be explored.

RESERVES

Published figures on petroleum reserves (including probable) of Iran at the end of 1961 totaled 35 billion barrels, about 11 percent of the total world reserves. These crude reserves rank Iran third in the Near East after Kuwait and Saudi Arabia. Reported natural gas reserves are 65 trillion cubic feet.

Figures on reserves by individual fields of the Consortium are not available. The major extension of the Gach Saran field and new discoveries at Ahvaz, Binak, Bibi Hakimeh, Khalafabad, Kharg Island, and Mansuri have added significantly to reserves in the Consortium area.

For the fields of NIOC, the Sarajeh structure's reserves are estimated at 70 million barrels of light oil and vast quantities of natural gas, but reserves of the Alborz structure have not been reported. It is still too

early to estimate oil and gas reserves of the Gorgan area. Remaining recoverable reserves of Naft-e Shah-Khaniqin field are reported as 194 million barrels, of which 116 million barrels are in Iran.

The reserves of the SIRIP Bahregansar offshore field are estimated at 438 million barrels, with a production potential of 2 million tons per year from the four existing wells. Reserves of IPAC are reportedly in the magnitude of billions of barrels.

Prospects for finding new reserves in Iran are good. In the Consortium Agreement area, numerous structures were already located before World War II and some of these were drilled. Deeper drilling with modern rigs may reveal other oil-bearing zones. More recent surface work and/or geophysical exploration have found additional structures that remain to be tested. The success of NIOC at Qom and at Gorgan encourages expectation of oil in other structures in central Iran and in the Caspian area.

PRODUCTION OF CRUDE OIL AND NATURAL GAS

Iran produced over 480 million barrels of crude oil in 1962, about 5 percent of the world's total output for that year. In 1962, Iran ranked third among Near East and sixth among world producers. Cumulative production has exceeded 5 billion barrels since 1908 when the discovery well at Masjed-e Soleyman was brought in. Annual production figures for 1911-62 and their relationship to world total output are given in table 11. Iranian output in 1962 was more than 4 times as large as that for 1955, the first full year of operations of the Consortium in the Agreement area.

Production trends in the seven operating fields of the Agreement area and the Naft-e Shah field operated by NIOC are illustrated by table 12 that gives production by individual fields for a number of years. Agha Jari and Gach Saran have shown continuous increase in production since 1955; output at Gach Saran virtually doubled between 1959 and 1960, and more than doubled again between 1960 and 1961. The last marked increase resulted primarily from the completion of the Kharg Island pipeline in 1960. Until completion of this pipeline, production from Gach Saran was limited by the capacity of the crude pipeline to Bandar Mashur.

As for future production, the contribution of Agha Jari and Gach Saran should be dominant, while Haft Gel, Masjed-e Soleyman, and Naft-e Safid will account for a declining percentage. Undoubtedly, newly discovered fields, such as those in the Qom area (NIOC), at Ahvaz (Consortium), and offshore in the Persian Gulf (SIRIP and IPAC), will also contribute to total future production as will the other older fields (Pazanun and Lali of the Consortium and Naft-e Shah of NIOC).

The prolific production of Middle Eastern fields is well known. The 1961 output of 427,488 thousand barrels by the Consortium was obtained from 113 wells, an average of 10,365 barrels per day per well, the highest in the world. Actual average daily production ranges from under 1,000 barrels (in the case of some of the older wells at Masjed-e Soleyman) to more than 30,000 barrels obtained from some of the new wells in Agha Jari and Gach Saran.

TABLE 11. - Production[1] of crude oil in Iran, 1911-61, and percentage of world production (19, 28, 36)

Year	Production, million barrels	Percentage of world production	Year	Production, million barrels	Percentage of world production
1911.....	0.2	([2])	1937.....	77.8	3.8
1912.....	.6	([2])	1938.....	78.3	3.9
1913.....	1.7	([2])	1939.....	74.0	3.8
1914.....	2.7	0.7	1940.....	66.3	3.1
1915.....	3.3	.8	1941.....	50.7	2.3
1916.....	4.6	1.0	1942.....	72.1	3.5
1917.....	6.6	1.3	1943.....	74.6	3.3
1918.....	8.1	1.6	1944.....	101.9	3.9
1919.....	9.8	1.8	1945.....	129.3	5.0
1920.....	12.6	1.8	1946.....	146.8	5.3
1921.....	16.8	2.2	1947.....	155.0	5.0
1922.....	21.5	2.5	1948.....	190.4	5.6
1923.....	27.1	2.7	1949.....	204.7	6.0
1924.....	32.1	3.2	1950.....	242.5	6.4
1925.....	34.6	3.2	1951.....	127.9	3.0
1926.....	36.6	3.3	1952.....	17.3	.4
1927.....	40.2	3.2	1953.....	16.5	.4
1928.....	43.2	3.3	1954.....	21.5	.4
1929.....	41.9	2.8	1955.....	120.2	2.1
1930.....	45.6	3.3	1956.....	197.4	3.2
1931.....	44.1	3.2	1957.....	269.5	4.1
1932.....	49.5	3.8	1958.....	305.6	4.6
1933.....	54.4	3.8	1959.....	344.8	5.7
1934.....	57.9	3.8	1960.....	390.8	4.8
1935.....	57.3	3.5	1961.....	434.0	5.3
1936.....	62.7	3.5	1962.....	481.8	([2])

[1] Listed figures in this table total 5,107.4 million barrels, 11.8 million barrels more than is listed in table 10. Sources for these tabulations differ and information included in this table is not reconcilable with that used in compiling table 10 for the period 1911-34.

[2] Not available.

TABLE 12. - Production of crude oil by fields in Iran for selected years and cumulatively through 1962, in thousands of barrels

	1939	1940	1949	1950	1955	1956	1957	1958	1959	1960	1961	1962	Cumulative, 1908-62
Consortium fields:													
Agha Jari.....	-	-	84,315	118,297	88,163	135,509	165,271	183,600	218,772	244,715	258,099	281,247	2,041,328
Ahvaz.....	-	-	-	-	-	-	-	-	19	2,208	2,555	11,888	16,670
Gach Saran.....	111	3,199	14,607	15,470	48	4,697	17,616	21,624	21,605	40,192	92,361	104,888	433,724
Haft Gel.....	53,084	48,743	72,673	70,775	14,301	30,753	43,980	52,520	54,921	59,466	45,633	48,653	1,354,525
Lali.....	-	-	3,020	5,587	1,931	2,580	3,868	6,376	5,449	4,718	4,016	2,753	47,507
Masjed-e Soleyman.....	20,015	13,715	21,105	21,847	11,897	14,254	21,084	17,737	22,379	22,104	12,777	14,135	1,005,315
Naft-e Safid...	-	-	7,833	9,221	2,533	7,643	15,698	21,857	19,728	14,981	12,047	11,356	141,465
Subtotal....	73,210	65,657	203,553	241,197	118,873	195,436	267,517	303,714	342,873	388,384	427,488	474,920	5,040,534
NIOC fields:													
Alborz.....	-	-	-	-	-	[1]	[1]	[1]	[1]	[1]	2,384	2,088	4,472
Naft-e Shah....	761	660	1,159	1,278	[2]1,330	1,925	1,969	1,913	1,915	2,371	2,904	[3]2,388	46,951
Subtotal....	761	660	1,159	1,278	[2]1,330	[1]1,925	[1]1,969	[1]1,913	[1]1,915	[1]2,371	5,288	4,476	51,423
SIRIP offshore...	-	-	-	-	-	-	-	-	-	-	1,098	2,281	3,379
IPAC offshore....	-	-	-	-	-	-	-	-	-	-	163	94	257
Total.....	73,971	66,317	204,712	242,475	120,203	197,361	269,486	305,627	344,788	390,755	434,037	481,771	5,095,593

[1] Some oil was produced from Alborz in 1956-60 during exploration and development, some of which was sold.
[2] Estimate.
[3] Net production, excludes part of production recycled to reservoir.

The bulk of crude produced has an intermediate base; API gravity varies between about 32° and 38°. Gasoline, kerosine, and gas-oil fractions constitute about one-half (by volume) of the crude; sulfur content is low to moderate, but sulfurous gases have presented health problems at times. Much of the crude produced is high in gas content, gas/oil volumetric ratios varying from a little over 40/1 at Masjed-e Soleyman to 150/1 at Agha Jari, and 180/1 at Naft-e Shah (NIOC).

All natural gas produced in Iran in recent years has been a byproduct of crude oil production, except for gas from Masjed-e Soleyman field that is obtained also from the gas cap. Pazanun, essentially a gasfield, has been shut-in since the early 1940's. Natural gas production by the Consortium and by NIOC during 1956-62 (28) was:

Year	Natural gas production, million cubic feet		
	NIOC	Consortium	Total
1956.....	1,265.0	140,484.2	141,749.2
1957.....	1,300.7	181,991.8	183,292.5
1958.....	1,324.7	204,646.1	205,970.8
1959.....	1,353.1	234,767.1	236,120.2
1960.....	1,677.6	264,454.2	266,131.8
1961.....	2,124.4	294,522.2	296,646.6
1962.....	2,162.7	322,117.6	324,280.3

In 1962, only about 11.5 percent of the total gas production was utilized as a fuel; another 21.6 percent (entirely Consortium production) was flared after being utilized expansively for driving turbines, leaving about 66.9 percent that was flared without being put to any use. Utilization of natural gas is discussed in more detail under the section on Consumption.

In drilling wells two to four strings have been used in Haft Gel for well completion, with the production casing set in the cap rock overlying the Asmari limestone. Production casings are 6-1/2 to 8-3/4 inches with open hole production of 6-1/2 and 7-3/4 inches, respectively.

Recent drilling in Gach Saran and Agha Jari called for a 20-inch casing set to about 500 feet, a 13-3/8-inch intermediate casing before entering high pressure formations (2,300 to 4,000 feet), and a 9-5/8-inch producing string set in the cap rock.

At each well, oil from the wellhead is first produced through a single step separator at the wellhead that permits separation of high pressure gas (fig. 17). Oil from a number of wells go to central production units that in several stages stabilize the crude to about atmospheric pressure. The surface flow lines between wells and production units vary from 6 to 12 inches in diameter.

Much pioneering work has been done in reservoir engineering in the Iranian oilfields. In the early 1920's, unit control and operation of individual fields was established. Reservoir pressure, fluid levels, production

FIGURE 17. - A Typical Wellhead Separator (Gach Saran).

rates, and gas-oil ratios of individual wells were measured regularly. The objective was to avoid a high rate of pressure changes and to control production to assure a uniform pressure drop in the oil zone throughout the whole reservoir. Recycling of surplus products and multistep gas-oil separation were other practices introduced in early 1930's.

As the characteristics of the different reservoirs were determined, it was possible to choose wide well spacing of 1.5 and 3.0 kilometers, thus saving a great deal on development costs. The rate of pressure drop can also be better controlled with wide well spacing.

REFINERY PRODUCTION

Abadan

Since resumption of refining activities for the export market in late 1954, the Abadan refinery and the Masjed-e Soleyman topping plant have steadily increased crude throughput, although the maximum of 130,855,000 barrels achieved in 1962 is only 63 percent of the 1950 peak when crude throughput was 192,000,000 barrels (more than 525,000 barrels per day). Refinery production data by commodity for 1948-50 and 1955-62 are given in table 13. The level of runs to stills and refinery output at Abadan for selected years were:

Year	Runs to stills, thousand barrels	Output, thousand barrels
1939.....	[1] 72,227.0	([2])
1940.....	[1] 67,812.0	([2])
1950.....	[3] 192,000.0	179,404.0
1955.....	55,311.5	50,327.0
1956.....	85,307.0	79,112.7
1957.....	114,571.9	107,770.7
1958.....	113,210.1	106,558.1
1959.....	117,564.4	109,123.9
1960.....	128,836.5	120,998.2
1961.....	113,970.0	[4] 103,397.4
1962.....	130,855.0	[4] 118,658.7

[1] Probably includes runs to stills at Kermanshah refinery.
[2] Data not available.
[3] Estimate, based on refinery output.
[4] Product shipments for export and domestic consumption; differs from actual output by the amount of changes in refinery stocks.

In 1962, 27.5 percent of the total Consortium crude output was refined in Iran. The lower level of refinery output in 1961 compared with 1960 and 1962 was due to the disruption of tanker traffic to Abadan as a result of the temporary closure of the Shatt-el Arab, the seaway leading to the loading facilities. The 1961 monthly statistics for refinery throughput show that, except in February when output was slightly reduced and in March and April when cutbacks were severe, output in 1961 was virtually on a par with that of 1960. Actually, throughput during October 1961 was at the highest level recorded for the period of Consortium operation, 1954-62.

Crude runs to stills under Trading Company and NIOC accounts, tabulated below for 1959-62 reflect the rise of Iranian consumption:

Year	Runs to stills, thousand barrels		
	Trading Company accounts	NIOC accounts	Total
1959.....	101,326.5	16,237.9	117,564.4
1960.....	110,222.9	18,613.6	128,836.5
1961.....	92,420.4	21,549.6	113,970.0
1962.....	109,773.1	21,082.1	130,855.2

The lower throughput and production of the Abadan refinery during 1955-62, relative to the 1950 performance, contrast sharply with increases in world product consumption, Iranian crude production, and, most significantly, Iranian consumption of petroleum products. Construction of new refineries in some of the countries importing Iranian crude and products and the temporary deterioration of the competitive position of Abadan refinery (see discussion of refining facilities) have been contributing factors in reduced scale of Abadan's production.

TABLE 13. - Refinery production by commodity in Iran, 1948-50 and 1955-61, in thousands of barrels

	1948	1949	1950	1955	1956	1957	1958	1959	1960[1]	1961[2]	1963[3]
Consortium:											
Motor gasoline...					12,861.3	15,553.3	16,959.0	16,859.5			
Cracked gasoline.	34,098.0	37,101.0	38,738.0	9,716.0	1,985.9	1,678.2	994.3	618.8	20,206.7	14,474.4	16,445.3
Aviation gasoline				390.0	2,697.3	4,349.5	4,481.1	4,531.8	4,985.1	4,258.1	5,232.5
Aviation turbine fuels.....	-	-	-	-	-	-	-	3,592.4	4,222.8	4,163.6	5,663.7
Kerosine.....	15,578.0	17,226.0	17,833.0	9,582.0	11,660.8	15,127.8	15,500.4	14,987.1	15,391.0	13,630.6	14,703.1
Gas oil.....	27,081.0	30,676.0	33,478.0	7,386.0	7,844.4	10,770.4	13,351.5	15,829.2	14,229.4	14,524.5	17,578.4
Diesel oil.....					5,711.8	8,151.7	6,785.7	6,546.8	6,667.0	4,434.9	4,486.3
Fuel oil (residual).....	71,035.0	79,385.0	87,826.0	22,770.0	32,236.2	47,306.8	43,399.2	41,843.4	50,553.1	43,499.7	49,763.6
LPG.....	(4)	(4)	(4)	(4)	8.5	8.9	13.3	22.0	[5]27.8	42.6	65.6
Vaporizing oil...	(4)	(4)	(4)	(4)	2,077.1	2,786.4	2,920.9	1,882.0	2,129.6	1,794.6	2,012.1
Special solvents.	(4)	(4)	(4)	(4)	597.4	677.1	767.2	688.8		755.0	1,249.6
Lubricating oil..	-	-	-	76.0	78.5	106.7	113.4	105.8	[6]952.2	136.3	129.2
Imshi.(insecticide base)....	(4)	(4)	(4)	(4)	5.7	3.7	4.6	5.1		(7)	(7)
Bitumen.....	1,022.0	1,391.0	1,529.0	407.0	1,347.8	1,250.2	1,267.4	1,611.2	1,633.5	1,683.1	1,329.3
Total[8].....	148,814.0	165,779.0	179,404.0	50,327.0	79,112.7	107,770.7	106,558.0	109,123.9	120,998.2	103,397.4	118,658.7
NIOC:											
Gasoline.....	(4)	(4)	(4)	360.5	450.5	450.4	437.0	368.0	282.0	303.0	(4)
Kerosine.....	(4)	(4)	(4)	360.5	302.7	319.7	294.0	276.9	226.0	258.0	(4)
Gas oil.....	-	-	-		62.3	28.6	27.3	22.9	70.0	89.0	(4)
Fuel oil (residual).....	(4)	(4)	(4)	669.0	175.2	153.9	108.3	85.9	341.0	570.0	(4)
Unfinished products.....	(4)	(4)	(4)		4.4	8.3	3.4	23.1	30.0	20.0	(4)
Total[8].....	(4)	(4)	(4)	1,390.0	995.1	960.9	870.0	776.8	949.0	1,240.0	(4)
Grand total...	[8]148,814.0	[8]165,779.0	[8]179,404.0	51,717.0	80,107.8	108,731.6	107,428.0	109,900.7	121,947.2	105,623.0	(4)

[1] Totals for Consortium and NIOC are those reported by these companies; distribution of Consortium total by products is based on a percentage distribution reported separately by that group.

[2] Figures do not add to listed grand total because Consortium data based on reported product shipments rather than actual production data, which was not available at the time of preparation of this report.

[3] Data are based on reported product shipments rather than actual production.

[4] Data not available.

[5] Data from supplementary sources; LPG included in "miscellaneous products" in principal source.

[6] Reported as miscellaneous products; presumably includes these commodities together with any other commodities not listed separately.

[7] Less than 50 barrels.

[8] Total of listed figures only.

Refinery output of major products in terms of percents of total major products in 1950, 1961 and 1962 were:

Product	1950	1961	1962
Fuel oil.....percent	49.0	43.2	43.2
Kerosine.....do...	9.9	13.6	12.8
Gas/diesel oil.....do...	18.7	18.8	19.2
Bitumen.....do...	.8	1.7	1.1
Gasolines.....do...	21.6	18.6	18.8
Aviation turbine fuel.....do...	0	4.1	4.9
Total.....	100.0	100.0	100.0

The data show a number of changes in the relative position of various products over the period indicated. Fuel oil, though still the largest single commodity produced by the Consortium, constituted a smaller share of total production in 1962 than in 1950. Comparing 1950 to 1961, kerosine, gas/diesel oil, and bitumen all increased their shares of total output, but declines in kerosine's and bitumen's shares occurred in 1962. The percentages of total output accounted for by motor and aviation gasoline were somewhat lower in 1962 than in 1950, but aviation turbine fuel, not produced in 1950, accounted for almost 5 percent of the 1962 production.

Masjed-e Soleyman and Minor Consortium Plants

The Masjed-e Soleyman topping plant produces fuel oil principally for NIOC account: A heavy fraction, which is pumped to Abadan for further treatment, and a light fraction, of which a significant quantity is reinjected into the reservoirs. Throughput and distribution of output for 1957-61 were:

Crude throughput and production	1957	1958	1959	1960	1961
Crude throughput.....thousand barrels	23,473	16,024	16,034	15,945	22,133
Production:					
Delivered to Abadan.....do.....	12,986	6,678	4,292	5,016	8,290
Delivered to NIOC[1].....do.....	3,716	4,615	5,306	5,579	6,544
Recycled to reservoir.....do.....	5,944	4,157	5,814	4,771	6,608
Total.....do.....	22,646	15,450	15,412	15,366	21,442

[1] Apparently included under Consortium refinery output in table 11.

Several small field distillation units, with a total capacity of about 1,760 barrels of crude per day are operated exclusively for field requirements.

Naft-e Shah Topping Plant and Kermanshah Refinery

Crude runs to stills and product output at Kermanshah for 1955-61 were:

Year	Runs to stills, thousand barrels	Output, thousand barrels
1955.....	([1])	1,390.0
1956.....	1,010.3	995.1
1957.....	975.6	960.9
1958.....	883.6	870.0
1959.....	778.7	776.8
1960.....	1,005.0	949.0
1961.....	1,028.6	1,240.0

[1] Data not available.

Output by product, excluding refinery fuels and losses, is given in table 13; all finished products are obtained from the Kermanshah refinery except for the fuel oil, some of which is obtained from Naft-e Shah. Refinery fuels and losses for 1960 and 1961 are reported as 56,000 and 46,000 barrels, respectively.

The entire production from the Kermanshah refinery and Naft-e Shah topping plant is used domestically. However, in spite of increased Iranian consumption, production from the topping plant and the refinery declined every year from 1954 to 1959 because of obsolescence. A modification and modernization program completed in late 1960 led to increased output indicated above.

FOREIGN TRADE

Crude oil and petroleum products constitute Iran's largest single-industry export. During 1948/49-1950/51[6] and 1955/56-1961/62 when the industry was operating normally, the ratio of values of petroleum exports to total exports varied from a minimum of about 54 percent to a maximum of about 90 percent. The low figure was for 1955/56 when the industry had not fully recovered from the sharply reduced operations during 1951-54. Since 1955/56 this figure has increased to 87 percent in 1959/60; with 1960/61 and 1961/62 exports being roughly of the same order.

Iranian petroleum export statistics during 1948/49 to 1961/62 reveal certain trends (see table 14). Crude exports in 1961/62 were almost 4 times the prenationalization peak of 1950/51, but product exports were only 59 percent of those of 1950/51, the peak year for products. There has also been a shift in geographical distribution. In 1960/61 almost all countries took a larger quantity of crude than in 1950/51. However, the proportional share of Asia and Oceania increased in 1960/61 and that of Europe decreased.

