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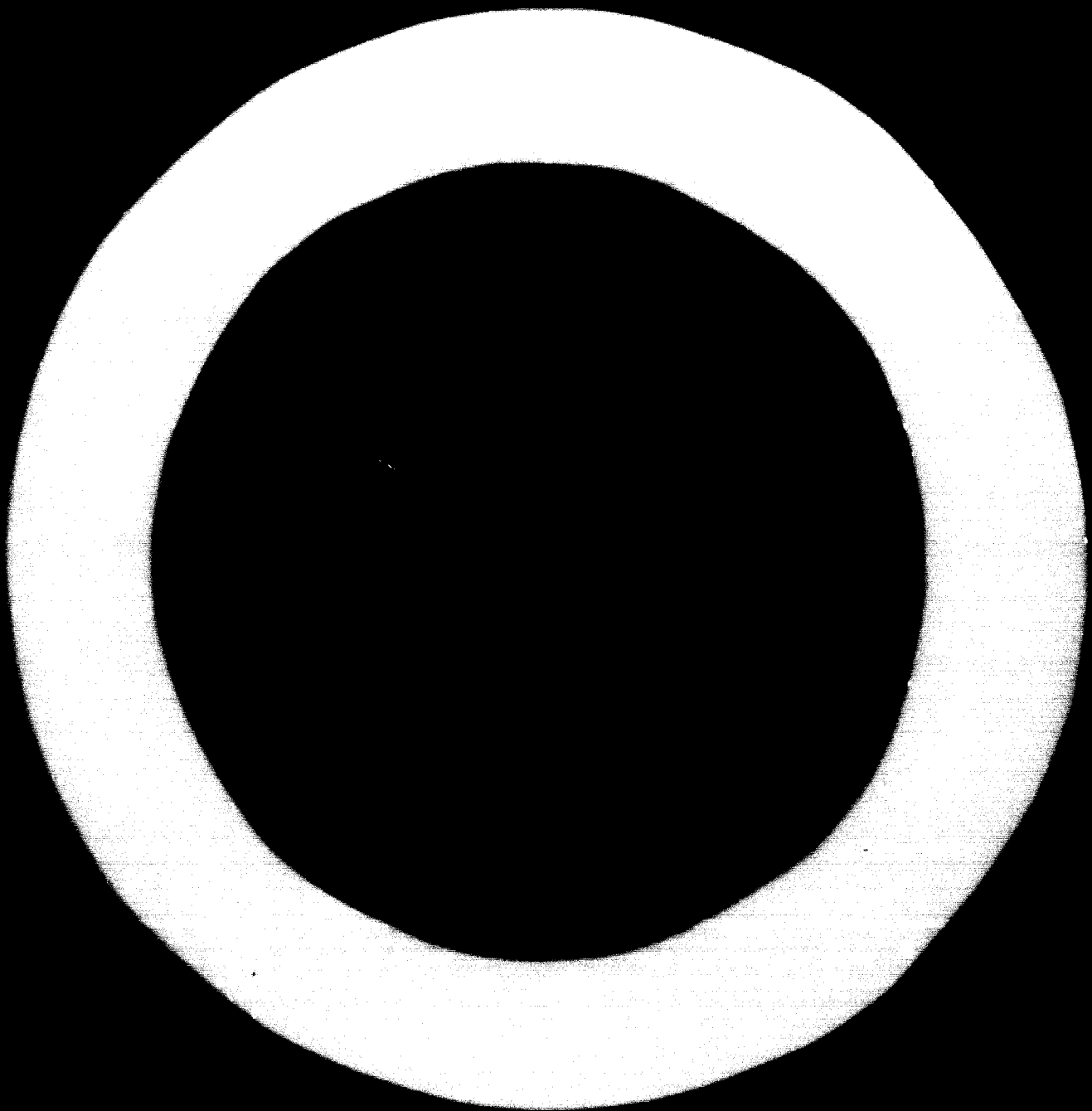

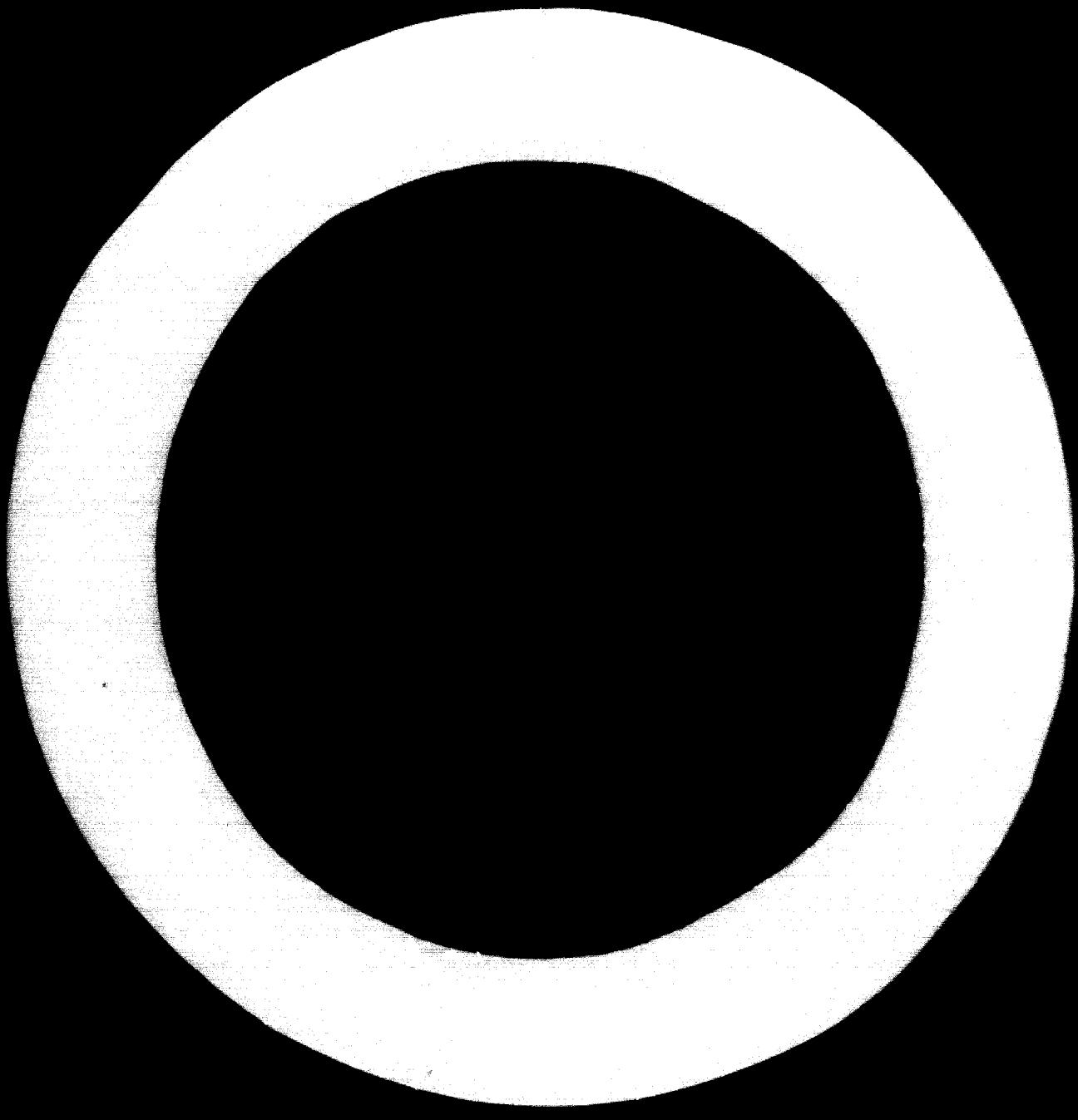

REPORT OF THE FIRST UNITED NATIONS INTERREGIONAL CONFERENCE ON THE DEVELOPMENT OF PETROCHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES

[illegible], [illegible]
10-20 November 1964

UNITED NATIONS
New York, 1966

[redacted]

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CONTENTS

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ANNEXES

INTRODUCTION

The first United Nations Interregional Conference on the Development of Petrochemical Industries in Developing Countries was held in Teheran, Iran, from 16 to 30 November 1964. 1/

The Conference was organized by the Centre for Industrial Development, in co-operation with the Bureau of Technical Assistance Operations of the United Nations Department of Economic and Social Affairs, the Economic Commission for Asia and the Far East, the Economic Commission for Europe and the Economic Commission for Latin America, and it was sponsored locally by the Government of Iran.