Accurate comparison of unit value of exports is not feasible because the Iranian currency was devalued during the above period, and Iranian customs statistics do not reveal the exchange rates used for arriving at the real value of exports.

[6] Iranian trade statistics are officially reported on the basis of the Iranian calendar years, March 21 to March 20 of the succeeding year in the Gregorian calender.

TABLE 14. - Statistical summary of petroleum exports from Iran, 1948/49-1961/62 (16)

	Quantity, thousand metric tons			Value, million rials		
	Crude	Products	Total	Crude	Products	Total
1948/49.....	5,729.1	14,623.8	20,352.9	3,911.5	13,228.6	17,140.1
1949/50.....	3,960.1	17,545.1	21,505.2	2,372.7	12,936.6	15,309.3
1950/51.....	11,705.7	19,510.9	31,216.6	7,102.0	15,082.4	22,184.4
1951/52.....	2,532.6	6,511.3	9,043.9	1,636.2	5,206.3	6,842.5
1952/53.....	11.0	2.4	13.4	5.7	5.2	10.9
1953/54.....	41.7	197.2	238.9	57.3	205.8	263.1
1954/55.....	1,937.1	1,497.4	3,434.5	921.5	1,086.7	2,008.2
1955/56.....	9,928.8	5,435.9	15,364.7	5,036.9	4,368.3	9,405.2
1956/57.....	14,418.0	8,732.7	23,150.7	6,880.1	9,028.9	15,909.0
1957/58.....	19,424.6	11,689.5	31,119.1	9,373.6	9,924.2	19,297.8
1958/59.....	24,358.7	12,200.2	36,558.9	11,652.5	11,207.0	22,859.5
1959/60.....	30,302.5	11,220.7	41,523.2	30,224.9	19,224.9	49,449.8
1960/61.....	32,442.0	13,309.0	45,751.0	32,304.0	21,086.0	53,390.0
1961/62.....	41,823.0	11,521.0	53,344.0	40,244.0	16,227.0	56,451.0

Crude Exports

The 1961/62 crude export of 41,823,000 metric tons[7] was a peak for Iran's petroleum industry. In 1961, Iran ranked fourth among Middle Eastern exporting countries after Kuwait, Saudi Arabia, and Iraq, and Iran's share of total world crude export was almost 10.3 percent, ranking the country fifth among world exporters. Export of crude by tonnage and value are shown in the summary table 14 and by destination in table 15.

Destinations of Iranian crude have been influenced by changes in the world refinery distribution pattern. On a major area basis, Europe is still the largest market for Iranian crude, although with the exception of 1959/60, European deliveries since 1954/55 have constituted a smaller share of total crude exports than in 1948/49-1950/51, before nationalization. In spite of the declining European share of total, the United Kingdom remains the largest single recipient of Iranian crude oil; about 24 percent of all crude exports during 1948/49-1961/62 went to this country. The pattern of receipt of a larger volume but smaller percentage of total Iranian exports has been generally true for the Western Hemisphere. Shipments to Asia and Oceania however, have increased considerably, both on a weight and percentage basis compared to the prenationalization level. Large Indian and Australian imports have been important factors in this development. African receipts of crude from Iran showed considerable increase in 1957/58-1961/62.

[7] Iranian foreign trade data are officially reported in metric tons, and this unit has been used throughout the discussion of foreign trade, departing from the pattern of using barrels, which has been followed elsewhere in the discussion of Iran's petroleum industry. Conversion to barrels has been avoided because data before 1958/59 were not given in sufficient detail to permit application of recognized conversion factors.

TABLE 15. - Exports of crude oil from Iran by country of destination, 1948/49-1961/62 in thousand metric tons (16)

Destination	1948/49	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62
Europe:														
Belgium	52.2	80.1	90.4	6.2	-	-	15.9	271.6	552.5	850.9	1,002.9	1,428.5	1,073.0	1,232.0
France	884.4	423.1	1,608.6	415.1	-	-	228.7	1,133.4	1,408.4	1,842.3	1,535.9	2,143.9	1,086.0	862.0
Germany	20.0	7.9	34.2	-	-	-	53.4	67.0	17.6	358.7	585.9	2,241.6	3,719.0	5,678.0
Italy	591.9	109.7	410.5	116.4	10.6	37.9	246.3	979.4	461.0	395.5	573.3	2,360.2	1,434.0	990.0
Netherlands	44.4	33.6	170.7	.8	-	-	75.2	540.3	1,401.3	2,090.8	3,311.9	2,034.1	855.0	806.0
Spain	50.1	-	208.4	12.0	-	-	-	116.8	572.8	645.1	908.6	956.8	1,112.0	2,095.0
Sweden	9.1	55.3	527.5	184.3	-	-	15.0	128.5	168.5	257.9	110.9	649.0	821.0	634.0
United Kingdom	1,934.9	1,501.8	3,938.3	1,209.4	-	-	349.6	1,831.5	2,268.0	1,990.6	7,427.3	7,409.9	9,139.0	9,290.0
Other Europe	300.7	161.0	848.8	15.0	-	-	121.3	235.3	-	167.6	321.9	961.6	755.0	996.0
Western Hemisphere:														
Argentina	123.5	1,324.5	1,454.7	385.7	-	-	-	-	-	-	-	-	-	-
United States	634.9	15.1	21.1	10.2	.3	-	-	664.8	682.1	1,008.8	811.8	1,993.1	1,683.0	1,255.0
Other Western Hemisphere	68.6	15.2	10.5	-	-	.2	119.1	-	-	-	-	367.2	1,721.0	3,672.0
Middle East and Asia:														
Aden	120.6	-	62.2	36.4	-	-	-	42.9	48.3	1,715.8	482.4	319.8	824.0	1,548.0
India	218.4	27.1	397.7	48.7	-	-	59.2	1,076.2	1,828.3	2,591.6	1,138.1	2,197.3	3,029.0	3,636.0
Japan	-	-	23.2	-	-	3.5	266.6	533.3	556.7	505.7	1,103.7	964.4	957.0	2,875.0
Oman[1]	7.7	-	1.0	.9	.1	([2])	.1	-	998.5	729.5	84.5	183.3	50.0	-
Other Middle East	112.2	78.5	613.6	16.9	-	.1	-	-	157.0	-	-	-	29.0	424.0
Other Asia	71.1	27.6	218.5	23.9	-	([2])	-	-	60.1	-	-	6.2	3.0	66.0
Oceania[3]	108.3	46.5	417.2	50.7	-	-	265.6	1,692.9	2,463.7	1,813.1	2,725.5	1,867.4	1,883.0	3,057.0
Africa[4]	371.1	53.1	648.6	-	-	-	121.1	600.5	731.4	2,429.2	2,186.7	2,218.2	2,269.0	2,707.0
Destinations not specified	1.0	-	-	-	-	-	-	14.4	41.8	31.5	47.4	-	-	-
World total	5,729.1	3,960.1	11,705.7	2,532.6	11.0	41.7	1,937.1	9,928.8	14,418.0	19,424.6	24,358.7	30,302.5	32,442.0	41,823.0

[1] Exports of crude to Oman may have been actually to Bahrain or to Gulf of Oman for orders for further destinations.
[2] Less than 50 tons.
[3] Includes 65,991 tons credited to New Zealand in 1950/51; all other exports listed were to Australia.
[4] Because of statistical inconsistencies in sources, all African nations are grouped together.

Product Exports

In contrast to crude, refinery product exports have not yet attained the prenationalization maximum, with 1961/62 exports equal to 59 percent of those of 1950/51 (table 14). It is significant, however, that in 1961/62 28.7 percent of the value of exports is represented by products. The decline in this percentage in 1962 was brought about largely by increases in crude exports. The relationships of crude and refinery product exports for 1948/49-1961/62 are tabulated below in percent of all oil exports including crude oil, natural gas liquids, and their derivatives:

Year	Crude oil		Refinery products	
	Weight-percent	Value, percent	Weight-percent	Value, percent
1948/49.....	28.1	22.8	71.9	77.2
1949/50.....	18.4	15.5	81.6	84.5
1950/51.....	37.5	32.0	62.5	68.0
1951/52.....	28.0	23.9	72.0	76.1
1952/53.....	82.1	52.3	17.9	47.7
1953/54.....	17.5	21.8	82.5	78.2
1954/55.....	56.4	45.9	43.6	54.1
1955/56.....	64.6	53.6	35.4	46.4
1956/57.....	62.3	43.2	37.7	56.8
1957/58.....	62.4	48.6	37.6	51.4
1958/59.....	66.6	51.0	33.4	49.0
1959/60.....	73.0	61.1	27.0	38.9
1960/61.....	70.9	60.5	29.1	39.5
1961/62.....	78.4	71.3	21.6	28.7

There have been a number of reasons for the shift in weight and value in favor of crude shown in the above tabulation. Total world refinery throughput capacity increased by about 110 percent during the 1950-60 period and that of Western Europe--the principal market for Middle East oil--by about 300 percent. New refineries were built not only in Europe but also Aden, Kuwait, Japan, India, Australia, and smaller consuming countries such as Turkey, Jordan, and Syria to supply a greater share of internal requirements by domestic processing. Aside from the desirability of locating such an important industry as petroleum refining within national boundaries, consumer countries save in foreign exchange by having crude processed with local labor and facilities. Transportation of crude in large tankers also results in some economy to the consumer. This trend is continuing, and many countries with relatively small consumptions are planning to build refineries. Aside from these world refinery developments, competition from the British Petroleum Company refinery in Aden has also been an important factor.

Besides changes in the trend of international trade of crude and products noted above, there have been two other significant factors influencing the export of products from Iran. First, dismantling of obsolete distillation units at the Abadan refinery reduced the capacity from about 525,000 barrels per day in 1950 to 455,500 barrels per day in 1962. Relative market demands for gasolines (constituting about 20 percent of Abadan's production during 1955-61) have declined in many consuming countries in favor of middle

distillates; and motor gasoline made by Abadan's thermal reformers has a lower average octane grade than purchasing countries generally desire. Modifications in the refinery, partly completed with the inauguration of the catalytic reformer in 1962, are intended to remedy this situation and to bring refinery production more in line with the demand forecast for coming years. Second, Iran's own rising consumption has resulted in a larger offtake of Abadan products for indigenous use. In 1961, nearly 90 percent of Iran's internal consumption was supplied by the Consortium facilities and the balance of Kermanshah refinery. Total Iranian consumption of the four major products in 1961 (24,641,715 barrels) was equivalent to about 25 percent of Abadan's output for that year.

Exports of total refinery products by significant destinations and of major classes of products by continents are shown in tables 16, and 17, respectively. Exports of individual major products by destinations appear in tables 18, 19, and 20. Shipments of major products to Europe since 1954/55 have averaged about 27.3 percent of the 1950/51 peak because of the refinery construction in Europe already referred to. The decline in product exports to Europe is partly compensated for by larger shipments to some African and Asian nations (table 17). The bulk of exports of bitumen and other minor products referred to in footnotes to table 17 were shipped to a wide variety of Middle Eastern, Asian, and African countries except in 1951/52 when by far the largest share was reportedly destined for the United Kingdom.

The relative share of each major class of product in the total of product exports in years of normal operation (1948/49-1959/60) does not show a constant pattern except for kerosine, which has accounted for 9 to 16 percent of the total. For example, the share of exports accounted for by gasolines and fuel oils varied considerably, the former from 17 to 37 percent and the latter from 47 to 69 percent of the total.

Detailed information on the composition of the broad categories of "fuel oils" and "gasoline" are not available except for 1958/59-1959/60; these data appear as footnotes 4 and 5 to tables 18 and 19 respectively.

TABLE 16. - Exports of all classes of refinery products from Iran by country of destination, 1948/49-1960/61,[1] in thousand metric tons (16)

Destination	1948/49	1949/50	1950/51	1951/52	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62
Europe:												
Belgium	362.8	205.6	580.4	191.8	-	8.6	43.7	56.0	72.3	81.0	85.0	47.0
Denmark	25.2	136.0	342.8	74.8	0.1	10.6	7.9	16.0	70.1	38.1	33.0	45.0
France	196.0	121.7	198.9	112.4	.4	91.0	275.5	97.5	84.0	152.7	150.0	202.0
Germany	70.1	72.2	.8	7.7	3.5	92.1	25.4	37.3	95.6	183.6	224.0	245.0
Greece	135.8	303.3	454.9	109.5	-	39.6	18.6	13.7	55.1	46.4	88.0	34.0
Italy	606.9	269.1	612.4	202.0	73.9	59.5	41.6	109.5	145.9	216.7	197.0	175.0
Netherlands	103.6	278.7	486.9	122.7	21.0	123.1	216.9	261.1	337.0	371.1	183.0	188.0
Norway	376.8	702.2	673.3	234.7	2.6	72.8	154.0	194.5	188.0	148.9	144.0	186.0
Portugal	41.5	26.7	53.2	-	-	180.4	126.5	54.9	26.7	84.7	47.0	59.0
Spain	80.6	136.8	209.9	106.7	-	61.9	88.1	105.6	47.0	30.8	16.0	16.0
Sweden	92.8	389.9	664.3	281.1	2.3	16.9	206.5	231.9	101.6	169.7	162.0	46.0
United Kingdom	6,362.2	6,355.7	4,860.8	1,636.6	120.6	559.2	837.0	1,133.9	1,995.6	1,385.1	1,902.0	1,397.0
Western Hemisphere:												
Columbia	88.6	-	-	-	-	-	293.8	298.0	15.8	-	-	-
Panama	9.1	77.6	58.2	33.1	15.2	4.0	28.4	40.4	47.2	80.9	111.0	35.0
United States	184.3	76.2	126.5	56.9	17.4	66.9	89.4	67.9	54.7	104.9	92.0	56.0
Middle East and Asia:												
Aden	541.0	104.8	87.4	389.9	208.6	375.8	204.8	465.3	435.4	574.0	791.0	904.0
Burma	-	100.0	134.2	-	11.9	-	16.2	12.2	53.9	171.9	55.0	50.0
Ceylon	93.0	182.4	242.0	116.8	87.5	246.2	132.4	200.6	587.6	425.3	615.0	475.0
India	1,781.2	1,806.0	2,187.5	768.9	183.1	934.5	1,008.5	690.2	1,067.4	1,170.0	1,256.0	1,271.0
Iraq	154.6	185.8	160.5	96.4	4.6	16.4	24.4	32.6	24.2	1.1	3.0	3.0
Japan	-	-	3.0	-	413.6	238.6	103.8	341.1	313.0	186.4	447.0	631.0
Kuwait	139.3	384.3	28.8	39.7	26.3	335.7	591.0	1,097.9	17.9	17.9	23.0	-
Pakistan	-	252.1	482.8	257.0	42.5	238.0	445.0	1,240.6	1,233.9	950.6	1,255.0	945.0
Saudi Arabia	355.0	1,469.3	1,706.9	198.4	-	-	6.6	2.6	6.0	-	-	-
Singapore	-	149.9	227.2	89.4	7.1	104.7	116.4	-	212.7	194.4	312.0	243.0
Turkey	1.1	111.6	139.8	26.2	.8	18.3	-	82.4	59.2	93.2	-	21.0
Oceania:												
Australia	438.7	433.4	1,049.0	531.1	71.7	190.3	417.1	322.4	274.3	232.5	269.0	329.0
New Zealand	11.5	201.0	269.4	23.1	31.1	55.3	119.0	84.4	121.5	123.3	96.0	117.0
Africa:												
Egypt	704.1	1,383.3	1,178.3	241.6	52.0	193.2	251.4	-	93.9	66.8	109.0	85.0
Ethiopia	-	10.2	29.9	8.2	-	.2	.1	8.0	2.2	454.9	12.0	69.0
Sudan	48.4	76.1	-	8.1	35.4	4.6	120.1	240.4	332.0	329.2	367.0	232.0
Union of South Africa	705.2	280.4	1,328.6	147.1	63.5	332.9	83.2	-	1,204.8	1,496.0	1,186.0	([2])
Other Africa	419.7	1,049.9	597.2	332.4	.7	601.7	2,119.5	3,483.8	2,393.9	1,074.6	2,461.0	2,931.0
Other	494.7	212.9	335.1	77.0	-	162.9	519.0	671.8	429.8	564.0	618.0	483.0
World total	14,623.8	17,545.1	19,510.9	6,511.3	1,497.4	5,435.9	8,732.7	11,689.5	12,200.2	11,220.7	13,309.0	11,521.0

[1] Exports in 1952/53 and 1953/54 totalled 2.4 and 197.2 thousand tons, respectively, but are not reported by destination below. Principal recipient of 1952/53 exports was Oman (2.0 thousand tons of total); principal recipient of 1952/53 exports was Japan (153.5 thousand tons of total).

[2] Included in "Other Africa".

TABLE 17. - Exports of major classes[1] of refined products from Iran by continental destination, 1948/49-1960/61, in thousand metric tons (16)

	1948/49	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	[2]1960/61
Europe:													
Kerosine	774.6	1,410.6	932.2	272.9	-	-	38.2	81.2	101.6	81.9	64.1	72.1	-
Fuel oils	6,184.4	6,098.3	4,814.5	1,478.5	([3])	30.9	149.7	841.3	1,207.2	1,387.6	3,008.7	2,718.5	-
Gasolines	1,518.4	1,571.7	3,481.9	457.8	-	10.1	36.5	393.2	734.0	897.6	152.3	134.4	-
Others	74.4	([3])	57.1	901.0	-	-	-	-	-	-	5.7	7.5	-
Total	8,551.8	9,080.6	9,276.7	3,110.2	([3])	41.0	224.4	1,315.7	2,042.8	2,367.1	3,230.8	2,932.5	3,290.0
Western Hemisphere:													
Kerosine	31.3	58.3	3.6	4.2	-	-	-	-	9.5	6.5	-	16.0	-
Fuel oils	217.1	76.4	172.5	79.7	0.1	1.1	32.0	33.2	406.8	398.1	127.6	218.4	-
Gasolines	35.3	20.4	41.4	21.5	([3])	-	.6	37.7	24.4	7.6	5.3	18.8	-
Others	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	283.7	155.1	217.5	105.4	.1	1.1	32.6	70.9	440.7	412.2	132.9	253.2	319.0
Middle East:													
Kerosine	203.2	398.3	123.7	40.2	1.5	.4	5.1	14.8	4.3	75.9	41.0	46.8	-
Fuel oils	955.8	1,738.3	1,535.3	663.1	.3	.2	222.4	749.2	627.9	1,330.0	534.4	752.6	-
Gasolines	82.2	196.5	555.8	60.3	.1	.4	13.3	48.1	234.3	406.8	128.4	108.1	-
Others	20.2	.1	19.0	10.5	.3	.6	.1	-	-	-	6.4	13.9	-
Total	1,261.4	2,333.2	2,233.8	774.1	2.2	1.6	240.9	812.1	866.5	1,812.7	710.2	921.4	[4]996.0
Oceania:													
Kerosine	151.2	61.6	170.3	39.6	-	-	-	13.3	104.5	135.3	78.3	69.4	-
Fuel oils	120.6	396.6	386.8	262.9	-	-	65.7	127.5	104.2	37.5	162.9	111.5	-
Gasolines	178.4	176.2	717.6	241.2	-	-	37.1	104.8	327.4	234.0	153.0	174.9	-
Others	-	-	43.7	.5	-	-	-	-	-	-	1.6	-	-
Total	450.2	634.4	1,318.4	544.2	-	-	102.8	245.6	536.1	406.8	395.8	355.8	365.0
Asia:													
Kerosine	101.9	198.3	899.9	327.4	.1	([3])	95.0	418.5	742.3	840.8	951.3	1,045.2	-
Fuel oils	1,275.5	1,548.7	1,115.5	604.5	-	17.4	465.7	797.7	546.8	938.3	2,231.4	1,720.5	-
Gasolines	523.1	794.6	1,205.5	283.3	-	136.1	185.0	547.4	557.4	746.6	408.4	473.4	-
Others	7.0	-	109.6	17.9	-	-	-	-	-	-	112.5	97.1	-
Total	1,907.5	2,541.6	3,330.5	1,233.1	.1	153.5	745.7	1,763.6	1,846.5	2,525.7	3,703.6	3,336.2	[4]4,204.0
Africa:													
Kerosine	69.0	426.6	444.0	82.3	-	-	5.5	197.9	388.0	503.5	545.7	440.6	-
Fuel oils	1,290.9	1,724.2	1,372.9	473.1	-	-	78.2	492.4	912.0	1,838.4	2,273.2	1,956.2	-
Gasolines	499.1	649.1	1,285.0	172.5	-	-	67.2	442.3	1,274.3	1,384.3	1,189.7	971.9	-
Others	18.4	-	32.1	9.5	-	-	-	-	-	-	18.2	52.9	-
Total	1,877.4	2,799.9	3,134.0	737.4	-	-	150.9	1,132.6	2,574.3	3,726.2	4,026.8	3,421.5	4,135.0
Destination not specified:													
Kerosine	9.0	-	([3])	-	-	-	-	1.3	34.0	100.6	.1	-	-
Fuel oils	96.4	.2	([3])	-	-	-	.1	82.2	322.7	192.1	-	-	-
Gasolines	186.3	-	([3])	-	-	-	-	11.9	69.1	146.1	([3])	-	-
Others	.1	.1	([3])	6.9	-	-	-	-	-	-	-	-	-
Total	291.8	.3	([3])	6.9	-	-	.1	95.4	425.8	438.8	.1	-	-
World totals:													
Kerosine	1,340.2	2,553.7	2,564.7	766.6	1.6	.4	143.8	727.0	1,384.2	1,744.5	1,680.5	1,690.1	-
Fuel oils	10,140.7	11,582.7	9,397.5	3,561.8	.4	49.6	1,013.8	3,123.5	4,127.6	6,122.0	8,338.2	7,477.7	-
Gasolines	3,022.8	3,408.5	7,287.2	1,236.7	.1	146.6	339.7	1,585.4	3,220.9	3,823.0	2,037.1	1,881.5	-
Others	120.1	.2	261.5	946.3	.3	.6	.1	-	-	-	144.4	171.4	-
Grand total	14,623.8	17,545.1	19,510.9	6,511.3	2.4	197.2	1,497.4	5,435.9	8,732.7	11,689.5	12,200.2	11,220.7	13,309.0

[1] Major classes listed here are those reported in official sources, and for the period 1948/49-1957/58 are not further subdivided. So far as can be determined, the "kerosine" category includes only kerosin; "fuel oils" include gas oil, diesel oil, and true fuel oil; "gasolines" include both motor and aviation gas; "others" includes lubricating oils and grease, vaseline, asphalt and other unspecified exports in 1948/49-1957/58 and asphalt only in 1958/59-1959/60.

[2] Preliminary figures, distribution by product classes not available.

[3] Less than fifty tons.

[4] Some portion of 29.0 thousand tons credited in source to "Other Middle East and Asia" presumably was shipped to "Middle East" but is inseparable on basis of source data and has been included under "Asia."

TABLE 18. - Exports of fuel oils[1] from Iran by country of destination, 1948/49-1959/60,[2] in thousand metric tons (16)

Destination	1948/49	1949/50	1950/51	1951/52	1954/55	1955/56	1955/56	1957/58	1958/59	1959/60
Europe:										
Belgium	200.2	80.0	184.8	86.4	-	4.5	20.3	47.6	66.7	81.0
Denmark	-	92.9	222.7	61.5	-	5.0	7.6	5.5	70.1	38.1
France	67.8	81.0	108.8	96.1	-	71.4	215.1	83.4	84.0	152.7
Germany	70.1	30.5	.8	2.9	2.8	75.8	18.9	25.6	95.6	183.6
Greece	92.2	164.5	224.3	66.5	-	39.6	16.4	3.1	55.1	46.4
Italy	481.9	142.1	339.5	185.0	47.9	53.7	31.7	71.1	145.9	216.7
Netherlands	67.8	166.4	272.3	84.9	.4	70.7	106.5	244.5	322.0	367.1
Norway	290.0	417.1	470.9	204.1	-	39.1	72.0	76.8	174.4	136.9
Portugal	41.5	9.7	25.2	-	-	64.5	18.9	19.7	26.7	75.4
Spain	56.1	115.5	118.6	106.7	-	43.5	87.2	83.4	47.0	16.2
Sweden	83.2	259.6	442.0	205.6	.4	-	144.6	68.0	101.6	169.6
United Kingdom	4,689.8	4,482.7	2,340.0	352.9	98.2	373.5	467.8	656.2	1,807.7	1,223.5
Western Hemisphere:										
Columbia	88.6	-	-	15.5	-	-	293.8	298.0	15.8	-
Panama	([3])	23.4	45.6	33.1	15.2	4.0	22.4	36.6	47.2	67.5
United States	128.5	53.0	94.1	31.2	16.8	29.2	61.5	63.5	49.4	92.3
Middle East and Asia:										
Aden	349.8	97.3	87.3	366.5	201.1	343.6	117.4	376.0	428.1	522.8
Burma	-	37.7	11.9	-	11.9	-	16.2	-	22.3	164.0
Ceylon	28.3	133.5	98.5	81.2	34.3	149.1	-	-	442.8	214.4
India	1,247.2	1,157.7	731.0	345.9	100.8	374.6	177.1	38.5	320.9	275.5
Iraq	94.9	151.5	71.4	50.7	-	4.7	7.5	.2	11.7	-
Japan	-	-	3.0	-	285.5	91.3	69.5	214.1	306.8	177.1
Kuwait	111.5	285.8	24.7	37.6	20.5	329.7	499.6	921.3	-	([3])
Pakistan	-	134.3	253.9	177.4	33.2	181.1	261.3	666.5	957.6	678.6
Saudi Arabia	334.8	1,109.4	1,315.2	198.2	-	-	-	-	-	-
Turkey	-	57.2	17.0	6.7	.8	9.0	-	.9	31.2	42.0
Oceania:										
Australia	119.2	258.4	294.4	239.9	65.7	112.6	47.4	37.5	100.7	70.6
New Zealand	1.4	138.2	92.4	23.0	-	14.9	56.8	-	62.2	40.9
Africa:										
East Africa	107.8	497.6	125.3	107.5	-	-	-	-	922.7	.7
Egypt	618.4	1,029.2	690.5	194.5	40.3	156.3	190.0	-	73.1	43.2
Sudan	28.1	54.3	-	8.1	23.5	3.0	59.1	157.7	231.4	228.3
Union of South Africa	374.4	75.5	445.2	62.3	14.4	332.9	-	-	640.9	777.4
Other	367.2	246.7	246.2	129.9	.1	146.2	1,041.0	1,926.3	676.6	1,348.2
World total	10,140.7	11,582.7	9,397.5	3,561.8	1,013.8	3,123.5	4,127.6	6,122.0	[4]8,338.2	[5]7,477.7

[1] Includes gas oil, diesel oil, and fuel oils.

[2] Exports in 1952/53 and 1953/54 totalled 0.4 and 49.6 thousand metric tons respectively, but are not given by destination.

[3] Less than 50 tons.

[4] Detailed breakdown by type was as follows, in thousands metric tons: Gas oil 1,139; diesel oil 1,731; and residual fuel oil and other 5,468.

[5] Detailed breakdown by type was as follows, in thousands metric tons: Gas oil 1,178; diesel oil 927; and residual fuel oil and other 5,373.

TABLE 19. - Exports of gasolines[1] from Iran by country of destination, 1948/49-1959/60[2] in thousand metric tons (16)

Destination	1948/49	1949/50	1950/51	1951/52	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60
Europe:										
Belgium	140.9	99.8	362.3	82.0	-	4.1	22.7	8.3	5.6	-
Denmark	25.2	10.9	105.8	13.3	0.1	5.6	.3	10.5	-	-
France	32.4	26.6	84.4	16.3	.4	19.6	60.4	14.1	-	-
Greece	34.6	91.4	187.3	32.0	-	-	2.2	10.6	-	-
Italy	49.0	65.2	269.5	14.3	.3	5.8	9.9	38.3	-	-
Netherlands	35.8	65.8	174.9	31.0	20.6	26.8	108.6	-	-	(3)
Norway	44.0	120.7	162.6	27.9	2.6	33.7	82.0	117.7	13.0	12.0
Portugal	-	-	28.0	-	-	83.6	63.8	31.8	-	-
Spain	24.5	9.6	90.0	-	-	18.4	.9	22.2	-	11.1
Sweden	8.8	68.1	142.1	47.9	1.9	16.9	58.8	162.3	-	.1
Switzerland	45.6	5.1	46.0	4.3	-	-	-	52.5	-	-
United Kingdom	1,069.9	973.5	1,804.5	187.0	9.9	162.4	317.9	417.6	133.7	106.1
Western Hemisphere: United States	35.3	-	29.3	215.	.6	37.7	18.4	3.8	5.3	-
Middle East and Asia:										
Aden	22.3	-	-	13.7	7.5	32.2	87.4	46.9	6.2	35.9
Ceylon	39.3	35.0	117.4	25.7	43.9	67.3	88.0	122.5	77.2	67.9
India	451.5	539.2	727.2	176.2	10.8	201.1	287.6	100.5	101.2	172.4
Iraq	34.9	29.3	55.9	18.4	-	6.2	16.7	32.4	12.4	.9
Japan	-	-	-	-	113.9	147.3	30.9	118.0	6.2	9.3
Kuwait	11.7	15.0	1.7	1.3	5.3	6.0	88.5	159.3	17.9	14.5
Pakistan	-	81.7	140.7	38.3	9.3	42.6	100.3	377.2	99.2	94.1
Saudi Arabia	8.0	58.7	359.3	(3)	-	-	6.6	2.6	6.0	-
Singapore	-	89.8	135.3	43.1	7.1	89.1	49.1	-	62.2	83.0
Turkey	-	53.5	79.1	8.5	-	-	-	69.2	13.1	31.4
Oceania:										
Australia	168.3	140.9	572.0	241.2	6.0	65.4	274.0	158.2	111.4	109.5
New Zealand	10.1	35.3	145.6	-	31.1	39.4	53.4	75.8	41.6	65.4
Africa:										
Egypt	52.9	112.6	329.6	22.5	11.7	23.7	47.9	-	14.6	18.8
Sudan	20.3	18.3	-	-	11.9	1.6	57.1	62.0	87.4	63.1
Union of South Africa	292.3	110.2	617.2	51.2	43.6	-	65.2	-	367.1	500.7
Other Africa	133.6	408.0	338.2	98.8	-	417.0	1,104.1	1,322.3	720.6	389.3
Other	231.6	144.3	181.3	20.2	1.2	31.9	118.2	286.4	135.2	96.0
World total	3,022.8	3,408.5	7,287.2	1,236.6	339.7	1,585.4	3,220.9	3,823.0	[4]2,037.1	[5]1,881.5

[1] Includes motor gas and aviation gas.

[2] Exports in 1952/53 and 1953/54 totalled 0.1 and 146.6 thousand metric tons respectively, but are not given by destination.

[3] Less than 50 tons.

[4] Detailed breakdown by type was as follows, in thousand metric tons: Aviation spirit 517; motor spirit 1,520.

[5] Detailed breakdown by type was as follows, in thousand metric tons: Aviation spirit 460; motor spirit 1,421.

TABLE 20. - Exports of kerosine from Iran by country of destination, 1948/49-1959/60,[1] in thousand metric tons (16)

Destination	1948/49	1949/50	1950/51	1951/52	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60
Europe:										
Belgium	21.7	25.8	33.3	23.4	-	-	0.7	0.1	-	-
France	95.8	14.1	5.7	-	-	-	-	-	-	-
Greece	9.0	47.4	43.3	11.0	-	-	-	-	-	-
Italy	76.0	61.8	3.4	2.7	25.7	-	-	.1	-	-
Netherlands	-	46.5	39.7	6.8	-	25.6	1.8	16.6	15.0	4.0
Norway	42.8	164.4	39.8	2.7	-	-	-	-	.6	-
Sweden	.8	62.2	80.2	27.6	-	-	3.1	1.6	-	-
United Kingdom	528.5	899.5	659.2	195.7	12.5	23.3	52.2	60.1	48.5	55.3
Western Hemisphere:										
United States	20.5	23.2	3.1	4.2	-	-	9.5	.6	-	12.6
Middle East and Asia:										
Aden	168.9	7.5	.1	9.7	-	-	(2)	42.4	(2)	11.1
Burma	-	39.2	40.0	-	-	-	-	5.6	1.7	6.1
Ceylon	18.4	13.9	26.1	9.9	9.3	29.8	44.4	78.1	60.8	87.5
India	82.5	109.1	673.1	238.1	71.5	358.8	543.8	551.2	630.5	714.2
Iraq	8.6	4.9	25.0	20.9	4.6	5.5	.2	-	(2)	.2
Kuwait	12.2	83.5	2.0	.4	.4	-	2.9	17.3	-	3.4
Pakistan	-	36.1	80.8	33.1	-	14.3	83.4	196.9	149.0	153.2
Saudi Arabia	12.1	301.2	29.6	.2	-	-	-	-	-	-
Singapore	-	-	77.0	46.3	-	15.6	67.3	-	65.8	56.6
Turkey	1.1	.9	43.3	7.3	-	9.3	-	12.3	14.9	19.8
Oceania:										
Australia	151.2	34.1	147.5	39.6	-	12.3	95.7	126.7	62.2	52.4
New Zealand	-	27.5	22.8	(2)	-	1.0	8.8	8.6	16.1	17.0
Africa:										
East Africa	-	86.9	30.4	15.9	-	184.7	352.6	482.8	284.0	1.5
Egypt	30.7	241.5	158.2	24.6	-	13.2	13.5	-	-	3.0
Union of South Africa	38.3	94.7	235.8	33.6	5.5	-	18.0	-	196.8	217.9
Other	21.1	127.8	65.3	12.9	14.3	33.6	86.3	143.5	134.6	274.3
World total	1,340.2	2,553.7	2,564.7	766.6	143.8	727.0	1,384.2	1,744.5	1,680.5	1,690.1

[1] Exports in 1952/53-1953/54 totalled 1.6 and 0.4 thousand metric tons, respectively, but are not given by destination.

[2] Less than 50 tons.

Unit Value of Exports

Values of crude and product exports per ton for 1951/52 and 1959/60 as indicated in Iranian customs statistics were:

Commodity	1951/52, rials/ton	1959/60, rials/ton
Crude	646	997
Gasoline	1,236	2,442
Kerosine	941	2,398
Diesel oil	[1]658	2,040
Gas oil		2,280
Fuel oil		883
Other (chiefly bitumen)	643	1,291

[1] Largely fuel oil; comparable figure for 1959/60 based on weighted average for all combustible oils is 1,247 rials.

The relative amount of foreign exchange accrued by exports is not reflected in the figures because the Iranian rial was devalued in 1957 from US$1.00 equals 32.5 rials to US$1.00 equals 75 rials. The principal difficulty in making a meaningful comparison of unit value of crude and products is that it is not possible to determine at what rate of exchange the rial value of exports were calculated by the customs authorities in any given year.

Imports

Iranian imports of petroleum products have not been significant; data for 1945/46-1959/60 are given in table 21. Lubricants have been the most important item in recent years. Modest amounts of other refinery products such as phenol, naphthalene, anthracene, vaseline, and paraffins are also imported but are not included in the table of imports because of their wide variety, small volume, and highly specialized and essentially nonfuel uses. The unusually large imports of lubricating oil in 1949/50, that is, 403,435 metric tons, and the large exports of lubricants, bitumen, etc., classed as "Others" in 1950/51 and 1951/52 (table 17) cannot be explained.

CONSUMPTION

Refinery Products

The role of the petroleum industry in the economy of Iran as a supplier of domestic petroleum requirements is overshadowed by the importance of the industry in the country's export trade and balance of payments. Yet availability of petroleum products in all parts of Iran, no matter how remote, and for most items at modest and uniform prices, without the outlay of foreign exchange is an aid to the country's economy. The value of petroleum products consumed in Iran during 1961 (based on 1959 prices) approximates US$116.6 million of foreign exchange. Consumption has increased rapidly during the last decade, reflecting expansion of industry and of transportation as well as a rising standard of living. Simultaneously, there has been a change in the

percentage of various products within total consumption resulting from increasing use of diesel equipment; per capita consumption in the Tehran area is nearly twice the national average.

TABLE 21. - Imports of petroleum to Iran products by commodity, 1945/46-1960/61, in metric tons (16)

	Gasoline	Kerosine	Fuel oils	Diesel oils	Lubricating oils	Asphalts	Unspecified refined products	Total
1945/46...	3,438	9,405	1,503	3,824	8,101	69	-	26,340
1946/47...	6,692	28,665	10,227	7,425	8,026	87	-	61,122
1947/48...	6,787	14,191	4,035	5,412	12,195	1,077	-	43,697
1948/49...	7,311	6,073	1,003	1,954	14,260	6	-	30,607
1949/50...	28	6	23	603	403,435	102	-	404,197
1950/51...	151	210	1,770	157	13,246	(1)	-	15,534
1951/52...	(1)	3	1,230	27	5,674	(1)	-	6,934
1952/53...	6	15	1,131	230	4,113	24	-	5,519
1953/54...	-	-	1	160	14,111	-	273	14,545
1954/55...	188	-	16	210	7,677	(1)	251	8,342
1955/56...	(1)	-	-	61	27,818	(1)	367	28,246
1956/57...	190	-	-	108	17,910	-	35	18,243
1957/58...	-	-	(1)	142	14,114	-	-	14,256
1958/59...	4	-	65	325	20,858	-	14	21,266
1959/60...	1	-	4	92	18,054	-	-	18,151
1960/61...	4	-	523	280	26,015	1,039	6	27,867

[1]Less than 0.5 metric ton.

During the 12-year period, 1950-61, consumption of refined petroleum products by consumers other than the petroleum industry increased 311 percent compared with a 98 percent increase for the entire free world and a 264 percent increase for Western Europe. The 1961 per capita consumption in Iran was 1.26 barrels, compared with 0.11 in India, 2.3 in Japan, and 19.4 in the United States. Consumption by type of product during the period 1950-62 (exclusive of Consortium and NIOC consumption) based on actual NIOC sales, are given in table 22 and shown in figure 18. Allowing for oil industry consumption, the 1962 estimated total exceeded 30 million barrels of liquid refined products (gasoline, kerosine, fuel oil, gas/diesel oil, aviation fuels, solvents, lubricating oils and bitumen) and 3,000 metric tons of miscellaneous products (butane, propane, wax, grease and other minor products not convertible from reported weight units to volumetric units). Table 23 lists consumption of minor refinery products for 1958 and 1959, by type.

Although annual fuel oil consumption increased 200 percent between 1950 and 1962, its share of total consumption declined from 41.0 percent in 1950 to 28.3 percent in 1962 (fig. 19). In 1959, powerplants, sugar refineries, and cement and textile plants consumed about 40 percent of this fuel oil; public baths, bakeries, and other small consumers took 35 percent; brick, lime, and other kilns accounted for 20 percent; and railroads consumed 5 percent (25).

TABLE 22. - Consumption[1] of principal refined petroleum products in Iran 1950-60 (excluding oil industry consumption, 1954-60) in thousand barrels (25, 28)

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Gasoline[2]	1,547	2,040	1,740	1,950	2,170	2,847	2,679	2,916	3,296	3,615	3,935	4,056
Kerosine	1,704	2,186	2,100	2,576	2,213	3,147	3,741	4,484	4,729	5,574	6,137	6,866
Gas/diesel oil	528	768	834	1,014	1,210	1,938	1,871	2,420	3,300	4,479	5,353	6,125
Fuel oil	2,654	2,868	3,050	3,800	4,880	4,385	5,251	4,777	5,499	6,459	7,212	7,595
Lubricating oils	-	[3]108	[3]100	[3]100	[3]100	125	([4])	([4])	88	95	([4])	([4])
Bitumen	-	[3]100	[3]100	[3]100	[3]100	176	([4])	([4])	11	13	([4])	([4])
Other[5]	42	-	-	-	-	-	561	1,032	737	948	1,801	1,947
Total[6]	6,475	8,070	7,924	9,540	10,673	12,618	14,103	15,629	17,660	21,183	24,439	26,589

[1] Largely based on internal sales.
[2] Excludes aviation gasoline.
[3] Estimate.
[4] Included in other.
[5] Includes 41,500 barrels of aviation gasoline in 1950; 237,000 barrels of aviation gasoline and 88,000 barrels of aviation turbine fuels in 1958; 225,000 barrels of aviation gasoline and 182,000 barrels of aviation turbine fuels in 1959; and unspecified quantities of these products in 1956, 1957, and 1960.
[6] Total of listed figures only; annual totals 1950-59 do not include butane, propane, wax, grease, vaseline, and solid paraffin; annual totals 1950-55, in addition, do not include aviation turbine fuels, solvent, insecticide base, ether, benzine, turpentine, hemp oil, liquid paraffin, and other unspecified products; annual totals 1951-55 do not include aviation gasoline.

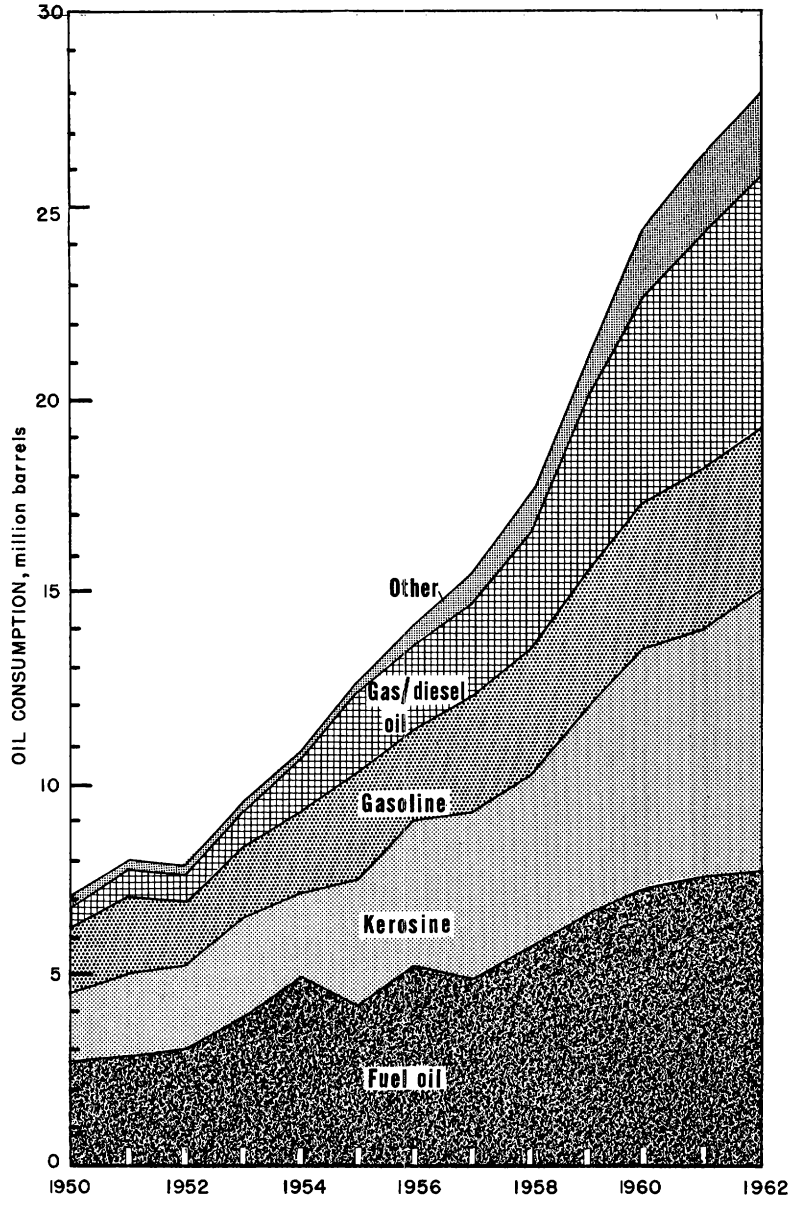


FIGURE 18. - Consumption of Petroleum Products by Type, Iran, 1950-62, Excluding Oil Industry Consumption (25, 28).