Developing countries, especially those with abundant petroleum and natural gas resources, have shown increasing interest in the development of petrochemical industries. In the recent past, the petrochemical industry has shown a very high rate of growth in the world economy. It is a dynamic industry which supplies intermediate products to a number of other industries and also provides substitutes for traditional materials, such as steel, lumber, paper, rubber, natural fibres, soaps, etc.

The petrochemical industry is characterized, inter alia, by high capital requirements and a large scale of operations. The relatively large size required for economic operation is a limiting factor in the establishment of petrochemical plants in countries where local demand is limited.

The field of petroleum chemistry is the subject of intensive research and development efforts and it is, as a consequence, undergoing constant technological change. Under the impact of such change, new products and processes replace old ones, and new uses are discovered for existing products. The accelerated rate at which new products and processes are developed, together with the reduction in the economic life expectancy of existing products and markets, demands substantial new capital investment to embody these new technologies. This is especially relevant in the selection and transfer of technology to developing countries.

Taking into account the above considerations, the purpose of the Conference was to bring together responsible officials at both the policy making and the technical levels from developing countries in Africa, Asia and the Far East, Latin America, Europe and the Middle East, and experts from the petrochemical industry in developed countries, to discuss technical, economic and policy aspects of the establishment and operation of petrochemical plants in developing countries.

1/ Project II.2 of the work programme of the United Nations in the field of industrialization drawn up by the Committee for Industrialization at its third session and approved by the Economic and Social Council (see Official Records of the Economic and Social Council, Thirty-sixth session, Supplement No. 1A, annex IV).

[illegible]

(a) Participants invited from the following developing countries: Argentina, Brazil, Burma, Chile, China, Colombia, Ecuador, India, Indonesia, Iran, Israel, Kuwait, Libya, Malaysia, Mexico, Morocco, Pakistan, Peru, Poland, Romania, Saudi Arabia, Syria, Trinidad and Tobago, Turkey, United Arab Republic, Uruguay, Venezuela, Yugoslavia.

(b) Experts and representatives of industry and academic and research institutions from the Federal Republic of Germany, France, India, Italy, Japan, Lebanon, the Netherlands, Switzerland, the Union of Soviet Socialist Republics, the United Kingdom, and the United States of America, who were invited to present papers to the Conference.

(c) Participants from the International Finance Corporation (IFC) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

(d) Representatives from two intergovernmental organizations: the Business and Industry Advisory Committee to the Organisation for Economic Co-operation and Development (BIAC) and the Organization of Petroleum Exporting Countries (OPEC).

(e) Representatives from the Economic Commission for Africa, the Economic Commission for Europe and the Economic Commission for Asia and the Far East.

(f) Experts or officers from several business firms, who attended as observers.

A list of participants and observers is given in annex II of this report.

The opening address was given by the Prime Minister of Iran, Mr. Hassan Ali Mansour. Addresses were also given by the Chairman of the Conference, Mr. M. Eghbal, and the Director of the Conference, Mr. [illegible], and messages were read from His Imperial Majesty Mohammad Reza Shah, Dr. Victor Hoo, United Nations Commissioner for Technical Assistance, and Mr. I.H. Abdel-Rahman, United Nations Commissioner for Industrial Development.

Mr. Manouchehr Eghbal (Iran) was unanimously elected Chairman. The Conference also elected as Vice-Chairmen: Mr. [illegible] (Kuwait), Mr. [illegible] (Yugoslavia), Mr. [illegible], Mr. [illegible] (Uruguay) and Mr. [illegible] (India).

In order to facilitate discussions and the preparation of the report of the Conference, a group of leaders and rapporteurs was appointed for the major substantive items of the agenda. The Conference also established a committee to prepare the report of the Conference. [illegible]

[illegible]

[illegible]

Summary of the [illegible]

The Conference held a total of twenty-one meetings, at which [illegible] and fifteen information papers were presented. [illegible] the presentation of the papers was followed by a clear discussion at each meeting [illegible] each substantive item.

The agenda of the Conference included the following substantive items:

(a) **Characteristics of the petrochemical industry and strategies for its development**

This item was intended to introduce the subject-matter [illegible] the [illegible] and to offer a survey of the major economic and technological characteristics of the petrochemical industry affecting its growth in developing countries. Papers presented on this item included: "General Characteristics of Petrochemical Industries and Factors Conditioning their Development", by the Centre for Industrial Development, "The Petrochemical Industries - Section I", by the Institut Français du Pétrole, a consultant to the Conference, and papers by industry experts on technology and choice of [illegible] in petrochemical industries for developing countries, and recent petrochemical developments.

(b) **[illegible] demand and supply of petrochemical products**

Under this item, the market determinants of petrochemical growth were presented, including statistical data and projections of production, consumption and trade in fertilizers, plastics, synthetic fibres and synthetic rubber, and the importance of market size for the economic production of petrochemicals. [illegible] included two papers by the Centre for Industrial Development on "Recent Trends in Production, Consumption, Trade and [illegible] in Selected Petrochemical Products" and "The Role of the Domestic Market in the Development of Petrochemical Industries and the Need for Exports in relation to Economies of Scale". Papers presented by experts from industry dealt with recent trends in the world petrochemical industry, the role of market research, and synthetic petrochemical substitutes of natural products.

(c) **Recent trends in research and technology in the petrochemical industry**

Papers presented under this item outlined recent technological advances in regard to new processes, products and alternative [illegible] for petrochemicals, emphasizing those that were deemed promising for the developing countries. The Centre for Industrial Development presented a review paper, "Recent Trends in Research and Development in the Petrochemical Industry". [illegible] [illegible] representatives, including Professor [illegible] [illegible] and other [illegible] authorities, [illegible] papers [illegible] [illegible] petrochemical research and development [illegible] a paper by [illegible] [illegible] companies [illegible], and [illegible] [illegible] [illegible] presented by [illegible]

[illegible]

(d) Industry studies

Papers relating to this portion of the Conference agenda dealt with the technological aspects of petrochemical production. Data were presented on capital and other input requirements, production costs, economies of scale and alternative production processes. The papers emphasized differentials in capital and other costs associated with the transfer of the technologies described to developing countries. Particular attention was paid to products and technologies that are promising for developing countries. The subjects covered were arranged under the following headings:

(i) Raw materials and basic intermediates

On this, as well as on most other petrochemical productions covered in this section of the agenda, the Centre for Industrial Development presented a paper prepared by the Institut Français du Pétrole as consultant to the Centre for Industrial Development, "The Petrochemical Industries - Section II", which covered all basic products, or first-generation petrochemicals. On raw materials proper, the papers presented covered different aspects of the utilization of natural gas, naphthas for steam cracking and heavy oils. Extensive coverage was given to the paraffins, olefins and aromatics petrochemical building blocks, including different production processes relevant for developing countries. A total of nineteen working papers and two information papers were presented by industry experts, in addition to a presentation by the Special Fund of the United Nations and an information paper by the Centre for Industrial Development on the utilization of natural gas.

(ii) Nitrogenous fertilizers

Special attention was given to technological and economic aspects of the production of ammonia - the basic component of nitrogenous fertilizers - in developing countries. Papers were presented by industry experts, Centre for Industrial Development consultants, and participants from developing countries.

(iii) Plastic materials

Papers presented by experts from industry and academic and research institutes covered the main thermoplastics: polyethylene and other polyolefins, mono- and polyvinyl chloride, mono- and polystyrene, acrylics, and polyamides (nylon). Prospects for the application of plastics as construction materials were specifically analysed in a detailed paper submitted by the Battelle Memorial Institute.

(iv) Synthetic rubbers

The styrene-butadiene (SBR) rubber and the more recent butyl-rubber, and stereo-rubbers, were covered in papers presented by Centre for Industrial Development consultants and industry experts.

(v) Synthetic fibres

The processes for the manufacture of polyamides (nylon), polyesters (dacron-terylene), and acrylic (orlon) fibres, were reviewed in several working papers contributed by industry experts and Centre for Industrial Development consultants. Special attention was paid to the different processes available for the production of polyamides.

(vi) Selected end-products

In this section presentations were made on the following petrochemical end-products: sulphur, carbon black, detergents, methanol and pesticides.

(e) Country studies

Participants from developing countries and selected industrialized countries presented their experience in developing petrochemical industries. A total of thirty country studies were presented, grouped as follows: in Asia and the Far East - Burma, China (Taiwan), India, Indonesia, Iran, Japan, Malaysia, Pakistan; in North Africa and the Middle East - Israel, Kuwait, Libya, Morocco, Saudi Arabia, Syria, United Arab Republic; in Europe - Poland, Romania, Turkey, USSR, Yugoslavia; in Latin America - Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Trinidad and Tobago, Uruguay, Venezuela.

(f) Regional development

The United Nations regional economic commissions: the Economic Commission for Asia and the Far East (ECAFE), the Economic Commission for Latin America (ECLA), and the Economic Commission for Europe (ECE), prepared studies dealing with the development of the petrochemical industry in their regions. These studies covered items such as the production of petrochemicals, plans for new plants, regional markets, raw material situation, and special problems and features characterizing the development of petrochemical industries in each region.

(g) Financial and legal aspects of the petrochemical industry

Studies presented covered aspects of the financial structure of the industry, international resources available for the development of petrochemical industries in developing countries, prevailing financial and legal arrangements, and forms of ownership: state, joint and private ventures. Papers presented by industry experts dealt separately with patents, licensing and know-how agreements in the petrochemical industry. The Centre for Industrial Development presented a paper, "Financing of Petrochemical Ventures in Developing Countries", the International Finance Corporation-International Bank for Reconstruction and Development contributed a paper, "The Role of the International Finance Corporation in Promoting Industrial Ventures in Developing Countries", and the Business and Industry Advisory Committee to the Organization for Economic Cooperation and Development presented a paper, "The Role of Foreign Investment in Petrochemical Manufacture".

(h) Location factors in the petrochemical industry

Papers presented under this item surveyed and analysed factors affecting the location of petrochemical plants, such as: natural resources, size of domestic

markets, and the development of regional markets, taking into account foreseeable economies of scale, regional economic arrangements, international trade policies and new technological developments. Special attention was given to new developments in ocean transportation techniques for ammonia and ethylene, and the trend towards integrated production in petrochemical complexes. Studies were presented by Centre for Industrial Development consultants, industry experts, and participants from developing countries.

The present report covers the above-described eight agenda items, giving in each case a synthesis of the subject as presented to the Conference and a summary of the discussion that followed. The report also includes the recommendations and observations of the Conference, and five annexes containing the programme of the Conference, a list of participants, a list of the officers of the Conference, the official messages and addresses delivered at the opening and closing meetings, and a list of the documentation of the Conference.

Recommendations and observations of the Conference

At its concluding meeting on 30 November 1964, the Conference approved a number of observations and recommendations.

The Conference recommended first that studies should continue on the development of the petrochemicals industry, as well as projections of production, demand and trade in petrochemicals in the various parts of the world, so that the developing countries could undertake their petrochemical projects with the full knowledge of the developments in this field.

It also recommended that studies should be undertaken regarding the substitution of traditional materials by synthetic products and/or the use of synthetic products to improve the quality of these materials, and also regarding the new uses of such products, in order to assist the developing countries to widen their markets and provide a larger basis for the development of petrochemical industries.

It recommended that pre-investment data studies should be undertaken for different petrochemical industries, such studies to include data on investments and inputs for various sizes of plant and various processes.

It also recommended that studies should be carried out into patents and licences for various petrochemical products, with a view to providing greater knowledge about the various alternatives open to the developing countries, including the evaluation of royalties and fees for licensing of petrochemical processes.

It recommended that the United Nations should assist the developing countries under its programmes of technical assistance and through the Special Fund in setting up technical petrochemical institutes for carrying out research into the uses of products, making pre-investment and feasibility studies for the implementation of petrochemical projects, training technicians and undertaking market research.

The Conference recommended that the United Nations should also, through its appropriate organs, assist developing countries in establishing national or regional technical design institutes, with a view to promoting the local manufacture of certain items of industrial equipment for the petrochemical industries, thus reducing the foreign exchange burden of the countries concerned.

It also recommended that the regional economic commissions of the United Nations should promote co-operation in the regions and between countries, with a view to specialization by member countries in the development of specific industries, including petrochemicals.

The Conference recommended that the Centre for Industrial Development should take steps to set up an appropriate panel of scientists and technical specialists of recognized standing and experience in the various aspects of petrochemical industry who could advise on problems raised by developing nations and whose expert guidance would be made available for assessing the general orientation of and progress being made in the petrochemical field.

The Conference noted the efforts being made by the developing countries to set up within the family of the United Nations an international finance institution to provide industry in the developing countries with long-term low interest development loans, since at the present time such assistance is not available from international institutions. It recommended that efforts in that direction should be continued and intensified; the need for long-term development loan financing for the developing countries for the promotion and rapid growth of petrochemical industries was very urgent, and no effort should be spared to set up such an international institution at the earliest possible date.

The Conference also noted the efforts currently being made by the developing countries and the appropriate organs of the United Nations with regard to problems of licensing know-how and transferring new technology. It made the following recommendations for consideration by these organs, with particular reference to the rapid promotion of petrochemical industries in the developing countries:

(a) Fees now being charged for the licensing of know-how should be reviewed so that these charges may be levied in accordance with the size of the project and not irrespective of it.

(b) In order to provide incentives for the lowering of licensing fees, the Governments of developed countries should provide licensors with some form of tax relief in respect of income from such fees and from royalties originating in the transfer of technologies to the developing countries, especially in petrochemical fields.

(c) In view of the need for part of the new production of the petrochemical industries in the developing countries to be exported, licensing agreements should not be restrictive in this respect. The developed countries should encourage such imports from the developing countries by sharing their own export markets with their licensees in the developing countries. Such measures are essential for the rapid promotion and growth of the petrochemical industries and also in order to reduce the burden of foreign currency payments by earnings from such exports.

The Conference also recommended that the United Nations should consider the possibility of holding similar petrochemical conferences every two or three years so that the developing countries could keep pace with the rapid changes taking place in the industry.

The Conference noted with appreciation in that connexion the invitation extended to the Centre for Industrial Development and all the participants in the Conference to hold the next conference in Mexico City, not later than 1976.

It also noted with appreciation the offer by the Mexican participants representing Petróleos Mexicanos (PEMEX), to make available to the Centre for Industrial Development personnel to assist it in the following activities:

(a) The elaboration of market research studies on petrochemicals in the developing countries.

(b) The elaboration of country surveys for the establishment or expansion of petrochemical industries in the developing countries.

(c) The elaboration of investment programmes and feasibility studies for petrochemical projects in the developing countries.

The participants in the Conference expressed their deep gratitude to His Imperial Majesty the Shahinshah, and to the Government and people of Iran for the hospitality extended to the Conference and in particular for the outstanding co-operation of the management and staff of the National Iranian Oil Company in the arrangements for the organization and holding of the Conference.