Simultaneous with the relative decrease in fuel oil consumption, there was an increase in total volume and percentage of gas/diesel oil consumption. A major cause for the shift has been conversion of the Trans-Iranian railway from oil-fired steam to diesel engines, principally during 1957-59. Increase in the number of diesel-powered trucks also was a contributing factor. The relative rank of principal gas/diesel oil consumers in 1959 was as follows: Diesel trucks, 35 percent; railroad locomotives, 11 percent; diesel-powered generators in factories, 15 percent; and diesel-powered utility plants, 11 percent. Other consumers include agricultural equipment and construction equipment.

The marked increase in gasoline (as well as diesel oil) consumption was brought about by an increase in the number of cars and commercial vehicles (table 24), which more than doubled between 1954 and 1959.

Kerosine is probably the most widely used fuel in Iran. It is utilized for illumination in the smallest peasant hut and for space heating and cooking in many middle and and high income dwellings. Kerosine sales in 1962 were about 4.3 times those of 1950, largely as a result of better distribution and the government's program of selling kerosine at uniform prices throughout the country. This program was initiated primarily to encourage the use of kerosine as a substitute for solid fuels, primarily forest products, which are in short supply and not uniformly available in all parts of the country.

TABLE 23. - Consumption[1] of minor refinery products in Iran by type (excluding consumption of Consortium Companies), 1958-59

Product	1958	1959
Imshi (insecticide base)....thousand barrels	5.6	6.4
Solvents (409 and 410)....do....	20.3	19.2
Benzine....do....	.9	1.0
Ether....do....	.9	.6
Turpentine....do....	3.0	4.5
Hemp oil....do....	.5	.7
Paraffin (liquid)....do....	3.0	2.3
Unspecified....do....	378.1	506.5
Total....do....	412.3	541.2
Butane and propane....metric tons	550	1,566
Grease....do....	615	780
Vaseline....do....	179	156
Paraffin (solid)....do....	482	255

[1] Internal sales.

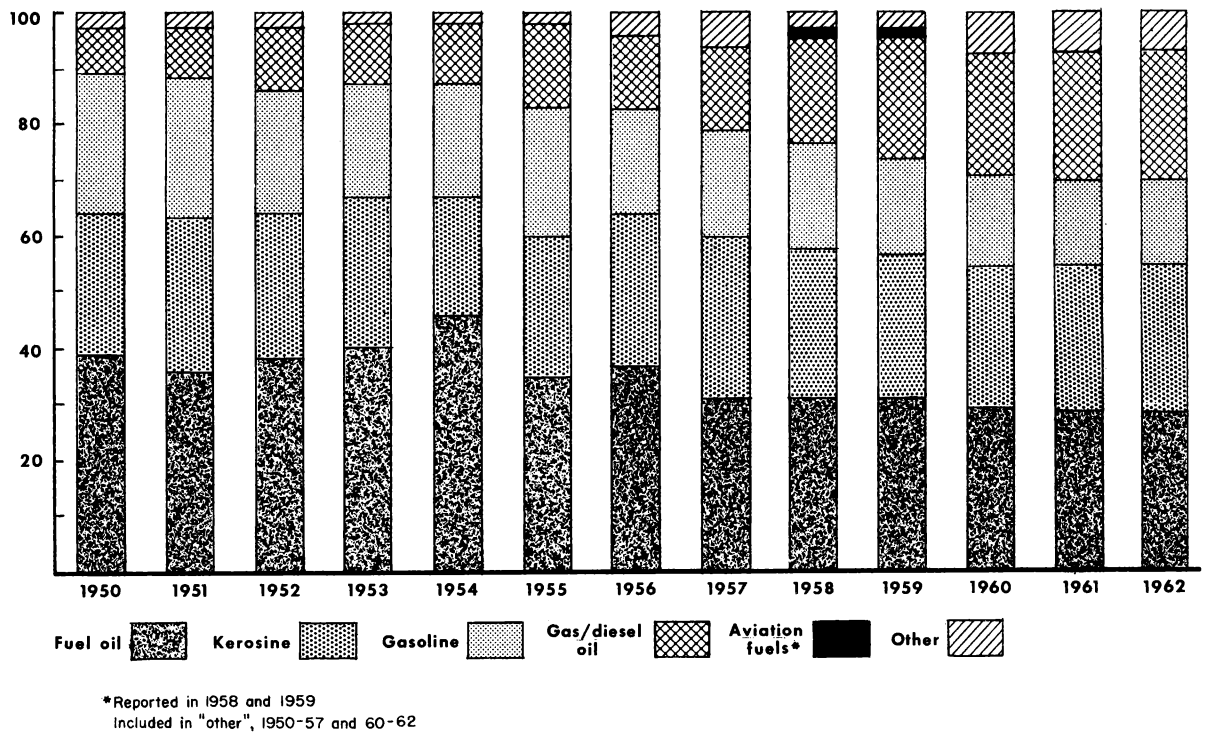


FIGURE 19. - Percentage Distribution of Petroleum Consumption by Major Classes of Products, Iran, 1950-62, Excluding Consumption by the Oil Industry.

TABLE 24. - Number of cars, trucks, busses, and motorcycles in use in Iran and percentage of all such vehicles in each class, 1954-59

	1954	1955	1956	1957	1958	1959
Cars	17,000	29,100	39,600	44,500	63,000	66,200
Trucks	26,500	18,800	21,300	21,900	27,800	28,500
Busses	3,200	5,800	6,500	6,600	7,000	7,100
Total	46,700	53,700	67,400	73,000	97,800	101,800
Motorcycles	2,300	3,200	3,400	4,500	6,100	7,500
Grand total	49,000	56,900	70,800	77,500	103,900	109,300
Cars, percent	34.7	51.2	55.9	57.4	60.6	60.5
Trucks, do.	54.1	33.0	30.1	28.3	26.8	26.1
Busses, do.	6.5	10.2	9.2	8.5	6.7	6.5
Total, do.	95.3	94.4	95.2	94.2	94.1	93.1
Motorcycles, do.	4.7	5.6	4.8	5.8	5.9	6.9

Iran has now three international airports (Tehran, Abadan, and Zahedan) and eight or more domestic commercial airports. As a result of international and domestic flights, consumption of aviation fuel (gasoline and turbine fuel) increased from 41,500 in 1950 to 407,000 barrels in 1959, the last year for which turbine fuels were separately reported.

Starting in 1957, butane and propane gases have been marketed, mainly in Tehran, Ahvaz, and Esfahan. First considered a luxury fuel, its consumption has increased with the importing of and local servicing of gas burner equipment. Consumption increased from 70 metric tons in 1957 to 2,600 tons in 1959.

Consumption in Iran by consumers other than the petroleum industry is concentrated in cities, and of these, Tehran's share is much the largest. In 1959 this area, with about 20 percent of Iran's population, consumed almost 40 percent of the total fuel oil, kerosine, gasoline, gas/diesel oil, and aviation fuel used in the country and averaged better than 2.08 barrels per capita consumption compared with a 1.05-barrel national average and a 0.80-barrel average for Iran exclusive of the Tehran district. Consumption credited to this district increased to 51 percent of the total in 1961, but partly because the district was enlarged. Imbalance results in part from disproportionate concentration of industries, commercial houses, and air flights at Tehran. The population of the city also enjoys a higher standard of living than the rest of the country. Internal sales of the total of the five major products (fuel oil, kerosine, gas/diesel oil, gasoline, and aviation fuels) by district are shown in table 25.

Data on the consumption of refined petroleum products by the Consortium is available only for 1958, when it was reported to have been over 2.8 million barrels distributed thusly:

Products	Consortium consumption, barrels		
	Refining company	Producing company	Total
Aviation gasoline.....	8	8,447	8,455
Motor gas.....	43,909	83,508	127,417
Kerosine.....	19,214	10,846	30,060
Special solvents.....	2,846	428	3,274
Gas oil.....	65,515	92,402	157,917
Diesel oil.....	24,493	23,548	42,041
Fuel oil.....	2,263,002	54,142	2,317,144
LPG.....	4,984	425	5,409
Imshi.....	2,737	1,683	4,420
Lubricating oil.....	7,832	10,215	18,047
Bitumen.....	24,988	67,370	92,358
Total.....	2,459,528	353,014	2,812,542

Presuming that Consortium consumption has changed only modestly since 1958, it ranks as the largest single consumer of fuel oil in Iran.

Data on consumption of refinery products by NIOC are not available.

TABLE 25. - Distribution of total petroleum product consumption by districts in Iran, 1958-59 (29)

District	1958	1959
Tehran.....percent	38.7	39.5
Khuzistan.....do...	13.9	12.1
Azerbaijan.....do...	7.9	7.8
Gilan and Mazandaran.....do...	6.9	7.3
Kermanshah and Hamadan.....do...	6.7	6.8
Esfahan.....do...	6.3	6.6
Khorasan.....do...	5.1	5.6
Fars.....do...	4.7	4.6
Kerman.....do...	1.8	1.7
Others.....do...	8.0	8.0

Natural Gas

Although by 1962 consumption of natural gas (as a fuel) in Iran had increased almost 140 percent over the level attained in 1956, a very large share of total natural gas output is still not utilized. In 1962, for example, 66.96 percent of the total production of 324,280 million cubic feet was flared without being put to any use, and an additional 21.59 percent was flared after being used expansively for driving turbines (a nonfuel use), as shown in table 26. Only 11.45 percent, or 37,143 million cubic feet, was utilized for its heat value, this almost exclusively by the petroleum industry. The Consortium uses gas principally as fuel for raising steam for the power plant and refinery at Abadan; lesser quantities are consumed in forges, foundry shops, and plaster kilns and as household fuels in the workers homes both at Abadan and in the fields. In addition, gas has been utilized at Masjed-e Soleyman in gas lifts for certain of the producing wells, and gas derived from Naft-e Safid is piped to a gas turbine power plant at Tembi. The NIOC consumes gas that it produces at Naft-e Shah field as an industrial fuel.

TABLE 26. - Production and consumption of natural gas in Iran, 1956-62 (28, 32)

Producer and use	1956		1957		1958		1959	
	Million cubic feet	Percent[1]	Million cubic feet	Percent[1]	Million cubic feet	Percent[1]	Million cubic feet	Percent[1]
NIOC:								
Utilized	756.93	59.84	793.37	60.99	816.86	61.66	825.30	60.99
Flared	508.01	40.16	507.39	39.01	507.87	38.34	527.79	39.01
Total production	1,264.94	100.00	1,300.76	100.00	1,324.73	100.00	1,353.09	100.00
Consortium:								
Utilized	14,794.80	10.53	24,784.88	13.62	25,470.99	12.45	31,230.05	13.30
Used expansively, then flared	23,852.60	16.98	41,149.72	22.61	53,259.93	26.02	58,796.95	25.04
Flared	101,836.82	72.49	116,057.16	63.77	125,915.13	61.53	144,740.11	61.66
Total production	140,484.22	100.00	181,991.76	100.00	204,646.05	100.00	234,767.11	100.00
Iran:								
Utilized	15,551.73	10.97	25,578.25	13.96	26,287.85	12.76	32,055.35	13.58
Used expansively, then flared	23,852.60	16.83	41,149.72	22.45	53,259.93	25.86	58,796.95	24.90
Flared	102,344.83	72.20	116,564.55	63.59	126,423.00	61.38	145,267.90	61.52
Production, grand total	141,749.16	100.00	183,292.52	100.00	205,970.78	100.00	236,120.20	100.00

Producer and use	1960		1961		1962	
	Million cubic feet	Percent[1]	Million cubic feet	Percent[1]	Million cubic feet	Percent[1]
NIOC:						
Utilized	869.64	51.84	756.48	35.61	681.54	31.51
Flared	807.93	48.16	1,367.89	64.39	1,481.20	68.49
Total production	1,677.57	100.00	2,124.37	100.00	2,162.74	100.00
Consortium:						
Utilized	35,429.55	13.40	33,963.65	11.53	36,461.81	11.32
Used expansively, then flared	68,063.96	25.73	69,501.36	23.60	70,017,16	21.74
Flared	160,960.68	60.87	191,057.20	64.87	215,638.60	66.94
Total production	264,454.19	100.00	294,522.21	100.00	332,117.57	100.00
Iran:						
Utilized	36,299.19	13.64	34,720.13	11.70	37,143.35	11.45
Used expansively, then flared	68,063.96	25.58	69,501.36	23.43	70,017.16	21.59
Flared	161,768.61	60.78	192,425.09	64.87	217,119.80	66.96
Production, grand total	266,131.76	100.00	296,646.58	100.00	324,280.31	100.00

[1] Percentage given for NIOC and Consortium are percentages of their individual production; those given for Iranian total are of national production total.

Considerable effort is being made to increase consumption of natural gas in the country. The fertilizer plant under construction in Shiraz will use natural gas as a source of hydrogen for making ammonia. In addition, a sugar mill, other industries, and private residences in the Shiraz area are expected eventually to consume natural gas delivered to that city by the new pipeline from Gach Saran. In September, 1961, NIOC announced that it would construct a natural gas pipeline from its Sarajeh field to Tehran. This gas would partially replace fuel oil, which must be transported from the southern fields, mostly via the single track Trans-Iranian railroad. The capacity of this rail line is insufficient to carry Tehran's anticipated requirements; thus, utilization of Sarajeh natural gas could fill an important economic need.

The possibility of the development of a petrochemical (polyvinyl chloride) plant at Ahvaz using natural gas piped from Agha Jari was studied by the Khuzistan Development Authority in 1959. This agency, acting for the Plan Organization, arranged for designing of such a facility by Montecatini of Italy. Plans were well along when the Plan Organization decided to "classify the project for the private sector of the economy." No further significant development has been reported.

In early 1961, NIOC announced the establishment of a Gas Utilization Company in conjunction with a French firm and a Swiss firm. The company was formed "to advise and assist Iranian industrial plants in Tehran and Shiraz in adapting their existing equipment to utilize natural gas, which will shortly be available in these two cities." The ownership of the firm is 51 percent NIOC and 24.5 percent, each, French and Swiss.

REFINERIES AND RELATED FACILITIES

At the end of 1962 the crude input capacity of Iranian refineries was reportedly more than 544,000 barrels per stream day, of which more than 84 percent was accounted for by the Abadan installation. Other plants include the Masjed-e Soleyman topping plant and four field distillations units all controlled by the Consortium and the Naft-e Shah topping plant and Kermanshah refinery of the NIOC. Products from Abadan are both exported and marketed in Iran. Fuel oil and gas oil from Masjed-e Soleyman, fuel oil from Naft-e Shah, and the entire output of Kermanshah refinery are for domestic consumption. Other facilities provide only fuel for field consumption and/or semifinished products that subsequently are refined in Abadan and Kermanshah plants.

Abadan Refinery

Capacity

Abadan still ranks as the second largest single refinery in the world, in spite of the extensive global refinery construction programs of the past 15 years and the decline in the rated economic capacity of Abadan itself. This capacity was reported as 412,000 barrels per day in 1961 by Dr. J. E. Carruthers of the Consortium (8), and has been increased to 455,500 barrels per day in 1962.

Abadan was first put in operation in 1911, with a design capacity of about 2,500 barrels per stream day. This capacity was increased to about 20,000 barrels by 1918 and to more than 60,000 barrels by 1922. Expansion continued through the 1930's; the capacity rose from about 100,000 barrels per day in 1930 to over 200,000 barrels per day in 1939. Additions to this plant to increase output generally and output of aviation gasoline in particular to meet Allied needs during World War II raised the rated daily capacity to about 350,000 barrels per day in 1945; by 1947, actual operating capacity was approximately 495,000 barrels per day. In spite of stress on output of aviation gas, product diversity also increased, so that by 1951, when the lubricant plant was installed, virtually all types of products were readily attainable from Abadan.

Data on the type and number of units and capacity of various sections are given below. The bulk of the data is as of mid-1960 but information from sources dated 1948 and 1956 are also included if the information is believed to be still valid. Figures 20, 21, and 22 are general views of the refinery.

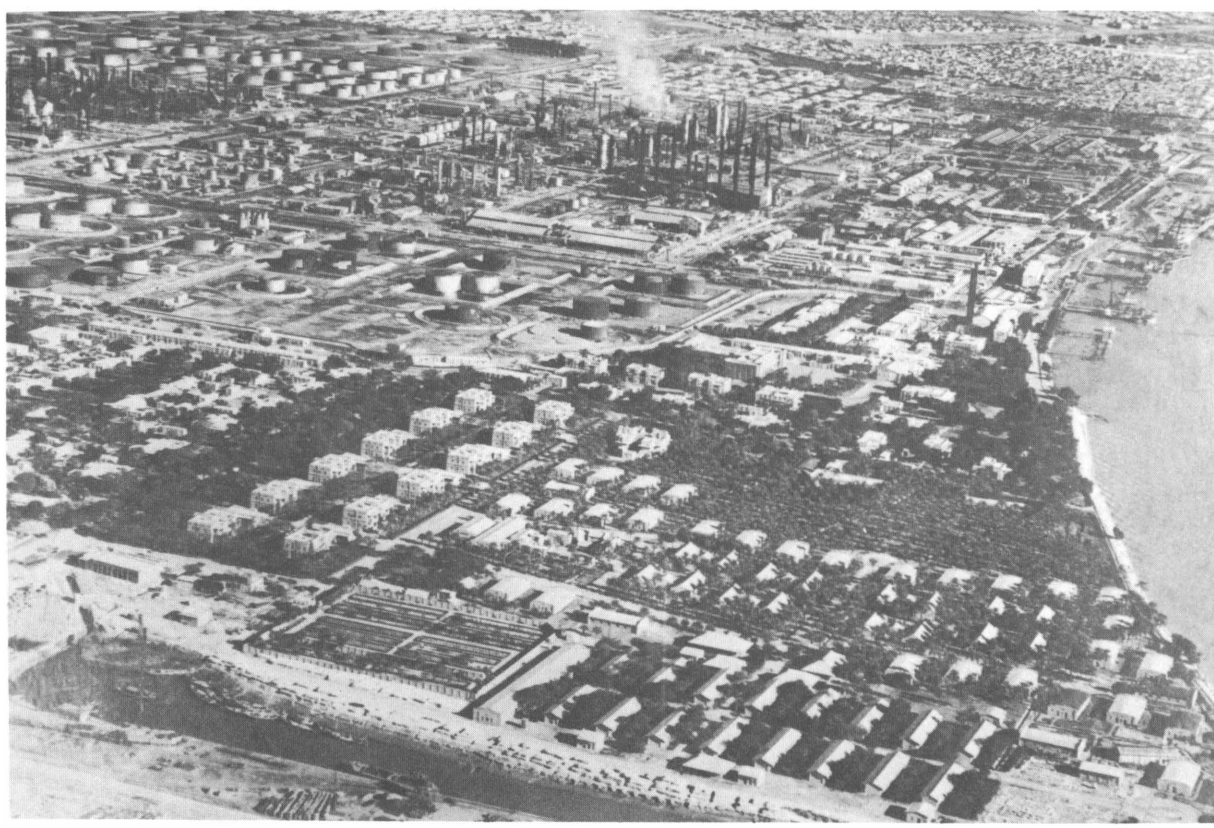


FIGURE 20. - Aerial View of Abadan Refinery Looking Southeast. The Shatt-el Arab appears along the right edge of the photo.

FIGURE 21. - General View of Abadan Refinery Looking Almost Due North From the Crude Oil and Bitumen Distillation Area. One of the primary distillation towers can be seen to the right of the black stack in the foreground. The catalytic cracking tower is on the horizon behind the left group of stacks. *(Courtesy of NIOC.)*

FIGURE 22. - General View of Abadan Refinery Looking Almost Due South From the Vicinity of the Catalytic Cracking Unit. Special products area boilers are in right foreground, and flare area is in left middle background.