The participants also expressed their thanks to the United Nations Centre for Industrial Development for organizing the Conference and to the members of the Conference secretariat for their untiring efforts in connexion with the substantive servicing and conduct of the meetings, which had contributed greatly to the successful achievement of the aims of the Conference.

I. CHARACTERISTICS OF THE PETROCHEMICAL INDUSTRY AND PROSPECTS FOR ITS DEVELOPMENT

(Agenda item I)

General characteristics

This section of the Conference was devoted to a discussion of the general characteristics of petrochemical industries and the main factors influencing the establishment and development of these industries in the developing countries.

Developing countries, especially those with abundant petroleum and natural gas resources, have shown increasing interest in the development of petrochemical industries. The petroleum refineries which are being established in a number of countries also provide a basis for establishing petrochemical complexes. In addition, there are countries with an already existing organic-chemical industry, which are substituting oil and gas for other traditional inputs, such as raw materials derived from coal or vegetables.

This industry is regarded as strategic to the inducement of further industrial development because most of its output goes to other producing sectors. It shares this characteristic of intermediate manufacture with other industries, such as iron and steel, paper and its products and petroleum products.

Stress was laid upon the following characteristics of the petrochemical industry, which should be borne in mind in establishing a programme for its development:

(a) A high degree of product homogeneity and standardization, continuity and stability of operations;

(b) A high capital intensity;

(c) A high proportion of skilled labour, including scientists and technicians;

(d) The availability of alternative production processes and raw materials, and a high rate of technological change. 1/

The high capital intensity and high rate of technological change imply, as a general rule, the need for a high rate of capacity utilization and the existence of economies of scale.

If output is trebled economies in capital investment range from 20 to [illegible] per cent, according to the type of production. Economies in production costs also arise from the reduction in unit costs of labour and capital. There is a great range of variation in the economies in production costs between [illegible]

1/ General Characteristics of Petrochemical Industries and Factors Affecting their Development (PET/CHEM/CONF.115).

[illegible] such as, for example, plastics and resins for fibres, and basic intermediates such as ammonia or ethylene, obtained in one or two [illegible] stages from oil or natural gas. While economies in production costs will be about [illegible] per cent for the first group, they will range between 15 and [illegible] per cent for the second group, if output is increased by three to five times.

[illegible] it was shown that, in the production of ethylene, the capital investment in dollars per ton may range from $[illegible] for a 10,000 ton/year capacity plant to $[illegible] for a [illegible] ton/year capacity plant. In ammonia from natural gas, $[illegible] per ton for a [illegible] ton/year plant to $[illegible] per ton for a [illegible] ton/year capacity plant [illegible]. In carbon black, from $[illegible] per ton for a [illegible] ton/year plant to $[illegible] per ton for a [illegible] ton/year capacity plant. In [illegible], from $[illegible] per ton for a [illegible] ton/year plant to $[illegible] per ton for a [illegible] ton/year capacity plant.

The [illegible] economies are to be achieved when output is increased in the low to the medium size capacity range, and they tend to disappear after large capacities are reached [illegible]. Accordingly, developing countries, which are in most cases characterized by rather small domestic markets, would still reap a good part of the potential scale economies while operating in the medium size capacity range.

Another important consequence for developing countries is that when economies of scale are operative, the relative share of raw materials in total cost rises with the increasing scale of production. Thus, while capital cost per unit of output is reduced, the contribution to unit production cost of raw materials – on which many developing countries can claim a comparative advantage – increases. Thus, while total absolute capital requirements are higher with the increased scale of production, [illegible] capital cost will be minimized and the potential comparative advantage in raw materials will be exploited to the maximum.

[illegible] requirements in the petrochemical industry are rather on the low side [illegible] while a high proportion of engineers, [illegible] and skilled operators is required. Some examples may illustrate the [illegible] in this type of industry, as regards quantity and quality. In [illegible], a complex for the production of synthetic rubber and other products, representing a $[illegible] million investment, will provide employment for [illegible] people, [illegible]. Another plant for the production of [illegible] [illegible] people, will use only [illegible] with [illegible] technicians, engineers and scientists. A carbon black plant [illegible] in a developing country uses only [illegible] per cent of unskilled labour, the rest [illegible], technicians, engineers and scientists. [illegible]

[illegible]

Petrochemical production is in most cases carried out in certain [illegible] in interrelated production facilities known as complexes. A petrochemical complex may provide for the utilization of a common large size unit supplying basic intermediates to several unit plants, the utilization of by-products or raw materials as inputs to another, the sharing of a common raw material feedstock and utilities facilities among several plants, etc.

Present distribution of petrochemical plants

Although petrochemical industries are still concentrated in the economically advanced countries, efforts at industrialization seem to have been accompanied in many developing countries by a pleasant high rate of investment in the petrochemical industry. Steps have also been taken among the centrally planned economies towards increasing investment in the petrochemical sector.

Of the approximately 1,000 petrochemical plants in existence, more than 80 per cent are located in the United States and Canada, about 10 in Western Europe, some fifty in Japan, and the rest are distributed among all other areas. However, at the end of [illegible], new projects or plants under construction were more evenly distributed among the United States, Western Europe, Japan and developing areas. Table 1 shows the world-wide distribution of petrochemical plants and projects.

Table 1

World-wide distribution of petrochemical [illegible]

Country	Existing plants (1)	Projected [illegible] (2)	[illegible] (1) + (2)
United States	[illegible]	[illegible]	[illegible]
Western Europe	[illegible]	[illegible]	[illegible]
Canada	[illegible]	[illegible]	[illegible]
Japan	[illegible]	[illegible]	[illegible]
All other areas[1]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]

1/ [illegible]

[illegible]

[illegible]

Table 2

Petrochemical plants and projects in developing countries - 1961, 1962, 1963

	Plants			Projects		
	1961	1962	1963	1961	1962	1963
Latin America	26	36	[illegible]	30	35	[illegible]
Asia and the Far East	5	6	10	20	32	32
Middle East	2	2	2	3	[illegible]	[illegible]
Africa	-	-	1	-	[illegible]	[illegible]
Total	33	44	[illegible]	53	[illegible]	[illegible]

Up to last year, most of the existing plants and projects in developing countries were still concentrated in Latin America and Asia, which accounted for [illegible] per cent of the total. More than [illegible] per cent of all the existing and projected plants were located in Latin America, concentrated largely in three countries: Argentina, Brazil and Mexico. In Asia and the Far East, India had the majority of the installed and projected plants.

This information is, of course, merely an indication of the [illegible] [illegible] important structural feature characterizing this [illegible] plants in developing countries is that the majority of the existing and projected [illegible] the production of ammonia and nitrogenous fertilizers, and only a [illegible] for the production of synthetic rubbers and fibres. Table 3 [illegible] [illegible] plants for the production of [illegible] [illegible] per cent of the total number.

Table 3

[illegible]

[illegible]	Plants	Per cent
[illegible]	[illegible]	[illegible]

Fertilizer plants rank first, on account of [illegible] fertilizers to increase food production, and the [illegible] technological "know-how". The production of synthetic [illegible] not demanding higher capital investment, [illegible] and also, in many developing countries. The development of these [illegible] imply the replacement of traditional industries sometimes based on [illegible] materials.

Factors conditioning the development of petrochemical industries in developing countries

The development of petrochemical industries in developing countries is controlled by considerations such as those mentioned above, and results in a pattern of production which does not [illegible] the experience of industrialized countries. In this respect, the following conclusions were presented to the Conference: 1/

(a) That developing nations have on account [illegible] to the development of petrochemical industries and that most of them [illegible] in this strategic section of industry.

(b) That petrochemical industries are being developed and supported by:

(i) Those developing countries which have a large enough market to [illegible]

(ii) Some developing countries which [illegible]

[illegible]

[redacted]

[redacted]

As regards the market situation, it was suggested that the production capacity of a planned plant should be based on the assumption that at least 50 to 60 per cent of the nominal capacity will have assured outlets in the local markets with tariff protection if necessary, or assured export outlets, by means of long term or barter contracts between Governments, or through co-operation with international companies having access to specific export markets.