Unit	Number of units	Capacity, barrels per day
Atmospheric distillation	9	412,000
Vacuum distillation	6	74,000
Thermal reforming	10	81,000
Catalytic reforming	1	20,000
Catalytic cracking	1	35,000
Alkylation	3	10,000
Isomerization		15,000
SO_2 extraction:		
Kerosine	4	44,000
Aviation aromatics	1	20,000
Furfural extraction	1	1,000
Washeries and special treatment[1]	37	[1] 532,000
Asphalt plant	1	5,000
Lubricants plant	1	380

[1] Includes caustic, bleach, sulfuric acid, and plumbite units.

Refinery Equipment and Operation

The description of Abadan refinery operations and the flowsheet (fig. 23) in this report are based primarily upon a simplified schematic flowsheet prepared by the Consortium in 1962. The flowsheet incorporates plant revisions through and including the installation of the catalytic reformer in mid-1962. Earlier information has also been utilized; foremost among these are a description and flowsheet of the Abadan refinery published in the special Middle East issue of Petroleum Times dated June 1948 (36), and a revised flowsheet without any accompanying text published in the special Middle East review issue of Petroleum Times, April 10, 1959 (37). It should be noted that figure 23 does not show refinery circuits for production of special boiling point spirits since these products are not included in the Consortium schematic referred to above. However, statistics indicate that production of these items has not been stopped, and for that reason, the general scheme of production as given in the Petroleum Times of April 10, 1959, is described in the text below.

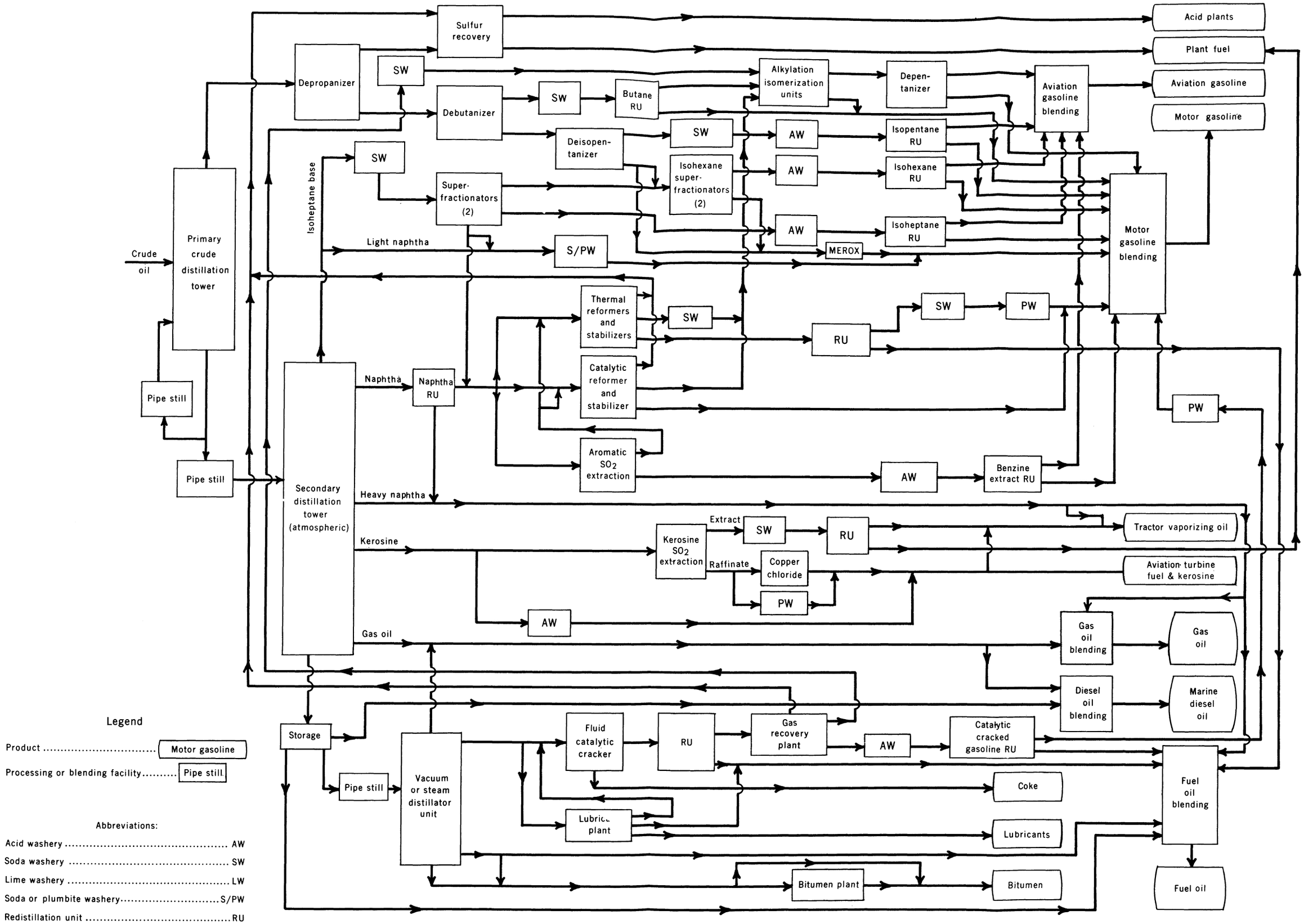
Aviation and motor gasoline constituents, special-boiling-point liquids, kerosine, and tractor vaporizing oil are all subjected to chemical refining and redistillation before blending and/or direct distribution. Gas oil and fuel oil are simply blended from their various constituents; bitumen and lubricants are derived in the various forms required from specialty plants.

All crude oil is fed to one of the primary crude distillation towers (fig. 24) after heating to about 335° F by heat exchange against hot products. These towers (fig. 23), which operate at 50 to 60 psi produce a liquid overhead (primary flash distillate) and a residue.

The primary flash distillate is fed to depropanizers, debutanizers, deisopentanizers, and a number of superfractionators in series that extract propane for use as plant fuel, and subdivide the other constituents. The bulk of these are subsequently treated by various washeries, redistillation units, and isomerization-alkylation units and are then blended with other products to produce aviation and motor gasolines.

The residue from the primary towers is fed to pipestills operated at atmospheric pressure. In the pipestills, the residue is heated to 550° F and is fed to the secondary (or atmospheric) towers except for a relatively small share that is recycled to the primary towers. Products derived from these secondary towers are varied to match requirements by modifying operating conditions, but six major fractions are commonly derived: An overhead, four side cuts, and a residue.

The overhead is subdivided into two major parts: Isoheptane base and light naphtha. The isoheptane base is fed to a soda washery and is subsequently superfractionated. The principal products of this superfractionation are isoheptane and isohexane for use in aviation gasoline. Other products include blending components for motor gasoline and a remainder, part of which joins the light-naphtha fraction of the overhead and the rest of which joins the naphtha side cut. The atmospheric-tower overhead probably still supplies the bulk of the feed to special-boiling-point-spirits production facilities,



Legend

Product ..... Motor gasoline

Processing or blending facility..... Pipe still

Abbreviations:

Acid washery ..... AW
Soda washery ..... SW
Lime washery ..... LW
Soda or plumbite washery..... S/PW
Redistillation unit ..... RU

FIGURE 23. - Schematic Flowsheet of the Abadan Refinery in 1961.

(Face p. 82)

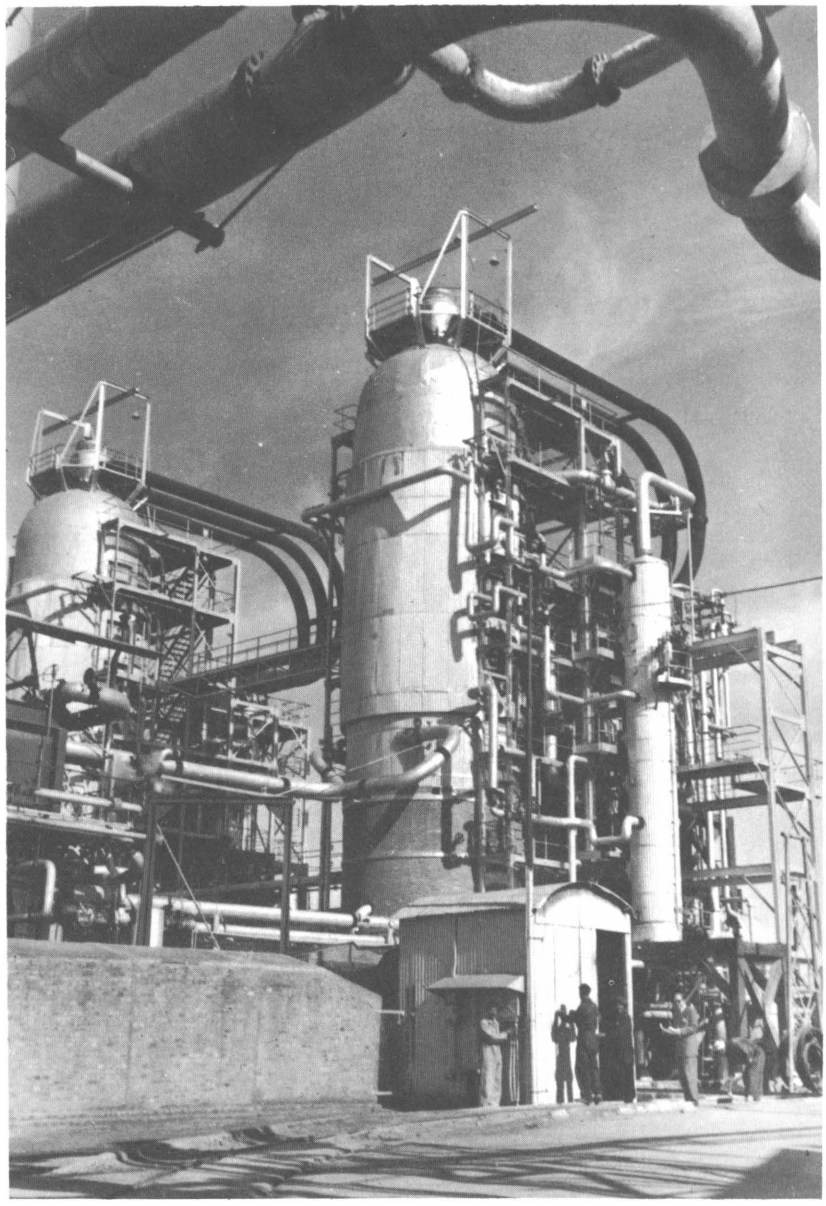


FIGURE 24. - Primary Crude Distillation Tower at the Abadan Refinery.

in addition to the isoheptane base and light-naphtha cuts mentioned above. According to the 1959 flowsheet (37), the special-boiling-point-spirits cut is fed first to a soda washery, then to an acid-treatment plant, and finally to a redistillation unit that separates the special-boiling-point-spirits from a motor-gasoline component. The light-naphtha portion of the secondary tower overhead is blended with isoheptane-base discards and is then fed to a soda-plumbite washery and finally to motor-gasoline-blending facilities.

The lightest of the secondary-tower side cuts, classified as naphtha-reforming stock, consists principally of aviation and motor-gasoline components, although quantities of fuel oil and gas-oil constituents as well as plant fuel gas are also recovered. The naphtha-reforming stock is first sent to a naphtha rerun unit, which separates a feed for reformers and aromatic SO_2 extractors from a residue, which is used for producing fuel oil, gas oil, and tractor vaporizing oil. The reformer-aromatic SO_2 extraction feed is blended with isoheptane-base discards, and is then divided into three parts for feed to (1) thermal reformers, (2) the catalytic reformer, and (3) the aromatic SO_2 extraction units. Thermal reforming produces (1) plant fuel gas, (2) a butane-butylene cut fed to alkylation-isomerization units after soda washing, and (3) thermal reformate, which, after redistillation to remove a heavy fraction for fuel

oil, is used in motor gasoline (after soda and plumbite washing). The catalytic reformer produces (1) plant fuel gas, (2) butane, which is fed to alkylation-isomerization units, and (3) a motor-gasoline cut, which requires no further treatment. The aromatic SO_2 extraction units provide (1) a benzine extract, which after acid-washing is redistilled into two fractions: One for aviation gasoline and the other for motor gasoline; and (2) a cut that is fed to thermal and catalytic reformers.

The second side cut from the atmospheric towers, a heavy naphtha, consists primarily of components used in fuel oil, gas oil, and tractor-vaporizing oil blending. Some part (not shown) may still be used in production of special-boiling-point spirits.

The third side cut is separated into two parts. One of these is simply subjected to an acid wash and is then used directly in the preparation of aviation turbine fuel, kerosine, and tractor vaporizing oil. The other part of this side cut is treated by the kerosine SO_2 extraction units. The extract from this installation is piped to a soda washery and is then redistilled, yielding two components: Tractor vaporizing oil and plant fuel. The raffinate is sent either to a plumbite washery or to a copper chloride treatment (these are arranged in parallel) and after treatment forms the bulk of the output of aviation turbine fuel and kerosine, with lesser shares being used in tractor-vaporizing-oil output.

The fourth and heaviest side cut, without further treatment, is used directly in the blending of marine diesel oil and/or gas oil.

The residue from the secondary towers constitutes nearly half of the crude input. A part of this heavy residue is used directly in the manufacture of fuel oil; the process consists simply of blending this material with fuel oil components derived elsewhere (fig. 23). Additional quantities are used in the blending of diesel oil. The remainder of the heavy secondary-tower residue is fed to vacuum distillation units where it is heated to about 700° F in pipestills and fractionated in columns yielding: (1) Vacuum gas-oil overhead, which is blended with lighter gas oil from the atmospheric towers; (2) a wax distillate cut, which serves as the feed for the catalytic cracker (fig. 25) and the lubricant plant; (3) a slop wax cut, which is used in fuel oil blending and in bitumen production; and (4) a residue, which is fed to the bitumen plant for the production of various asphalts.

The output of the catalytic crackers is processed and treated to produce: (1) A component for plant fuel; (2) a butane-butylene fraction, which after soda washing is fed to the isomerization-alkylation plants for the production of aviation and motor gasoline; (2) a catalytic-cracked gasoline cut, which, after acid treatment, redistillation to remove a fuel oil component, and plumbite washing, is sent to motor-gasoline blending; (4) a cycle oil cut, which is blended with lubricant plant residues and then used in fuel oil blending; and (5) petroleum coke.

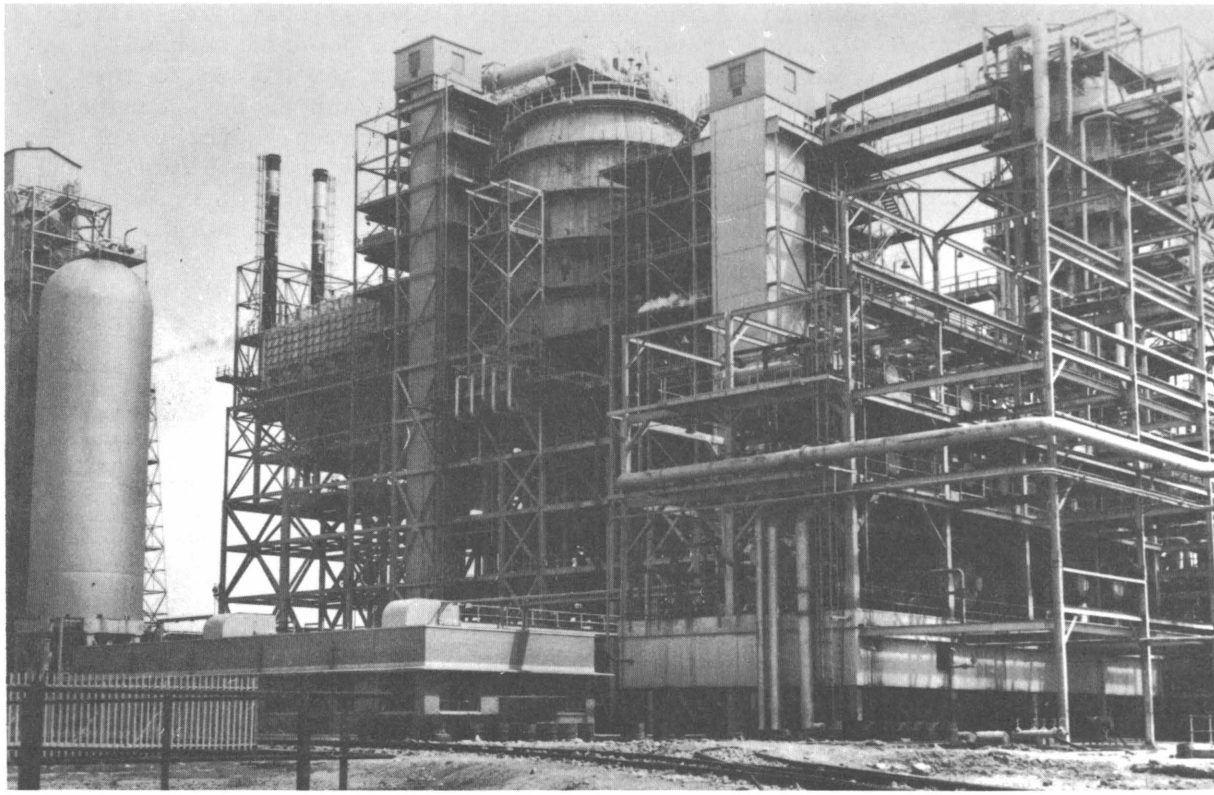


FIGURE 25. - Catalytic Cracker at the Abadan Refinery.

Consortium Field Topping Plants and Distillation Units

The Consortium operates a topping plant at Masjed-e Soleyman and four field distillation units, one each at Masjed-e Soleyman, Agha Jari, Haft Gel, and Gach Saran. The topping plant produces fuel oil and gas oil for distribution in Iran, a topped or "blended" crude for further processing at Abadan and a residue, which is recycled to the reservoir at Masjed-e Soleyman. Capacity of the topping plant is 78,000 barrels per day. The field distillation units, which simply provide field fuel, have rated capacities as follows: Agha Jari and Haft Gel, 570 barrels per day each; Masjed-e Soleyman, 430 barrels per day; and Gach Saran, 190 barrels per day.

Consortium Ancillary Facilities

Growth of the Abadan refinery has been paralleled by development of ancillary facilities in the area. These facilities (aside from housing, hospitals, schools, and personnel amenities) include power installations and plants for water purification and for production of lime, sulfuric acid, and other chemicals.

The 1961 installed power capacity was 145,000 kilowatts in two plants, designated No. 1 and No. 2, with 85,000 and 60,000 kilowatts, respectively.

Installed capacity in plant No. 2 includes a new 30,000-kilowatt generating unit installed in 1961. The older units are nine steam powered turboalternators of various sizes. The refinery powerplants supply power also to the towns of Abadan, Khorramshahr, and Ahvaz, the Bandar Mashur export terminal, and the Agha Jari and Ahvaz oilfields. The power requirements of the refinery have presumably increased with the catalytic reformer now in operation. However, power from the Dez dam, which may become available in 1963, will then supply the towns mentioned above, freeing the Abadan refinery-generated power for the use of the industry.

As of 1948, steam for powerplant No. 1 and process steam were raised in 69 boilers in four major batteries with a total capacity of about 3.7 million pounds per hour. One battery served the original powerplant, another served the cracking facilities, the third was situated in the special products area, and the fourth was located at one of the water pumping stations. Powerplant No. 2 includes four additional boilers of unreported capacity. Current water pumping capacity exceeds 41 million gallons per hour; at least 14 pumps are available including a 3.5-million-gallon-per-hour installation completed in 1961.

Masjed-e Soleyman is the field headquarters, and, therefore, has a larger population (60,000) than the other fields. There is a powerplant with 17,000 kilowatt capacity in two plants. One has two 4,000-kilowatt units, and the other, one 9,000-kilowatt unit. About 12,000 kilowatts is utilized.

As of 1956, the Consortium was reported to have in Abadan a capacity for producing 240 tons of sulfuric acid per day, exclusive of the capacity for recovery of spent acid from alkylation and from acid tar derivatives, reported in 1948 to be 130 tons and 90 tons, respectively. Fresh sulfuric acid is made both from purchased sulfur (imported and domestic) and from sulfur recovered from natural and refinery gases. At Masjed-e Soleyman field, the Consortium operates two plants to recover sulfur from the Masjed-e Soleyman and Lali gases that contain 10 to 12 and 30 to 35 percent H_2S, respectively. The plants have a combined capacity of 40 tons of sulfur per day. It also operates a refinery gas sulfur recovery plant at Abadan with a production capacity of 20 tons per day.

Hydrated lime is used for neutralizing acids contained in chemically treated products and for removing H_2S from crude distillates. Seashells collected from the Persian Gulf area are burnt in a kiln for the production of 25 tons of hydrated lime per day.

Plants for producing ice, oxygen, and carbon dioxide and for manufacturing containers are also operated by the Consortium.

Consortium Plant Modifications Under Way or Contemplated

Addition of the 20,000-barrel-per-day catalytic reformer, completed in mid-1962 provides more high octane motor gas than has been possible with existing equipment. It yields a greater volume of gasoline constituents relative to the feed volume, and its output, unlike thermal reformates now produced,

requires no further chemical treatment before blending in motor gasoline. It was predicted that without installation of this unit, Abadan would have been forced to reduce aviation gas and/or middle distillate production after 1962 in order to meet requirements for higher octane motor gasoline.

The four largest crude distillation towers have now been modernized, the fourth being finished in 1962. The principal purpose of this program is to increase the middle distillate (kerosine and gas oil) yield. Additions were also made in 1961 to the facilities for bitumen drumming and bulk loading, making Abadan one of the world's largest bitumen-manufacturing plants. In 1962 new facilities for blending and bulk handling of liquefied butane and propane were installed in Abadan, with a blending and storage capacity of 1,280 barrels.

A number of modifications and improvements are planned in order to reduce the cost of chemicals and fuels consumed by the refinery. These include improvements in vacuum distillation units to reduce catalyst consumption in the crackers; an increased sulfur recovery from refinery gases for use in production of sulfuric acid; and modification in refinery fuel circuits to make possible increased utilization of natural gas.

NIOC Refinery Facilities

The Kermanshah refinery and Naft-e Shah topping plant now have an input capacity of 9,500 barrels per stream day. Both were originally built by the Kermanshah Oil Company, a subsidiary of APOC, under terms of the 1933 Oil Agreement. The agreement called for the exploitation of Naft-e Shah field and use of its crude for making products for Iranian consumption. As originally developed under Kermanshah Oil Company, the Naft-e Shah and Kermanshah plants were virtually identical in construction, except that the Kermanshah plant had some finishing facilities not available at Naft-e Shah. The processing scheme then in effect consisted of topping about 3,000 barrels per day of crude, reinjecting into the reservoir the heavy fraction for which there was no market, reblending the lighter fractions, and forwarding them to Kermanshah through a 3-inch pipeline, to be rerun there to produce gasoline, kerosine, and diesel oil. Residual fuel oil could have been made from the heavy fraction that was being reinjected, but, in view of the very limited demand for this product in the area served by the Kermanshah refinery, the company found it more economical to supply these needs by shipments from the southern oilfields.

This scheme was continued through 1951 when the oil industry was nationalized. At this time, NIOC decided to produce residual fuel oil at Naft-e Shah, prompted principally by the desire to place Abadan on a standby basis rather than to operate it sporadically or on a greatly reduced scale. The residual fuel oil was produced from the material formerly reinjected into the reservoir. Kalantar on the Iran-Iraq highway and 70 miles north of Naft-e Shah was chosen as the best location for truck distribution of this product without recourse to extensive road construction. A 4-inch pipeline was built connecting Naft-e Shah to Kalantar.

In 1954, NIOC decided to expand the Naft-e Shah and Kermanshah operations further. A study showed that a certain portion of the residue obtained at Naft-e Shah could be reblended with the lighter fractions and successfully pumped through the 3-inch pipeline to Kermanshah. This procedure, coupled with pipelining of residual fuel oil to Kalantar, reduced the amount of residue being reinjected into the reservoirs. Nonetheless, engineering studies in 1958 revealed that reinjection was still proceeding at too fast a rate, and NIOC was forced for a time to burn-off the excess residue. This waste was temporarily controlled by reducing output at the topping plant and consequently at the refinery. The final solution to the problem was the construction of a 4-inch pipeline that could deliver the dense residual fuel to Kermanshah. While the new pipeline was under construction and the topping plant and refinery were operated at a reduced level, all existing equipment at both operations was overhauled. In 1960, the pipeline was completed, and, at the same time, an expansion and modification program for the entire Naft-e Shah--Kermanshah complex was initiated. This program, completed in 1961, was aimed at enabling the refinery to process the larger feed volume made available by the new pipeline and thereby to better enable NIOC to meet domestic requirements. It included general expansion and/or modification of existing distillation units, treatment plants, maintainence shops, and cooling, steam, process-water, and electrical systems at both plants and installation at Kermanshah of a solutizer (to increase octane rating of gasoline from 70 to 78) and two new separators (one with a capacity of 20,000 barrels per day, and the other, 5,000 barrels per day).

As presently operated, the Naft-e Shah plant (fig. 26) tops a portion of field production sending residual fuel oil to Kalantar and reblending other constituents for pipeline delivery to Kermanshah. Some residue is still reinjected. The synthetic crude plus untopped crude from the Naft-e Shah field, which is sent by the older pipeline, is processed at Kermanshah to yield gasoline, kerosine, gas/diesel oil, residual fuel oil, and some incompletely processed fractions. A plant at Kermanshah manufactures 20 liters cans; production capacity is 8,000 containers per day.

Proposed Tehran Refinery

The discovery by NIOC of significant reserves of crude oil in the Qom area has led that agency to plan a refinery in the vicinity of Tehran (32) with an initial capacity of 20,000 barrels per day that may be expanded to 100,000 barrels per day. The Tehran market area provides a logical outlet for such a refinery and might make unnecessary, at least for the time being, the expansion of the Trans-Iranian pipeline system that links Abadan with Tehran. The major consideration in respect to this refinery is its effect on the economic operation of Abadan refinery, which now sells about one-quarter of its output in Iran. If modernization plans for Abadan materially improve its competitive position in world markets, no difficulty would arise; otherwise, construction of a refinery in Tehran may make it necessary to operate Abadan on a reduced scale.

FIGURE 26. - NIOC's Naft-e Shah Topping Plant in Western Iran.
(Courtesy of NIOC.)

COMPETITIVE POSITION OF ABADAN REFINERY

The competitive position of the Abadan refinery is adversely affected by two recent trends in the market demand for petroleum products that have developed since erection of most of Abadan's equipment: Higher octane ratings for gasoline and greater demand for middle distillates. Although the Abadan refinery has some flexibility to vary the relative amount and grade of commodities produced, it has become necessary to make additions to and modifications of refinery equipment in an effort to retain markets traditionally supplied by the refinery.

According to Carruthers (8), the output of motor gasoline in 1960 at Abadan had an 84.6 pool octane number (weighted mean rating of total production), and output was distributed as follows, by research octane numbers (RON):

RON	Volume-percent
79.....	29.0
83.....	37.3
90.....	21.7
93.....	12.0

By comparison, Abadan's market area in the same year was reported to require gasoline having a pool octane number of 87.2. Projecting the 1957-60 trend, Yousefian (42) postulated that pool octane numbers of gasoline required in this area may increase to 92.2 in 1963. Present facilities, specifically thermal reformers, are incapable of economically producing motor gas having these higher octane ratings without significantly reducing aviation gasoline output for which a market exists.

The refinery also has the problem of increasing, or even maintaining present levels of middle distillate output in face of both declining potential middle distillate content in crude oil received, and increasing requirements for these commodities. In his discussion of Abadan's market position, Carruthers (8) shows that, as production declines in the old central fields and increases in Agha Jari and Ahvaz, a marked decline in the potential middle distillate segment of the refinery input will occur. The following table compares the various crude oils (8):

Property	Source of Crude		
	Haft Gel	Agha Jari	Ahvaz
API gravity.....	37.7°	34.4°	31.1°
Yields, percent of total volume:			
Debutanized gasoline.....	23.7	20.7	18.3
Middle distillates.....	36.8	32.1	32.2
Atmospheric residue.....	35.9	43.4	47.3
Viscosity of residue (Redwood 1 at 100° F)..sec	1,000	1,300	3,100

According to Carruthers, replacement of 100,000 barrels per day of Haft Gel crude by Ahvaz crude in the refinery feed would reduce middle distillate yield from 29,700 to 18,700 barrels daily, because such a change would require the

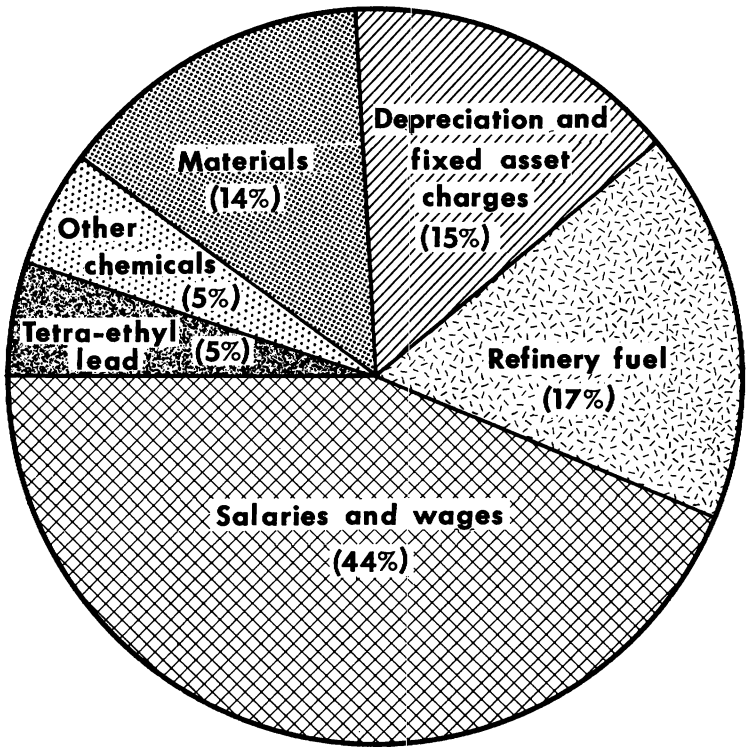


FIGURE 27. - Approximate Distribution of Operating Costs at the Abadan Refinery in 1961 (8).

addition of gas oil to the residue derived from Ahvaz crude in order for the fuel oil to meet the present viscosity requirement of 600 seconds (Redwood 1 at 100° F). Carruthers also suggests that in order to maintain or increase the output level for the middle distillates without greatly modifying the total throughput, some consideration should be given to establishing a market for fuel oil with a higher viscosity among the existing fuel oil purchasers.

Aside from the marketing factors just discussed, the management reportedly feels that operating costs need to be reduced. The distribution of refinery costs for 1961 is shown in figure 27. Whereas the company feels that all costs other than "depreciation and fixed asset charges" may be somewhat reduced, the greatest savings may be made in labor costs because, in the company's opinion, output per worker in the Abadan refinery is less than in refineries in the United States and Europe. The lower labor productivity is not adequately compensated by prevailing wage rates in Iran, which are lower than United States and European wages. In order to reduce excess manpower a severance benefit program was initiated at the beginning of 1961.

FACILITIES FOR STORAGE AND DISTRIBUTION OF CRUDE OIL, PETROLEUM PRODUCTS, AND NATURAL GAS

Storage and distribution facilities in Iran perform three important and distinct functions. A system of pipelines bring crude to the export terminals of Bandar-e Mashur and Kharg Island. Pipelines also transport crude from the Consortium fields to the Abadan refinery. Refined products for the export market are shipped from the Abadan port. In the past, these products were also shipped from Khosrovabad tank farm, which is now decommissioned. Facilities necessary for these functions are operated by the Consortium. The third function of storage and distribution facilities is the internal distribution of petroleum products. Pipelines, railroads, and trucks move the products to depots from which further distribution takes place. The distribution and storage facilities for the country are fundamentally different in nature and magnitude from the crude system and are operated by NIOC. The following table

gives some significant data on storage and distribution facilities of the Iranian petroleum industry:

Daily crude pipeline delivery capacity:	
For Export:	
To Bandar-e Mashur	345,000 barrels
To Kharg Island	330,000 barrels
Total	675,000 barrels
To Abadan refinery	425,000 barrels
Grand total	1,100,000 barrels
Consortium pipeline system serving export terminals and Abadan refinery, length	2,880 kilometers
Crude storage capacity:	
In fields, including storage for topping plant-derived black products	400,000 barrels
Abadan	667,000 barrels
Bandar-e Mashur	4,500,000 barrels
Kharg Island	3,260,000 barrels
Total	8,827,000 barrels
Products storage capacity, Abadan (including Bavardeh tank farm and Khosrovabad):	
Black products	12,000,000 barrels
White products	19,000,000 barrels
Total	31,000,000 barrels
NIOC pipeline system: Internal distribution lines,[1] length	4,976 kilometers

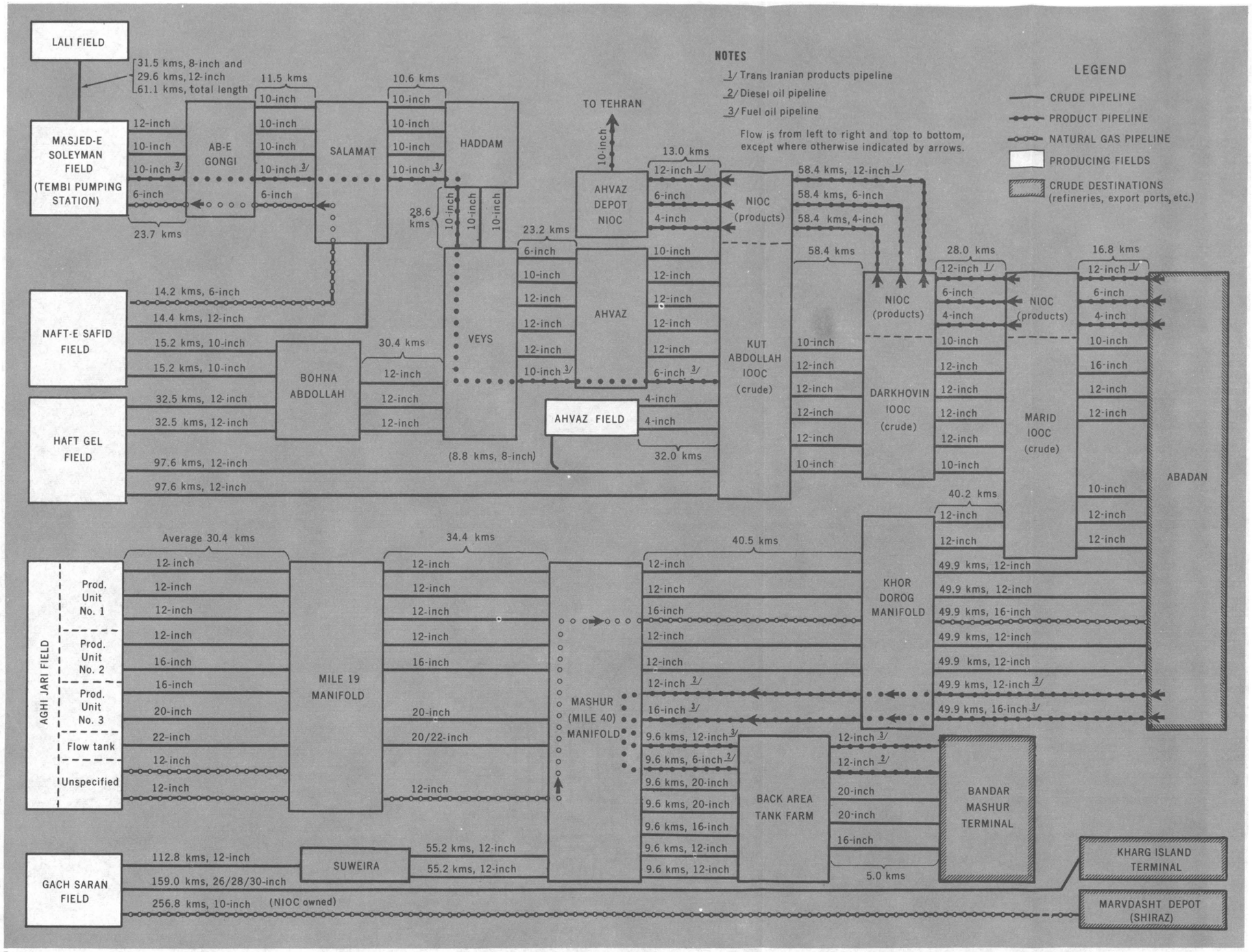
[1] Includes refined product lines, natural gas line, and lines moving topping plant products from Naft-e Shah to the Kermanshah refinery.

Facilities for Export of Crude

Crude is exported from two terminals, one at Bandar-e Mashur, a port on the Persian Gulf, and another at Kharg Island in the Persian Gulf 20 miles from the mainland. The Kharg terminal was completed in 1960. Relatively small quantities of crude have also been loaded from Abadan every year since the Consortium started operations.

Crude for export is obtained principally from the southeastern fields (Agha Jari and Gach Saran). These fields are connected by pipeline to Bandar-e Mashur and Abadan; another pipeline, completed in 1960, links Gach Saran with the Kharg Island terminal. These lines are shown schematically in figure 28 and their locations are shown on figure 29.

At Bandar-e Mashur, six single-vessel jetties with an average depth alongside of 41 feet, the newest completed in 1959, have an estimated total loading capacity in excess of 93,000 barrels of crude per hour using standard hose connections. Supertankers cannot be loaded at Bandar-e Mashur or Abadan because of inherent draft and navigational problems. These large tankers, however,



(Face p. 92)

FIGURE 28. - Schematic of All Consortium Crude Oil and Natural Gas Pipelines and NIOC Products Pipelines From Abadan to Ahvaz, Iran, 1962.

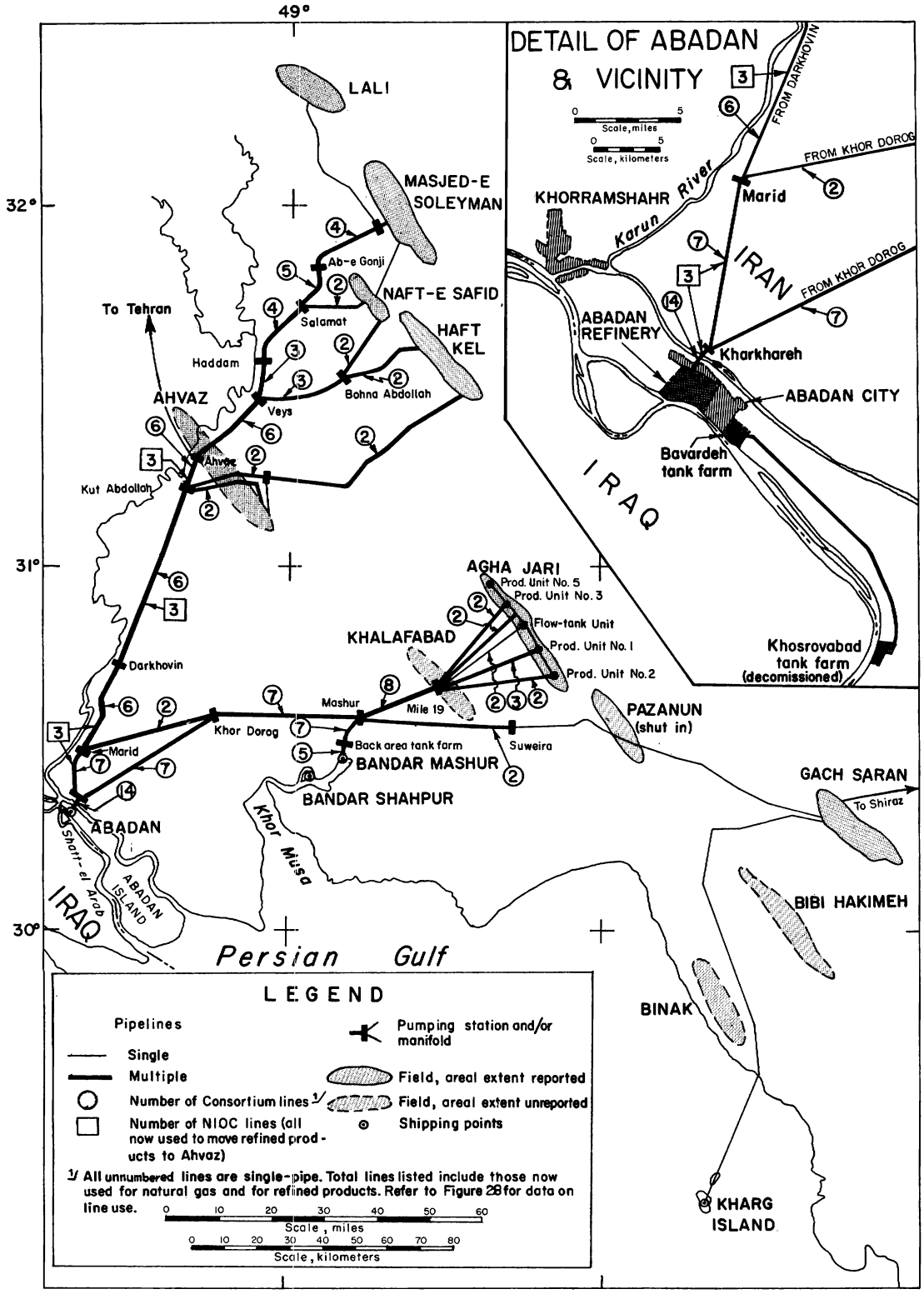


FIGURE 29. - Routes of Consortium Crude Oil and Natural Gas Pipelines, Iran, 1962. (Also shows route of NIOC products lines from Abadan to Ahvaz.)

can now be handled at the Kharg Island depot, which has a single pier with berths for one 100,000-ton one 45,000-ton, and two 35,000-ton tankers at one time. When four ships are berthed, the depot can load at the rate of 50,000 barrels per hour.

Crude from Gach Saran flows by gravity to 12 tanks on Kharg Island. These tanks are located on high ground (200 to 300 feet) on the west side of the Island. Crude flows from these tanks by gravity through two 36-inch lines to the loading terminal. In addition to crude tanks, there are three bunker fuel tanks, each with a capacity of 140,000 barrels.

Crude was being shipped at the rate of 330,000 barrels per day at the end of 1962. Future delivery will be at the rate of 550,000 barrels per day.