In order to solve the problem posed by the limited size of the market in many developing countries, the possibility is envisaged of market integration in certain areas, to allow the construction of units with large production capacities The regional allocation of producing units, accompanied from the very beginning by trade agreement acts, may serve as a mutual guarantee of supply, and also permit the operation of each production unit under the most favourable technical and economic conditions; and implantations of units which would be impossible if each country wanted to set up production of the entire range of products. 9/

Emphasis was placed upon the necessity of careful planning before starting any development plan in the petrochemical field. This planning is necessary in order to determine the actual situation and needs of the country concerned, and it will also facilitate requests for financial assistance from private or international organizations by providing them with a sound basis.

Technological aspects

The following technological aspects of modern petrochemical industry were brought forward as being relevant for developing countries considering the establishment of petrochemical industries: 10/

(a) Careful studies must be made before erecting big units, such as, for instance, a naphtha cracker, because of the techno-economic implications of such decisions, including the disposal of by-products.

(b) Developing countries should try to avoid the twin pitfalls of uneconomic plant scale, and obsolescent products and technology. Due consideration should be given to the latest new technology being made available in advanced countries.

(c) Recent technological improvements permit the production of similar products with less investment and at lower cost. As an example, it was suggested that caprolactam based Nylon-6 should be produced instead of Nylon-66, because it demands a smaller economic scale, investment and production costs are lower and the raw materials and know-how are readily available.

In the major fields of industrial and consumer goods, attention was called to the following points:

(a) Synthetic rubber. The construction of polyisoprene and cispolybutadiene rubber plants seems to be a less expensive approach towards supplying the synthetic rubber needs of the tyre industry in developing countries.

9/ See also chapter VI, "Regional Development", and chapter VIII.

10/ Problems of Technology and Obsolescence in Petrochemical Industries for Developing Countries (PET/CHEM/CONF.33). See also chapter III, "Recent trends in research and technology in the petrochemical industry".

(b) Synthetic fibres. Rayon is rapidly being phased out as the most important synthetic fibre. Its place is being taken by nylon. If a single fibre is to be selected by a developing nation, it should be nylon. Polyester fibres demand a more sophisticated technology and higher capital investments, and the availability of know-how is more limited. Acrylic fibres are in less demand because of the climate prevailing in many developing countries.

(c) Plastics. The plastic with the broadest range of properties and applications is polyethylene. Polyvinyl chloride and polystyrene rank next in importance.

(d) Fertilizers. Developing countries may in most cases justify large fertilizer plants on the basis of existing and potential demand from agriculture. Ammonia, urea, ammonium nitrate, ammonium sulphate and complex fertilizers are among the desirable choices.

(e) Detergents. The trend in developed countries is towards biodegradable detergents because of water pollution problems, but for developing countries dodecylbenzene sulphonate may still be a good choice as a detergent for some time to come.

As regards the availability of the technology necessary to start a petrochemical programme in a developing country, it was pointed out that in this respect it is much easier to establish such an industry today than it was some years ago.

Summary of discussion

The discussion that followed the presentation of the papers concentrated mainly on the general factors conditioning the development of petrochemical industries, some new technological trends, and the possibilities offered by international co-operation in this field.

As to the capital investment required, it was stated that the developing countries might reap some advantage by using a labour-oriented scheme to erect and operate the plants. It was also pointed out that an increasingly larger part of the equipment can be fabricated in many developing countries, a fact which lessens the need for foreign currency.

As regards production costs, it was argued that world prices should not be the only criterion in establishing domestic petrochemical industries. Developing countries may have the protection resulting from the cost of transportation from the developed countries and the tariffs imposed by their own Governments.

It was stated that the establishment of petrochemical industries should be considered as a means of improving the standard of living of the people of developing countries by meeting their domestic demand, and to some extent of solving these countries' problems of balance of payments.

It was suggested that the development of petrochemical industries in developing countries should be conceived within the framework of the over-all economic development of each country. It was pointed out that in the course of the discussions at the Geneva Conference on Trade and Development, the developing countries had stressed the need of protection for the establishment of industries

in the developing countries. In addition, it seemed unfair to compare the possibilities of petrochemical industries in the developing countries on a cost basis with those of the developed countries and within certain limits, local industry must be protected in a developing country.

As to the foreign exchange difficulties prevailing in many developing countries, a suggestion was made that in appraising the problem of paying for the foreign exchange portion of the investment a country should take into account its economy as a whole and not only the foreign currency savings and export possibilities deriving from a particular project.

Reference was made to the capacity range in which economies of scale were larger for petrochemical plants and also to the prevailing trend in the petroleum refineries towards small units to supply a given market area. It was also observe that this might be followed by petrochemical plants and complexes in the future.

It was pointed out that account should be taken of the fact that there was a difference in the products and a difference in the nature of the process between petroleum refineries and petrochemical plants, and that the influence of capital cost was more pronounced in petrochemical plants which were thus more sensitive to economies of scale. Petrochemical plants have to operate under more strict controls, owing to the specifications of the products and the waste involved if an operation miscarries. In refineries, on the other hand, a fault in operation control does not mean a total loss of production in most cases. Mention was also made of the differing needs for trained workers, chemical engineers and supporting staff. In the marketing of refinery products, for instance, only a limited number of the personnel requires a technical background, while in the marketing of petrochemical products, most of the personnel needs a chemical engineering degree or similar technical training.

On the other hand, a case was mentioned in which a new fertilizer plant erected in one country was put into operation without difficulty making use of refinery personnel.

With respect to the market situation in developing countries, it was noted that in many cases, the development of a domestic supply of a product stimulates the demand for it. As an example, it was stated that the consumption of detergent in one country had risen from 2,000 tons/year to 10,000 tons/year two years after the local production of this product was initiated.

In connexion with new technological trends, 11/ comments were made about the new synthetic rubbers and fibres, especially polyisoprene and the polyvinyl alcohol fibres with properties similar to cotton, and also about the possibilities of polypropylene fibre as a general-use fibre. It was mentioned in this respect that, in the United States, a plant producing 30,000 tons/year of isoprene rubber was operating in competition with natural rubber. As to polypropylene fibre, it was stated that there had been a great increase in the use of this fibre in the United States, and that most of the growth of the product was due to its utilization as fibre. The great difficulty, and the considerable cost, involved in introducing a new fibre into the market was mentioned.

11/ See also chapter III.

As regards international co-operation, 12/ the points raised dealt mainly with the possibility of co-operation between countries, sub-regions and regions, and the availability of technical assistance from developed countries and the United Nations.

It was mentioned that Yacimientos Petroliferos Fiscales (YPF), the State petroleum company of Argentina, favoured the idea of market integration so that large economic plants could be erected in developing countries.

Last October a meeting took place in Buenos Aires, with the participation of the State petroleum companies of Latin America, to which the United Nations Economic Commission for Latin America and all the LAFTA sent observers. At this conference, all the State petroleum companies agreed upon a number of points, including the joint marketing of surplus products and a wide exchange of information on the Latin American petrochemical situation. The problem of market integration was also discussed. As a result, another meeting will be held in Lima, Peru, in January, in order to prepare the ground for a Latin American Organization to deal with the problems of petroleum and petrochemicals on an interregional basis

It was also mentioned that Iran was negotiating with certain neighbouring countries with a view to setting up large and specialized petrochemical plants in each country, so that all could be supplied with products at lower cost on an exchange trade basis.

Several participants stressed the need for co-operation in order to establish economical petrochemical plants in the developing countries. Co-operation from the developed countries should be in the form of making available technical know-how and the improvements already made in technology, and in the form of joint ventures.

It was suggested that the United Nations could help the developing countries by collecting and making available to them the latest facts and statistical data on what the developed and developing countries were doing in this field.

It was also suggested that the United Nations should make an effort to help developing countries to acquire technology and process designs, with a view to reducing capital investment and the cost of petrochemical production.

Finally, stress was laid on the need for United Nations assistance in order to help the developing countries to decide upon the type of plants and processes to be adopted in their petrochemical projects.

12/ See also chapter VI.

II. ASPECTS OF DEMAND AND SUPPLY OF [illegible]

(Agenda item II)

Production, consumption and trade patterns

During the early part of this century, world [illegible] very modest rate, reaching an estimated value of [illegible] Over the past twenty years, the chemical industry [illegible] By 1955 production had reached $50,000 million and it [illegible] $100,000 million by 1965. Eight countries, the United States [illegible] the USSR, the Federal Republic of Germany, the United Kingdom [illegible] Japan and Canada, accounted for three quarters of total [illegible] In 1950, the United States produced about 50 per cent of [illegible] but the resurgence of the chemical industry in Europe and Japan [illegible] share to slightly under 40 per cent. It may be noted [illegible] total world market held by the above eight countries [illegible] past few years.

With respect to international trade, total export of [illegible] throughout the world has grown from over $6,000 million [illegible] $8,000 million in 1962. Over 90 per cent of world [illegible] the EEC and EFTA trade groups, the United States, [illegible]

Although total chemical export as a percentage of [illegible] 9 per cent, considerable variation exists among [illegible] Republic of Germany and the United Kingdom export about [illegible] production. This is partly a historical pattern but [illegible] association with the European trading groups.

In all industrial areas of the world, chemicals based [illegible] gas have exceeded the growth rate for the chemical industry [illegible] the first commercial chemical (isopropyl alcohol) based [illegible] in 1919, the trend did not become significant until [illegible] organic chemical products which find their origin in [illegible] constitute a large share of total chemicals.

The papers presented describe recent trends in the [illegible] petrochemicals, namely, plastics, synthetic fibres, [illegible] fertilizers. The major consuming centres for plastics [illegible] United States, Western Europe, Oceania and Japan [illegible] total world consumption. For nitrogenous fertilizers [illegible] have a lower share - 66 per cent; the remaining [illegible] planned economies (18 per cent) and Asia ([illegible] rubber, the above-mentioned consuming centres, [illegible] a major producer of synthetic rubber, consume [illegible] Since 1950, the share of the United States in [illegible] while Western Europe has developed as the [illegible] these products.

...ect to trade, available data for these four sectors indicate ... trade in total production, ranging between 20 and 30 per ... products within these sectors and individual countries are ... even higher, ranging up to 50 per cent for a number of ... trade in total production of plastics, synthetic rubber and ... recorded an increase over the last decade.

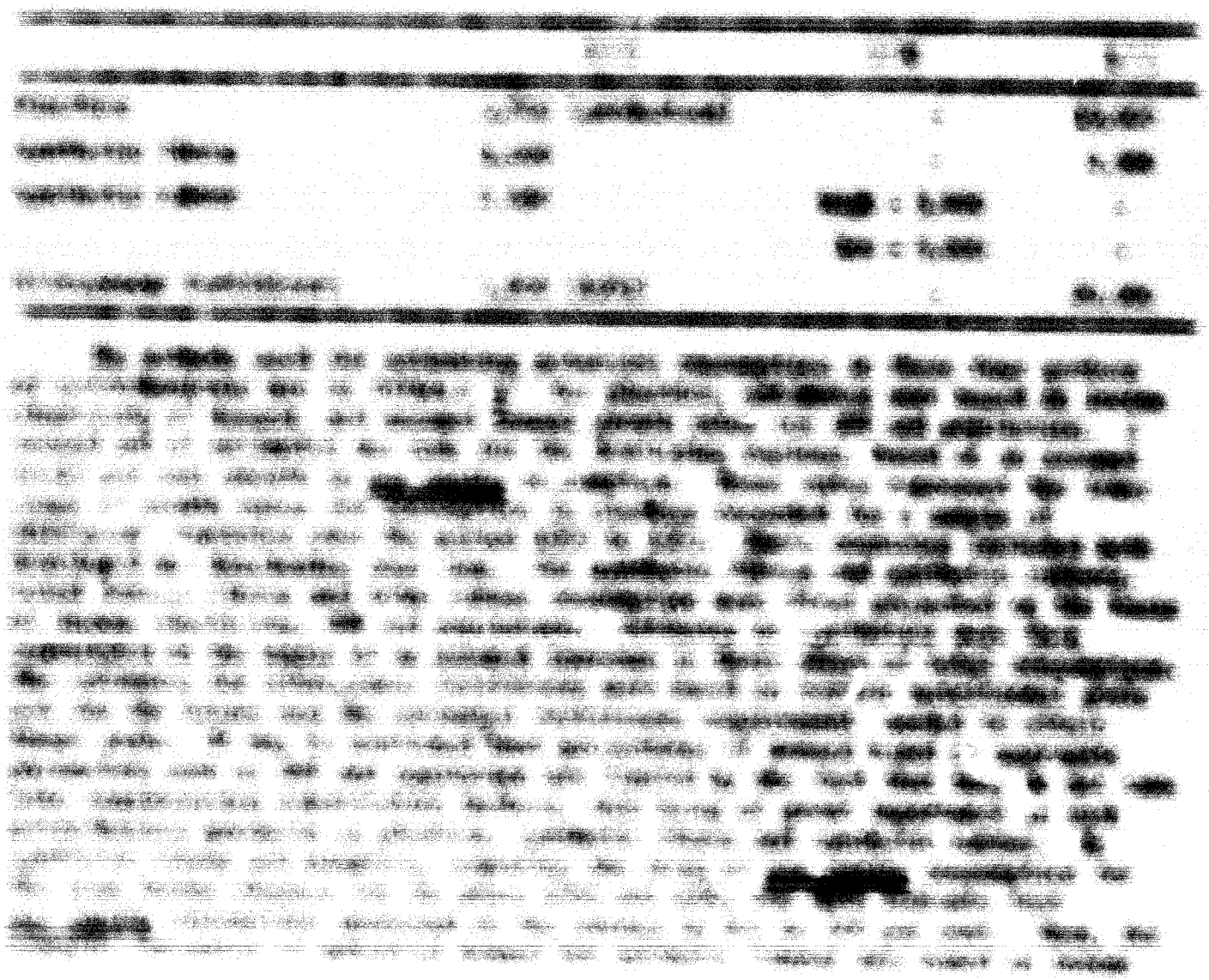
... on trade indicates that Western Europe is the major importing ... increased its share over the last decade for all of the four sectors ... nitrogenous fertilizers the share of which was kept approximately ... North America, on the other hand, recorded a relatively small share of imports ... products, excluding nitrogenous fertilizers, and Asia developed as an important ... for this petrochemical product.