The pier (fig. 30) is equipped with four banks of Chiksan hydraulic marine loading arms (five arms per bank). Each bank of these devices is operated by one man from an adjacent tower. They permit any vessel, while moored and loading, to move up to 25 feet fore or aft along the pier and to roll 30° in any direction from normal. In addition, the loading arms will extend from 20 feet above to 30 feet below the center of the trunnion on the arm. Thus, they will accommodate ships with a wide variety of above-waterline heights and, in addition, for most vessels, will allow for considerable vertical movement of the vessel at the pier. Although the pier extends considerably into the Persian Gulf and away from the shelter provided by the Island, even fairly rough seas should not necessitate cessation of loading operations.

For the years 1955-61, the number of tankers loaded at the two crude export terminals[8] were reported as:

	Bandar Mashur	Kharg Island
1955.....	479	0
1956.....	748	0
1957.....	958	0
1958.....	1,215	0
1959.....	1,253	0
1960.....	1,192	80
1961.....	1,149	367

Crude from the offshore wells of SIRIP, first exported in 1961, is piped 10 kilometers from the drilling platform to deeper water where two old T-2 tankers are used for storage. The pipeline terminates at a small fixed loading platform that, together with the tankers, constitute SIRIP's entire loading facility. IPAC, whose offshore well came into production in late 1961, as yet has no permanent loading facility. Crude is now pumped directly from the well platform through metering and separation equipment on a barge into waiting tankers.

---

[8] In addition, eight tankers loaded crude oil from Abadan in 1960, 10 in 1959, and an unspecified number during 1955-58.

FIGURE 30. - Jetty at Kharg Island. *(Courtesy of NIOC.)*

Facilities for Delivering Crude to Abadan

Abadan's current (1962) average daily crude requirements of almost 360,000 barrels is supplied principally from the central fields--Haft Gel, Masjed-e Soleyman, Lali, Ahvaz and Naft-e Safid--supplemented by crude deliveries from the southeastern fields--Gach Saran and Agha Jari. The central fields are connected to Abadan by a pipeline system shown in figures 28 and 29. Delivery of crude and topping plant products from the central fields is limited to about 283,000 barrels per day, the capacity of the Kut Abdollah pumping station.

Similarly, crude deliveries from Gach Saran and Agha Jari are at present restricted to about 142,000 barrels per day by the capacity of the Mashur Manifold-Abadan pipes. Thus, over any extended period, refinery throughput at Abadan is restricted to about 425,000 barrels per day by the capacity of incoming pipelines. The higher throughput recorded in the prenationalization period was realized because the pipeline that now transports gas from Agha Jari to Abadan and the two pipelines now carrying products from Abadan to Bandar Mashur previously carried crude.

Deliveries to Abadan from the central fields could be increased by about 42,000 barrels per day by the construction of additional lines and/or pumping stations linking the fields with Kut Abdollah; at present, lines linking that point with Abadan are adequate to permit delivery of 325,000 barrels per day. Likewise, Abadan receipts from the southeastern fields could be increased to almost 400,000 barrels per day by the construction of additional lines and/or pumping stations between Mashur manifold and Abadan (a distance of 88 kilometers) or by reconversion of pipelines carrying products to Mashur manifold or gas from Agha Jari to Abadan.

Product Loading for Export

In the Abadan-Bavardeh-Khosrovabad port area, at least 26 loading piers for various classes of products are available. Of these, 23 load liquid products. Individual loading capacities for these jetties, most of them capable of handling only one ocean-type ship at a time, vary from 3,000 to 8,000 barrels per hour and total about 106,000 barrels per hour. Of the three remaining piers, one loads lubricants, and the other two, bitumen. The number of tanker loadings at Abadan since 1955, including a few tankers loading crude oil, was:

	No. of tankers
1955.....	392
1956.....	745
1957.....	854
1958.....	846
1959.....	762
1960.....	890
1961.....	707

The tankers loading petroleum products from Abadan must go up the Shatt-el Arab on the west coast of Abadan Island. In this area the east bank of the river forms the frontier between Iran and Iraq except at Iranian port areas where the boundary is in the center of the river. There have been jurisdictional problems between the two countries concerning navigation on the Shatt. In 1961 the dispute over berthing of tankers calling at Abadan disrupted shipping of products from that port from February 16 to April 23, which is reflected by the decrease in tanker loadings listed above.

Reversibility of Pipeline Systems

Direction of flow in the pipeline delivering crude to Abadan may be (and at times has been) reversed. For example, during the Shatt-el Arab dispute when exports from Abadan were cut off, one of the Mashur Manifold-Abadan crude lines was utilized to move refinery products to Bandar Mashur for export. Heavy fractions from the refinery also have been returned to the central fields from the Abadan refinery for reinjection into the reservoirs when such fractions have been produced in excess of demand and refinery storage capacity. These reversals, though restricting availability of crude and topping plant products to the refinery, have made continuation of refinery operations possible although on a reduced scale, even when refinery storage capacity has been reached.

NIOC Crude Pipelines

Two 240-kilometer pipelines with a total capacity of 6,600 barrels per day link the Naft-e Shah field with the Kermanshah refinery (fig. 31 shows the route). According to the statement of NIOC officials, the newer 4-inch line, opened in 1959, transports the heavier fraction from the topping plant to the refinery while the lighter fractions move through the older 3-inch line. Addition of the second line enables the refinery to attain its increased design capacity more closely. Storage facilities at the Kermanshah refinery are estimated at about 166,000 barrels, comprising 59,000 barrels of black and 107,000 barrels of white products.

The Kermanshah refinery products, together with fuel oil obtained from the field topping plant and piped to Kalantar, are distributed entirely by truck to the neighboring areas--principally Hamadan, Sannandaj, Tabriz, and Rezaiyeh with surplus going to Tehran, Qazvin, and Rasht.

Proposed Future Developments of Export Facilities

The dispute concerning navigation on the Shatt-el Arab, already referred to, and the inability of the waterway to accommodate modern large tankers has led the NIOC to investigate the possibility of exporting Abadan refinery products through a port facility located elsewhere. Engineering studies on the feasibility of dredging the Bahmanshir River on the east side of Abadan Island and establishing a port there proved negative. This led NIOC to reevaluate a proposal, dating back to 1958, to develop a port at Khor Musa (fig. 29) and link it to Abadan by an extensive multiple-pipeline delivery system. As originally proposed, the Khor Musa project would have cost $80 to $100 million and

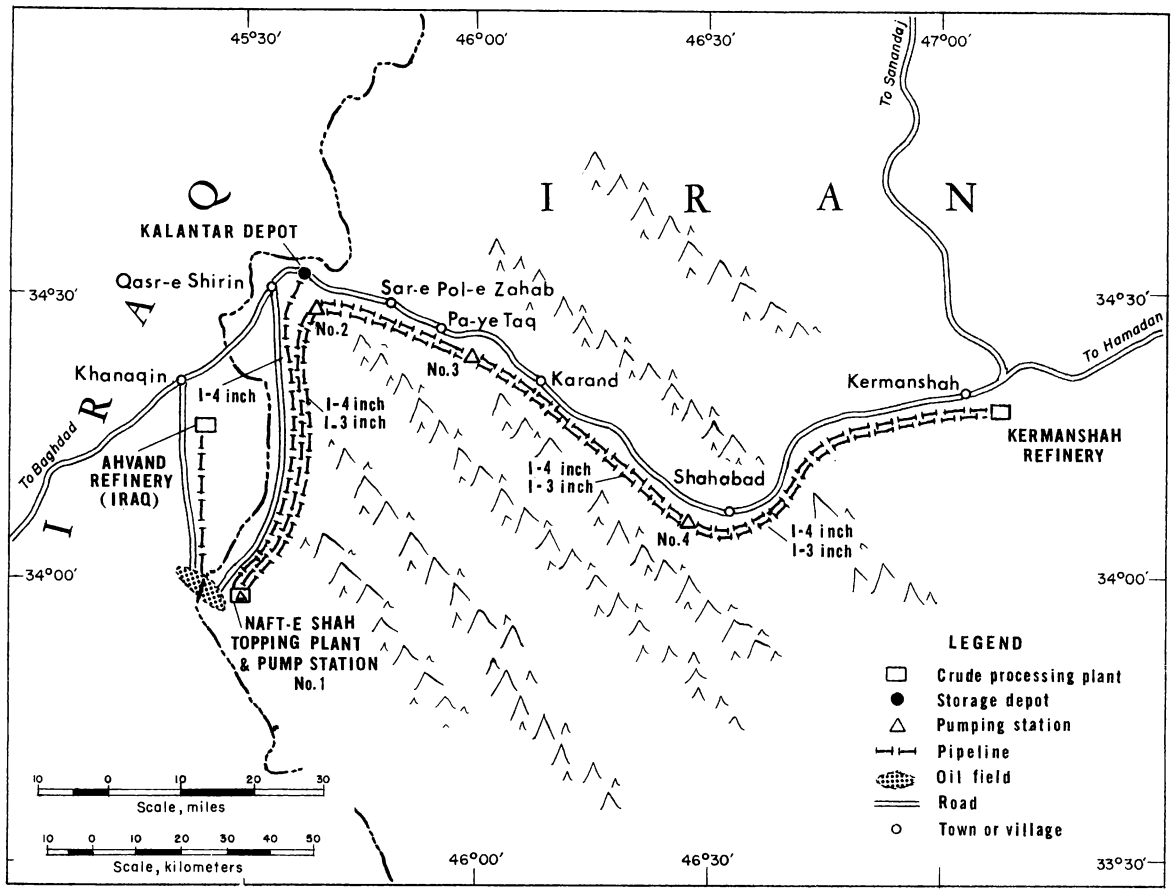


FIGURE 31. - Routes of NIOC Pipelines From Naft-e Shah Field to Kalantar Depot and Kermanshah Refinery, 1962.

included: 12 product pipelines ranging up to 18-inch diameter (two being heated lines); 100 tanks with a storage capacity of 6 million barrels; 7 bulk product loading jetties; 2 dry cargo jetties, a tug jetty, a 66-kv powerline; installations to supply 1.5 million gallons of potable water and 1 million gallons of untreated water daily; an embanked causeway for pipelines and a highway from Abadan; housing and other amenties. A number of alternatives have been proposed to reduce the cost of the project, among which the following proposals were most prominent: (1) To eliminate white product lines and storage facilities since they account for a smaller share of total volume exported compared to black products (heavy diesels, bunkers, and residual fuel oil); (2) to eliminate all storage facilities at Khor Musa, putting all loading on a remote control basis from Abadan, and thereby eliminating much of the ancillary facilities envisiaged the original proposal. Through the end of 1962 however, no specific action has been taken to implement the development of Khor Musa.

Another proposal yet to be realized is the development of a crude oil storage depot and loading facility for IPAC production. This company has been

promised a 1,100 acre grant on Kharg Island for loading jetties and a 5 million barrel farm capable of loading 100,000 barrels per day if such facilities are needed to handle its production.

Transportation and Distribution of Petroleum Products for Domestic Consumption

The NIOC is the sole distributor of petroleum products and natural gas for Iranian consumption, and owns such storage and distribution facilities as are necessary to bring the products to marketing outlets operated by this company or its sales agents or designated retailers. These facilities have been increased considerably since 1956. During 1956-61 almost 2,318 kilometers of products pipelines have been installed, and NIOC sales outlets increased from 1,124 in 1956 to 2,457 in 1960. Movement of petroleum products measured in millions of ton-kilometers also increased from 1,426 in 1956 to 2,837 in 1959 (table 27). The increase resulted from both larger consumption and distribution of products over a wider area.

Product Pipelines and Other Means of Transportation

An important development since 1956 has been the construction of a number of products pipelines. The most important of these is the Trans-Iranian pipeline that connects Abadan to the Rey depot, 12 kilometers southeast of Tehran. A branch line from Ezna on the Trans-Iranian pipeline goes to Esfahan. From the Rey terminal other lines have been extended northwest to Qazvin and Rasht and east to Mashhad.

Total length of product lines operated by NIOC as of 1962 was 2,568 kilometers varying from 4-inch to 12-inch diameter. Before completion of the Abadan-Tehran pipeline, three pipelines, 10-inch, 6-inch, and 4-inch, brought products from Abadan to Ahvaz. The two smaller lines are still in use, but the 10-inch line was replaced by a 12-inch line in 1960. The routes of these lines are shown in figure 32, and some data on the pipelines are presented in table 28. At present all gasoline, kerosine and gas oil requirements of Ahvaz, Ezna, Esfahan, Arak, Qom, Tehran, Qazvin, Rasht, Shahroud, and Mashhad are supplied entirely by pipeline.

Deliveries of these products by pipeline in 1958-59 were:

	1958	1959
Kerosine.....million barrels	4.5	6.3
Gas oil.....do.....	3.2	3.7
Gasoline.....do.....	2.1	3.0
Total.....do.....	9.8	13.0

Before 1957, refinery products were distributed essentially by railroad cars and trucks that were loaded at the Ahvaz railroad terminal.

TABLE 27. - Transport of petroleum products for Iranian consumption, in ton kilometers, and average transportation costs, in rials, by various transportation media, 1956-59 and 1961 (29)

	1956	1957	1958	1959	1961
	Quantity carried, millions of ton-kilometers				
Pipelines:					
New	0	271	858	1,312	(1)
Old	177	207	238	131	(1)
Total	177	478	1,096	1,443	1,655
Road tankers:					
Chartered	416	399	331	318	414
NIOC owned	107	101	115	121	138
Total	523	500	446	439	552
Railway	660	768	684	909	1,004
Ship	66	64	50	46	26
Grand total	1,426	1,810	2,276	2,837	3,237
	Percentage of total ton-kilometers				
Pipelines:					
New	0	15.0	37.7	46.3	(1)
Old	12.4	11.4	10.5	4.6	(1)
Total	12.4	26.4	48.2	50.9	51.1
Road tankers:					
Chartered	29.2	22.0	14.5	11.2	12.8
NIOC owned	7.5	5.6	5.1	4.3	4.3
Total	36.7	27.6	19.6	15.5	17.1
Railway	46.3	42.5	30.0	32.0	31.0
Ship	4.6	3.5	2.2	1.6	.8
Grand total	100.0	100.0	100.0	100.0	100.0
	Average price in rials per ton-kilometer				
Pipelines:					
New	0	0.990	0.410	0.382	(1)
Old	.040	.040	.040	.040	(1)
Total	.040	.579	.330	.351	.430
Road tankers:					
Chartered	1.840	1.867	1.827	1.740	1.850
NIOC owned	2.119	2.329	1.830	2.133	2.240
Total	1.897	1.960	1.828	1.848	1.950
Total	1.273	1.299	1.236	1.214	1.220
Ship	1.310	1.530	1.380	1.186	(2)
Grand total	.919	.270	.919	.872	(2)

1 Not available.

2 Shipboard transport cost in NIOC-owned vessels is quoted as 2.62 rials/ton, in contract vessels as 0.82 rials/ton. Relative part of total moved by each however, is not available, therefore, average cost for shipboard and average cost of grand total of products moved are not available.

TABLE 28. - NIOC refined product and natural gas pipelines, Iran, 1962

Pipelines	Diameter, inches	Length, kilometer	Annual capacity	Year completed	Remarks
Abadan-Ahvaz.....	4	125	100,000 metric tons	1939	Lines originally used (together with a 10-inch line no longer in use) to move all classes of products from Abadan to rail and truck loading facilities at Ahvaz depot. Now used for fuel transport only.
Abadan-Ahvaz.....	6	125	200,000 metric tons	1944	
Trans-Iranian pipeline:					
Abadan-Ahvaz.....	12	125	2.2 million metric tons.	1958	Until 1958, an above ground 10-inch pipe served as the Abadan-Ahvaz link in the Trans-Iranian line; it was replaced in that year by the 12-inch buried line listed here.
Ahvaz-Ezna.....	10	478	Slightly over 2 million metric tons.	1957	
Ezna-Rey.....	10	338	Slightly under 2 million metric tons.	1957	The entire Trans-Iranian products lines now has 13 pumping stations (see fig. 32 for location). Capacity of main line beyond Ezna is slightly lower than that of line entering Ezna to allow for tight line operation on main line beyond Ezna after withdrawal of products for transmission through branch line to Esfahan.
Total.....		941			
Azna-Esfahan.....	6	234	350,000 metric tons	1958	The single pumping station for this line is at Ezna.
Rey-Rasht:					
Rey-Qazvin.....	8	147	450,000 metric tons	1960	A single pumping station at Rey provides pressure for this line. Presumably, the capacity of the 6-inch portion of the line (beyond the Qazvin depot) is somewhat less than the 450,000 metric tons cited here, but is not reported in sources examined.
Qazvin-Rasht.....	6	190		1961	
Total.....		337			
Rey-Mashhad:					
Rey-Shahrud.....	8	373	300,000 metric tons	1960	One pumping station at Rey and one pumping station at Shahrud are now in operation. Two booster stations, one at Semnan between Rey and Shahrud, and the second about halfway between Shahrud and Mashhad, are planned. Addition of these stations should raise capacity to 450,000 metric tons annually.
Shahrud-Mashhad.....	8	440	300,000 metric tons	1962	
Total		813			
Gach Saran-Shiraz gas line.	10	257	20 million cubic feet per day.	1960	Built primarily to supply the new chemical fertilizer plant and sugar plants near Shiraz.

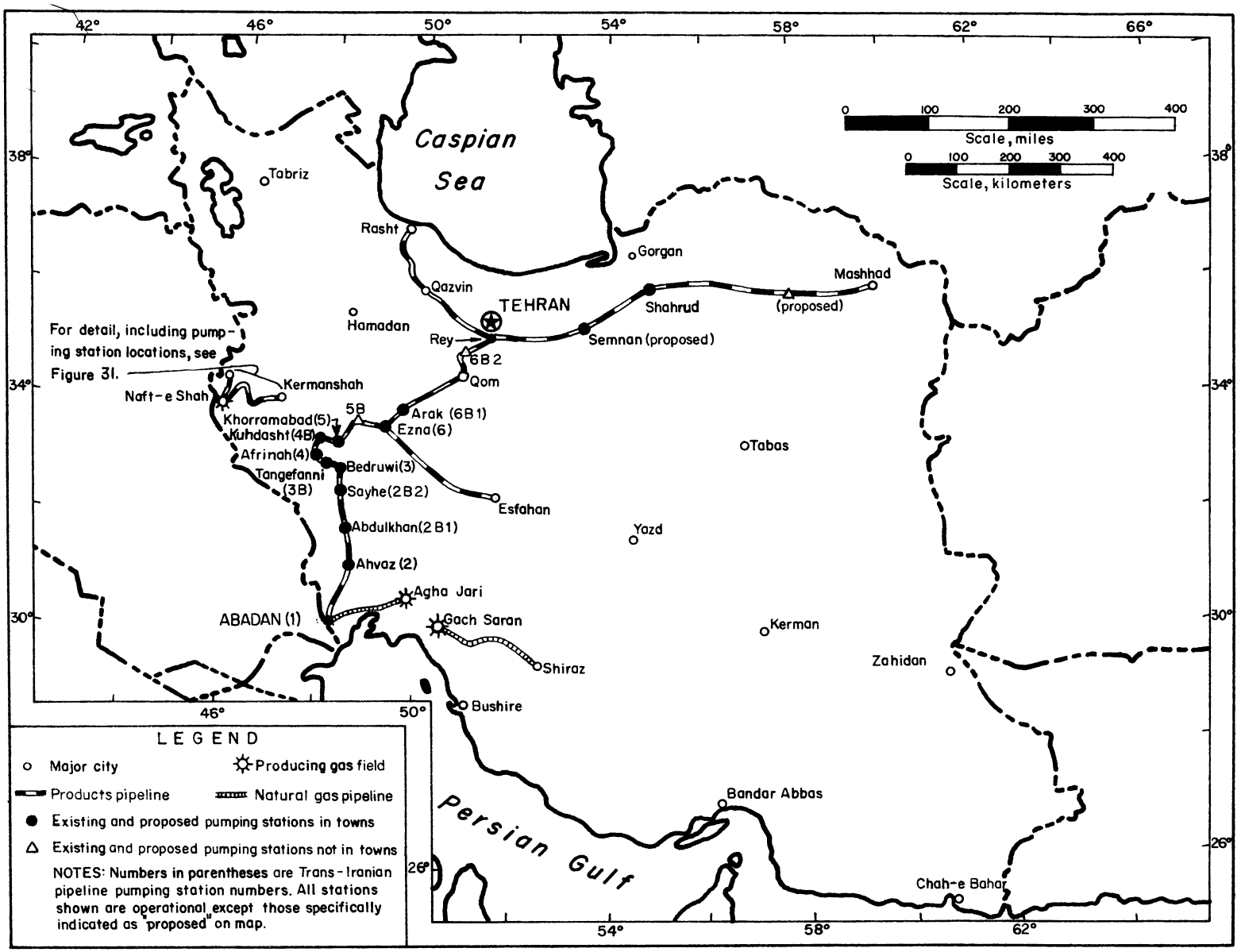


FIGURE 32. - Routes of NIOC Product Pipelines in 1962.

Fuel oil, to points beyond Ahvaz, continues to be moved by rail, supplemented by truck transportation for towns that are not on the railroad. Aviation fuels are also moved by rail or road transport rather than pipeline. Coastal shipments of all products take care of modest needs of Persian Gulf ports of Bushire, Bandar Abbas, Bandar Langeh, and other points.

The influence of the pipeline system on internal distribution by various transportation media is evident from table 25, which shows marked increase for 1956-59 in the share of pipelines in total ton-kilometers. Furthermore, the overall average shipping cost has declined, essentially because of the pipeline transportation.

Marketing and Storage

NIOC has set up a fairly extensive marketing organization to suit the country's requirements, which vary greatly geographically, and to assure availability of petroleum products within reasonable distance of consumers in all parts of the country. The sales outlets are classified as district centers, first and second class branches, sales agencies, town retailers, and out-of-town retailers. NIOC owns and operates the first three classes. In the case of sales agencies, NIOC builds the storage and pumping installations and a contractor provides labor and markets the products for a fee. Retailers own their own facilities and for a fee sell products, usually kerosine but sometimes other products as well, in a franchise-area allotted to them.

In 1960, the marketing organization consisted of 17 district centers, 37 branches (of both classes), 83 sales agencies, 916 out-of-town and 1,320 town retailers. In late 1961, the administrative organization was revised. The 17 districts were abolished, and the country was divided into 6 districts (fig. 33). Available data on the number and type of sales outlets for 1956-59, given below, although not reported on a strictly comparable basis with the 1960 data above, do indicate a shift in favor of sales agencies and retailers.

Type of sales outlet	1956	1957	1958	1959
Branches[1]	69	67	65	55
Sales agencies	59	61	64	78
Filling stations[2]	101	103	104	105
Out of town retailers	331	361	526	642
Town retailers	564	611	1,033	1,163
Total	1,124	1,203	1,792	2,043

[1] It is believed that figures given here include district centers and first and second class branches.

[2] NIOC owned only, operation believed to be controlled by district center and branch-type organization.

Gasoline is distributed from pumps in regular stations where population density and traffic volume justify pump installations; elsewhere gasoline is sold in 18-liter (4.8 gallon) cans. Agricultural consumers usually pick up their gasoline in their own conveyances from the closest sales outlet, but large consumers, government or otherwise, get free delivery.

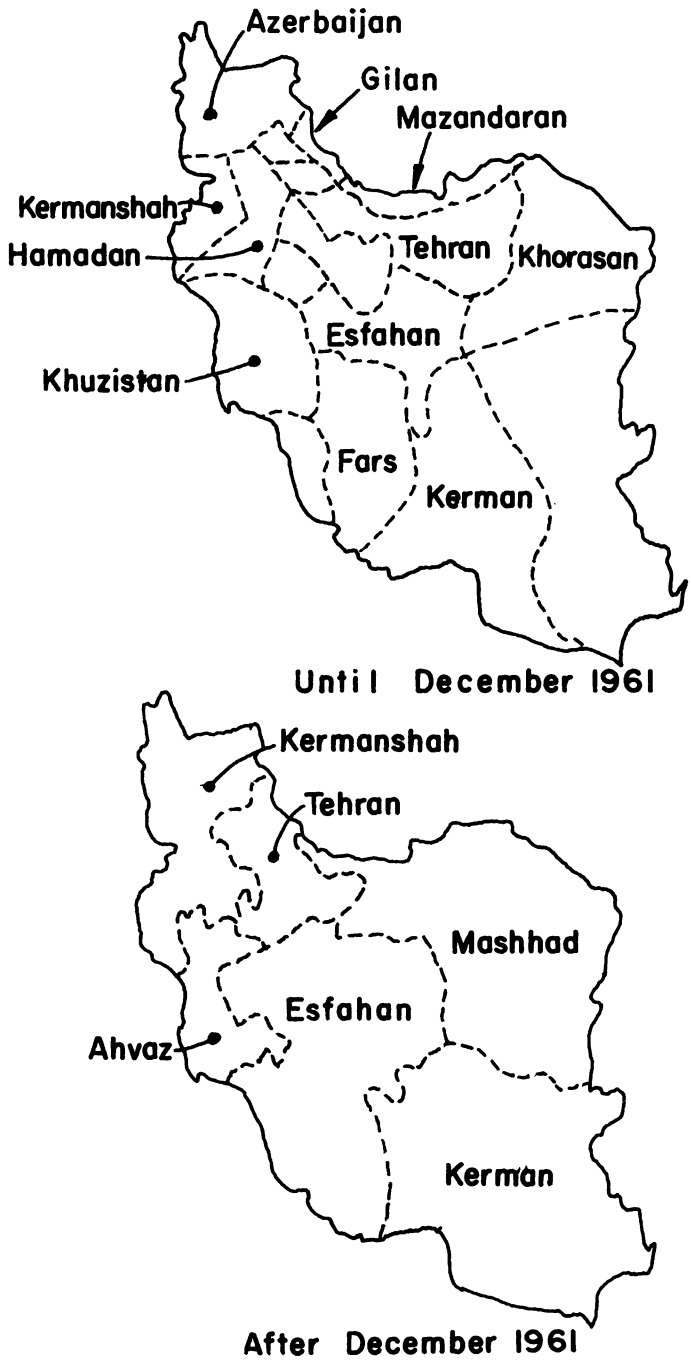


FIGURE 33. - Boundaries of NIOC Internal Distribution Districts Before and After December 1961. Consumption data given by district in Table 25 are for districts identified by name in upper sketch; data given for "Other" in Table 25 are for districts not specifically identified in that sketch (32).

Kerosine is sold in the majority of villages. Free home delivery of kerosine to customers with adequate storage facilities has started in Tehran and is being encouraged by NIOC.

Gas/diesel oil is sold from pumps in many, but not all, stations. Industrial consumers having storage capacity for at least one truck load (20,000 liters, or 5,284 gallons) get free delivery. The railroad has a large depot near Ahvaz and distributes for its own use.

Unlike the other products, furnace oil is delivered at the customer's expense. NIOC- or contractor-owned trucks deliver furnace oil to large consumers who have their own facilities for heating the oil during cold weather.

Current information on the capacity of the distribution system is incomplete. It is estimated, however, that distribution storage capacity of facilities that individually exceed 500 barrels each total about 1.8 million barrels, exclusive of tanks associated with pipeline pumping stations. Of this total, storage facilities for at least 640,000 barrels are located in the Tehran area. It is not clear, however, if this figure includes storage at the Rey depot of the Trans-Iranian products pipeline. Capacity of the depots completed in late 1961 at Mashhad (312,000 barrels) and Rasht (180,000 barrels in five tanks) are also included in the total.

Natural Gas Pipelines

At present, three sets of pipelines for the transmission of natural gas are in use in Iran (fig. 28). One links the Agha Jari field with the Abadan refinery and provides the refinery with plant fuel. This line consists of two 12-inch pipes in parallel from Agha Jari field to mile 19 manifold, one 12-inch line from the mile 19 manifold to Mashur manifold, and one 16-inch line from Mashur manifold to Abadan. The pipe in use is a low pressure type, originally used in part to move crude to Abadan. The second links Naft-e Safid field with Tembi in Masjed-e Soleyman field. This line for field fuel use is a 6-inch line (fig. 28). The third line is the first effort to provide natural gas to industry outside of the major oil producing and refining areas. It consists of a 10-inch line 257 kilometers long linking Gach Saran field with Shiraz, and was built principally to serve a chemical fertilizer plant and other smaller industries in the Shiraz area.

Discovery of vast natural gas reserves at Sarajeh field, near Qom, has resulted in plans for a 179-kilometer pipeline, possibly of 16-inch diameter, to convey this gas to Tehran.

BIBLIOGRAPHY[9]

1. Andresen, K. H. The Behavior of Asmari Reservoirs. Iranian Petrol. Inst. Bull. 6, 1962, pp. 153-163.

2. Anglo-Iranian Oil Company, Ltd. Reports of the Directors and Balance Sheets for 1935 through 1946. London, pub. 1936 through 1947.

3. _____. Annual Reports and Accounts as of Dec. 31, 1947, through Dec. 31, 1952.

4. Anglo-Persian Oil Company, Ltd. Reports of the Directors and Balance Sheets for 1909 through 1934. London, pub. 1910 through 1935.

5. Ansari, H. J. Resume of the Structural Geology of Iran and Some Iranian Oil Fields. 2d ECAFE Petrol. Symp. on Devel. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 5 pp.

6. Badakhshan, A. NIOC's Petroleum Engineering Laboratory Facility in Tehran with Emphasis on Core and Reservoir Fluid Study Facilities. 2d ECAFE Petrol. Symp. on Devel. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 21 pp.

7. Böckh, H., de, G. M. Lees, and F. D. S. Richardson. Contribution to the Stratigraphy and Tectonics of the Iranian Ranges. Ch. in the Structure of Asia by J. W. Gregory. Methuen and Co., Ltd., London, 1929, pp. 58-176.

8. Carruthers, J. E. The Development of Abadan Refinery. Iranian Petrol. Inst. Bull. 5. November 1961, pp. 113-134.

9. Djaafari, A., and C. Samii. Case History of Naft-e Shah Oil Field. Second ECAFE Petrol. Symp. on Develop. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 13 pp.

10. Farjam, Abdol Hamid. (Iran Pipelines.) Iranian Petrol. Inst. Bull. 4, June 1961, pp. 114-128.

11. Furrer, M. A., and P. A. Soder. The Oligocene-Miocene Marine Formation in the Qom Region (Central Iran). Proc. 4th World Petrol. Cong., Rome 1955, Sec. 1, pp. 267-277.

12. Gansser, A. New Aspects of the Geology in Central Iran. Proc. 4th World Petrol. Cong., Rome, 1955, Sec. 1, pp. 279-300.

13. Gibson, R. G. Iran's Geological Secrets Unlocked. Oil and Gas J., v. 60, No. 53, Dec. 31, 1962, pp. 81-83.

[9] Titles enclosed in parentheses are translations from the language in which the item was published.

14. Graham, W. J., George Hetherington, R. E. Old, Jr., and Vladimir Tuman. Effect of Production Restriction on Iranian Oil Reservoirs. Proc. 4th World Petrol. Cong., Rome, 1955, Sec. 2, pp. 395-416.

15. Henson, F. R. S. Observations on the Geology and Petroleum Occurrences of the Middle East. Proc. 3d World Petrol. Cong., The Hague, 1951, Sec. 1, pp. 118-140.

16. Imperial Government of Iran. Foreign Trade Statistics of Iran. Ministry of Commerce (and its predecessor agencies). Annual volumes for Iranian years 1327 (Mar. 21, 1948-Mar. 20, 1949) through 1339 (Mar. 21, 1960-Mar. 20, 1961).

17. Ion, D. C., S. Elder, and A. E. Pedder. The Agha Jari Oilfield, Southwest Persia. Proc. 3d World Petrol. Cong., The Hague, 1951, Sec. 1, pp. 162-186.

18. Iran Oil Company, National Iranian Oil Company. Geological Map of Iran. December 1959.

19. Iranian Oil Operating Companies (Consortium). Annual Reviews. 1955-56 and 1956-61.

20. _____. Case Histories of the Discovery and Development of Haft Gel and Gach Saran Fields in the Dezful Embayment of Southwestern Iran. 2d ECAFE Petrol. Symp. on Devel. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 98 pp.

21. Kent, P. E., F. C. Slinger, and A. N. Thomas. Stratigraphical Exploration Surveys in South-West Persia. Proc. 3d World Petrol. Cong., The Hague, 1951, Sec. 1, pp. 1141-1161.

22. Lees, G. M. Persia. A Review of Some Recent Geological Literature. Geol. Mag., v. 83, November-December 1946, pp. 285-288.

23. Lees, G. M. Persia. Ch. in World's Oilfields, ed. by V. C. Illing. The Science of Petroleum, v. 6, pt. 1, Oxford University Press, London, 1953, pp. 73-82.

24. Longrigg, S. H. Oil in the Middle East, Oxford University Press, London, 1961, 2d ed., 401 pp.

25. Moghavemi, Assadollah. (Distribution of Oil in Iran.) Iranian Petrol. Inst. Bull. 4, June 1961, pp. 104-113.

26. Mostofi, B. Recent Oil Exploration and Development in Iran (1950-61). 2d ECAFE Petrol. Symp. on Devel. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 12 pp.

27. Mostofi, B., and E. Frei. The Main Sedimentary Basins of Iran and Their Oil Possibilities. Proc. 5th World Petrol. Cong., New York, 1959, Sec. 1, pp. 337-345.

28. National Iranian Oil Company, Department of Economics and Statistics. Iran Petroleum Statistics 1956-58; and 1957-59. Tehran.

29. _____. Annual Reports for 1957, 1958, and 1959. Tehran, 24, 25, and 22 pp. respectively.

30. _____. Official Text of Agreement Between National Iranian Oil Company and Pan American Petroleum Corporation. Tehran, 1958, 59 pp.

31. _____. Official Text of Agreement Between National Iranian Oil Company and Sapphire Petroleums, Ltd. Tehran, 1958, 56 pp.

32. _____. News Letters. No. 8, Feb. 15, 1960, through No. 55, February, 1963.

33. _____. Report on the Research Centre of the National Iranian Oil Company (NIOC). 2d ECAFE Petrol. Symp. on Devel. of Petrol. Res. of Asia and Far East, Tehran, Sept. 1-15, 1962, 13 pp.

34. Oil Forum. Iran Presents Its Case for Nationalization. No. 6, March 1952, pp. 79-94.

35. _____. Anglo Iranian Answers Iran with Facts. No. 6, April 1952, pp. iii-v.

36. Petroleum Times. Review of Middle East Oil. June 1948, 115 pp.

37. _____. Special Middle East Review. Apr. 10, 1959, 320 pp.

38. Rouhani, F. International Agreements and Contracts in the Field of Petroleum. U.N. Inter-regional Seminar on Techniques of Petrol. Devel., New York. Jan. 23-Feb. 21, 1962. Seminar Paper No. 26, 41 pp.

39. Schlabach, E. J. Development of Gach Saran-Kharg Island Pipeline and Oil Handling Facilities at Kharg Island. Iranian Petrol. Inst. Bull. 4, June 1961, pp. 83-102.

40. Shwadran, Benjamin. The Middle East, Oil and the Great Powers 1959. Council for Middle Eastern Affairs Press, New York, 1959, 529 pp.

41. Slinger, F. C. P., and J. G. Crichton. The Geology and Development of the Gach Saran Field, Southwest Iran. Proc. 5th World Petrol. Cong., New York, 1959, Sec. 1, pp. 349-375.

42. Yousefian, G. Effect of Catalytic Reforming on Abadan Refinery Operations. Iranian Petrol. Inst. Bull. 3, February 1961, pp. 63-73.

APPENDIX 1. - BASIC D'ARCY CONCESSION[1] AND EVOLUTION OF THE ANGLO PERSIAN/ANGLO IRANIAN OIL COMPANY

The D'Arcy concession, signed on May 28, 1901, was initially granted for a period of 60 years from that date, and pertained specifically to petroleum, natural gas, asphalt, and ozocerite. It provided that the concessionaire was to have exclusive rights to explore for, produce, process for sale, transport to the Persian Gulf (for export) and to distribution centers (for domestic sale), and to market any or all of the above mentioned commodities. The concession covered the entire Persian Empire except for the five northern Provinces--Astrabad, Azerbaijan, Gilan, Khorasan, and Mazandaran--and provided for acquisition and retention by the concessionaire, on a tax free basis, of such lands as might be required for construction of facilities, either through gratuitous grant in the case of State-owned uncultivable land, or through purchase in the case of cultivable State-owned lands and all privately-owned lands. It also provided that all land acquired by the company, together with all supplies, buildings, and equipment owned by concessionaire companies, were to revert to the Government upon expiration of the concession.

Article 14 of the agreement bound the Persian government "to take all and any necessary measures to secure the safety and the carrying out of the object of" the concession, this including the security of both the physical assets and personnel of the company. Article 14 also says "The Imperial Government having thus fulfilled its engagements, the Concessionaire and the companies created by him shall not have power under any pretext whatever to claim damages from the Persian Government."

The concessionaire could form one or several companies to operate the concession, with all such companies enjoying all rights and privileges granted to D'Arcy so long as such companies assumed all responsibilities specified in the agreement. All workmen exclusive of managerial, supervisory, and technical employees were to be Persian nationals.

In return for rights and privileges granted, the concessionaire was to make an initial cash payment of £20,000 and an additional £20,000 in paid-up shares of the first company to be formed for exploitation, and thereafter was to pay the Government "annually a sum equal to 16 percent of the net profits of any company or companies" that might be formed to operate the concession. In addition, the concessionaire agreed to pay a salary of £1,000 annually to a commissioner appointed by the Government to advise the concessionaire and to supervise the protection of the Government's interests.

D'Arcy formed the First Exploration Company in May 1903, with a capital of £600,000 in shares of £1 each, of which 20,000 shares were given to the Persian Government. This firm actually held only 1 square mile in the Masjed-e Soleyman field area (known before 1926 as Maidan-e Naftun). Shortly afterward, D'Arcy formed the Bakhtiari Oil Company. Ltd., to exploit

[1] Only major terms are specified here; the reader is referred to the original text of the agreement for details.

additional tracts within the area controlled by the Bakhtiari Khans. This company, as formed, had 400,000 shares of stock valued at £1 each. Of the 400,000 shares, 12,000 (or 3 percent) were issued to the Bakhtiari Khans in return for rights to operate on their lands.

The financial resources of these companies were virtually depleted by exploration activities by 1905, when the financial help of the Burmah Oil Company and Lord Strathcona was enlisted. This led to the formation of the Concessions Syndicate, Ltd., which took over the assets of First Exploration Company. These additional resources were nearly exhausted before a significant discovery was made at Masjed-e Soleyman field in 1908.

In the following year, the Anglo-Persian Oil Company (APOC) was formed with an initial capital of £2,000,000 in shares of £1 each. At the time of its formation, APOC came into possession of 87.95 percent of the stocks of the First Exploration Company and 97 percent of those of the Bakhtiari Oil Company, Ltd., the balance being held by shareholders in Iran. In early 1914, distribution of the shares of APOC was reported at 970,000 held by Burmah Oil Company and 1,000,000 shares by Lord Strathcona. The balance of 30,000 shares was presumably held by Iranians.

Control of APOC shifted from private British hands to the British Government in mid-1914 as a result of Parliamentary approval of an agreement between the British Admiralty, the British Treasury, and APOC. Under this agreement, additional shares of stock were issued, and the British Government purchased £2,200,000 worth, giving it 51% ownership of the company. The principal purpose in this governmental purchase was to provide direct access for the British Admiralty to fuel oil reserves, in view of the growing importance of this commodity as a naval fuel.

APPENDIX 2. - TERMS OF THE 1933 REVISION OF THE D'ARCY CONCESSION[1]

Under this major revision of the 1901 agreement and its 1920 modifications, the operating period of the concession was extended to 1993, but the area was restricted to 100,000 square miles, the reduction to be carried out by the end of 1938. The selection of the area to be retained was left to APOC.

While the rights to explore for, produce, and process petroleum commodities obtained within the new restricted area were to be exclusively those of APOC (after 1935, the Anglo-Iranian Oil Company, or AIOC), rights for processing, transportation and distribution of petroleum products, elsewhere in Perisa, or Iran, as well as rights for pipeline construction and ownership, were placed on a nonexclusive basis.

Royalties were to be computed at 4 gold shillings per ton of crude petroleum consumed in or exported from Iran, instead of 16 percent of net profits provided in the old agreement. In addition, the Government was to receive a sum equal to 20 percent of the distribution to ordinary stockholders of APOC/AIOC, in excess of £671,250, whether the distribution was as dividends to stockholders for any one year, or whether it related to the reserves of APOC/AIOC, exceeding reserves on hand as of December 31, 1932. The total of the above payments was guaranteed by the company at a level of at least £750,000.

Income to the Government was raised further by a stipulation under which APOC/AIOC was to remain exempt from any general or specific taxes, "present or future" in consideration of the payment of 9 pence per ton on the first 6 million tons of oil annually and 6 pence per ton on oil in excess of 6 million tons annually for the first 15 years of the agreement. Corresponding payments during the second 15 years were 1 shilling and 9 pence, respectively. Under this provision, the Government was guaranteed an annual minimun of £225,000 in the first 15 years and £300,000 for the second 15 years. Thus the Iranian Government was assured of a minimum annual income of £975,000 annually for the first 15 years and of £1,050,000 annually for the next 15 years of the agreement.

The revised agreement required APOC/AIOC to develop the Naft-e Shah field on the Iran-Iraq border west of Kermanshah and to process its output for Iran's domestic consumption. In addition, the company agreed to make efforts to increase its employment of Iranian nationals, specifically to replace non-Iranian on its technical and commercial staff.

The provision of the original agreement concerned with the settlement of disputes was modified to provide for arbitration, with the selection of an umpire left to the President of the Permanent Court of International Justice if the arbitrators representing the company and the Government were unable to select one by mutual agreement. The new agreement further specified that the

---

[1] Only major terms are specified here; the reader is referred to the original text of the revision for details.

"concession shall not be annulled by the Government" and that its terms could not be altered by any means, executive or legislative. Only a decision by the Arbitration Court could annul the agreement, such an annulment resulting only from failure of the company to perform in accordance with terms of the agreement.

A number of other provisions of the original D'Arcy concession remained essentially unchanged; most modifications in these sections simply defined more precisely the procedures to be followed in various activities such as obtaining title to land for the company.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1964 O - 718-803