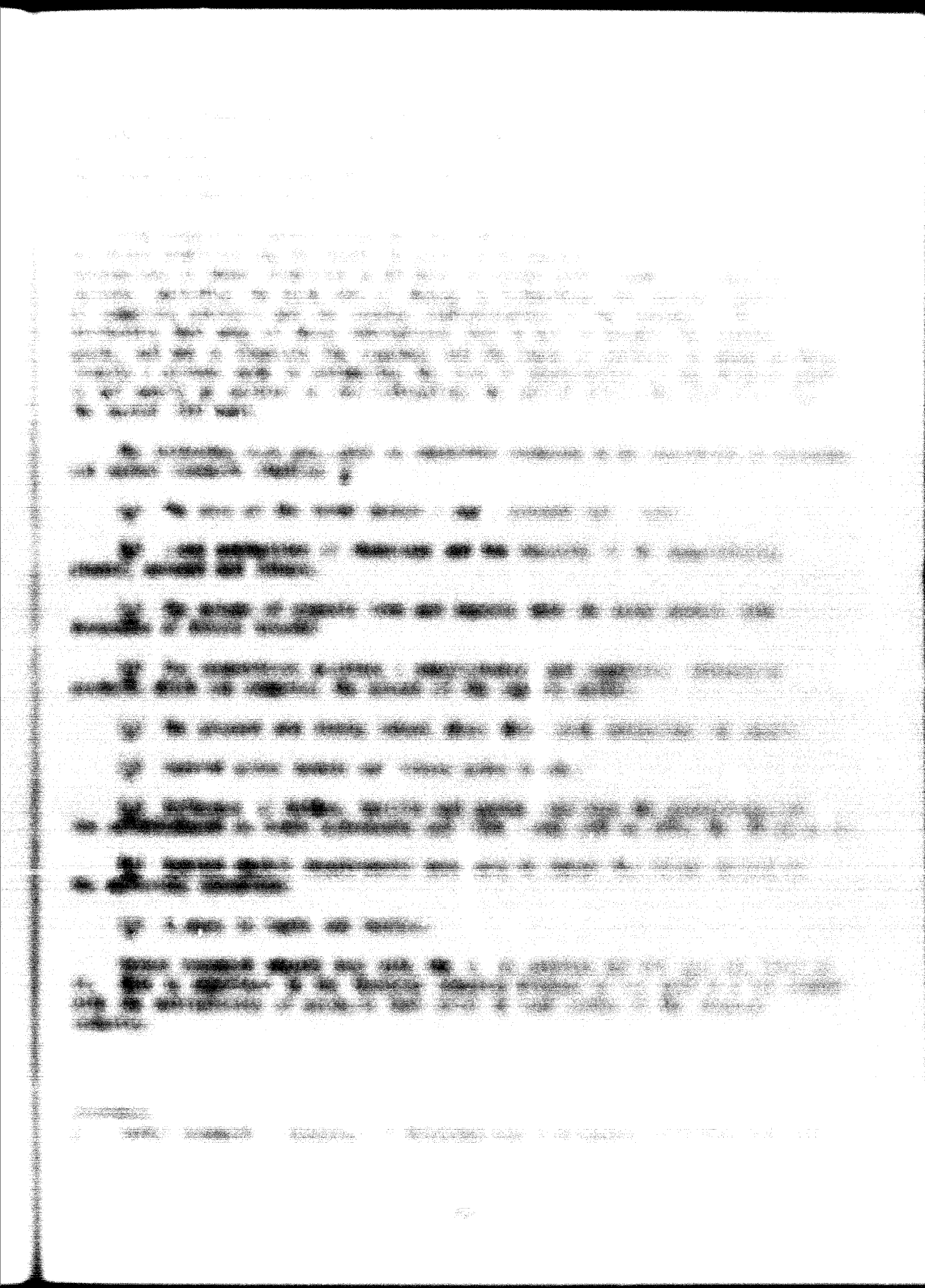
... is concentrated in a small number of countries: for plastics, the United States, the Federal Republic of Germany, the United Kingdom, Japan, ... and France; for synthetic fibres, Switzerland may be included in addition to the above countries; for synthetic rubber, the United States and Canada are the major exporters. In contrast, the export of nitrogenous fertilizers is less concentrated. This pattern of export reflects the concentration of production facilities in ... countries. With respect to developing countries, a number have already ... the production of petrochemicals, but their share is relatively low; for synthetic rubber, synthetic fibres and plastics, their share ranged from under ... to 1.7 per cent.

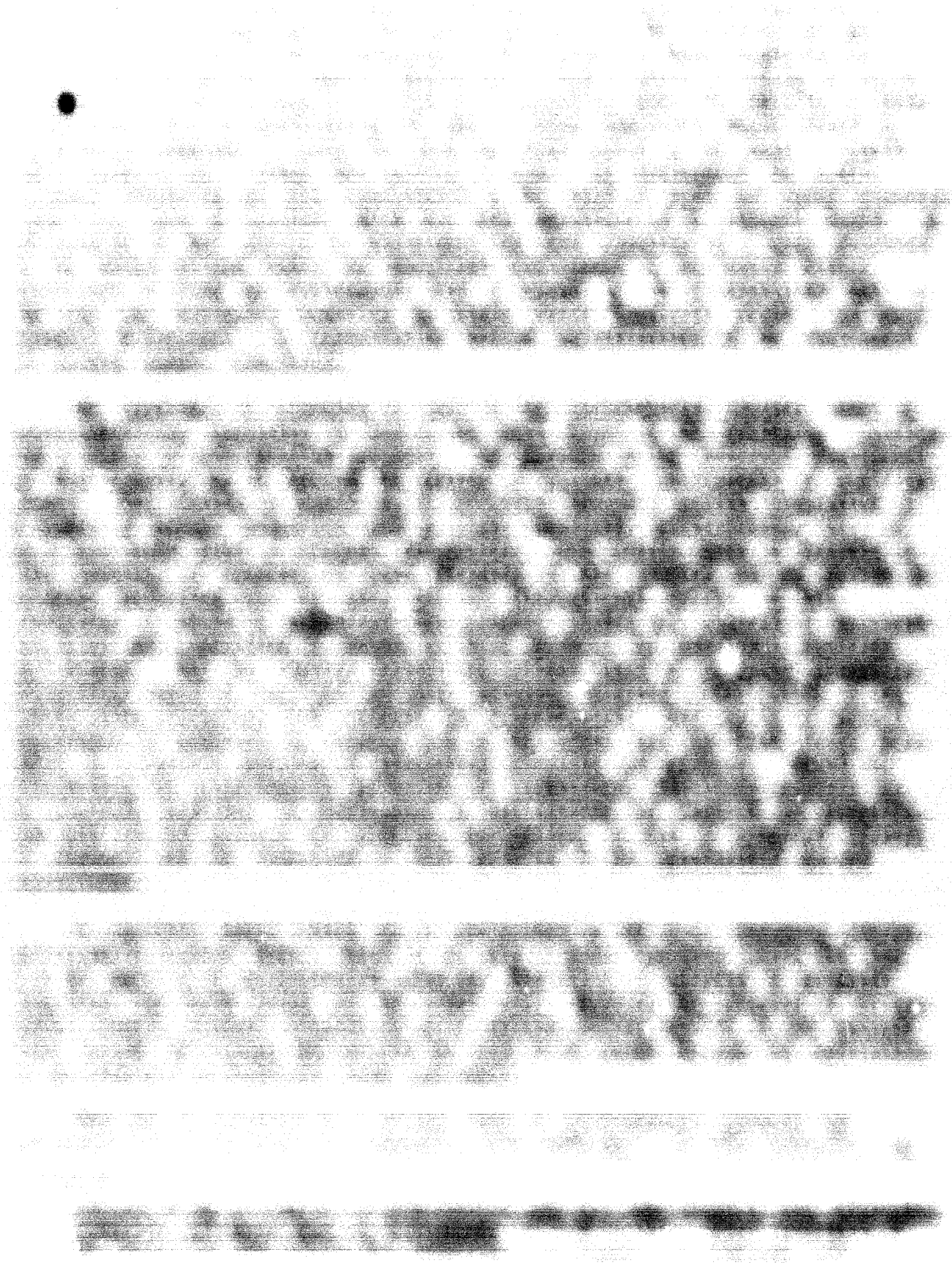
... characteristics of the industry

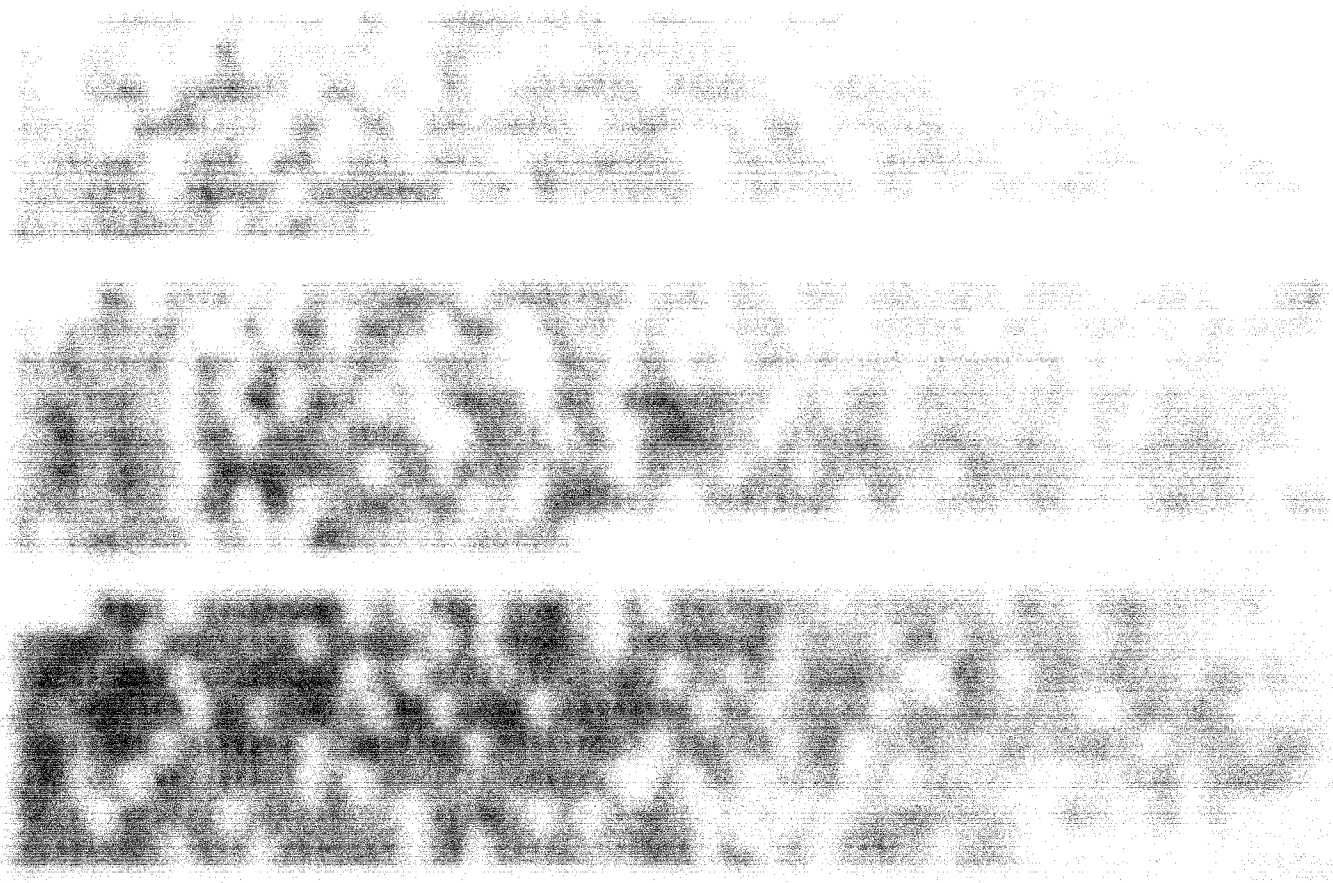
The petrochemical industry has been characterized by a high rate of growth. ... available for Western Europe and the United States indicate a faster growth ... in recent years, for organic chemicals when compared with rates recorded for total chemicals as well as total industrial production. Similarly, the four sectors of petrochemicals, except nitrogenous fertilizers for Western Europe, recorded annual rates of growth higher than total chemicals and total industrial production, as well as a number of selected products including textiles, cement, steel and aluminium.

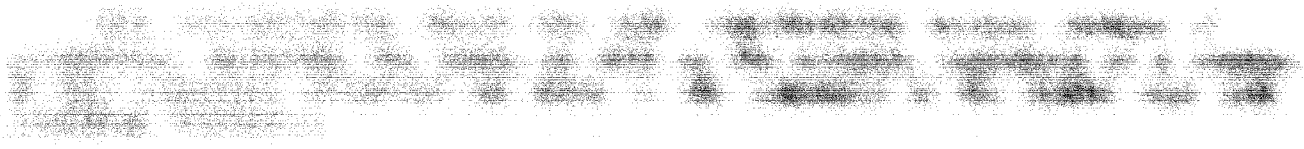
This high growth rate may be explained on the supply side by the increasing ... of the chemical industry for basic raw materials, and the subsequent ... substitution of oil and natural gas for traditional raw materials such as coal. ... the demand side, a number of these products have a high income elasticity of ... and have been gaining by substituting and supplementing other products, ... substitution in certain end-uses for lumber, metal and paper, etc.; synthetic ... for natural rubber; detergents for soap; substituting and supplementing ... and natural fibres, etc. Gains through substitution have been greatly ... by improvement in the properties of and development of new applications ... petrochemical products, and by the introduction of new products with ... properties and extensive promotion activities with respect to ... and consumers. Furthermore, the prices for a number of these ... have declined in absolute terms or in relation to competing products, thus ... further impetus to the substitution process.

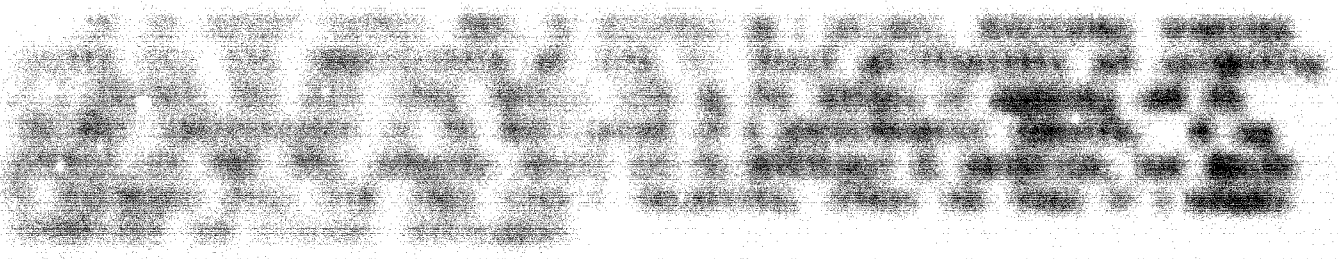


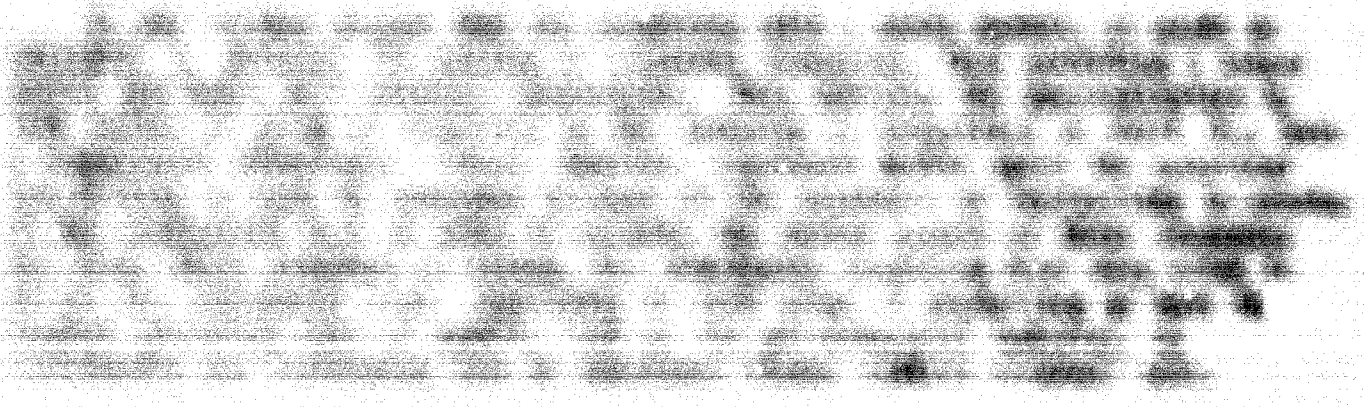


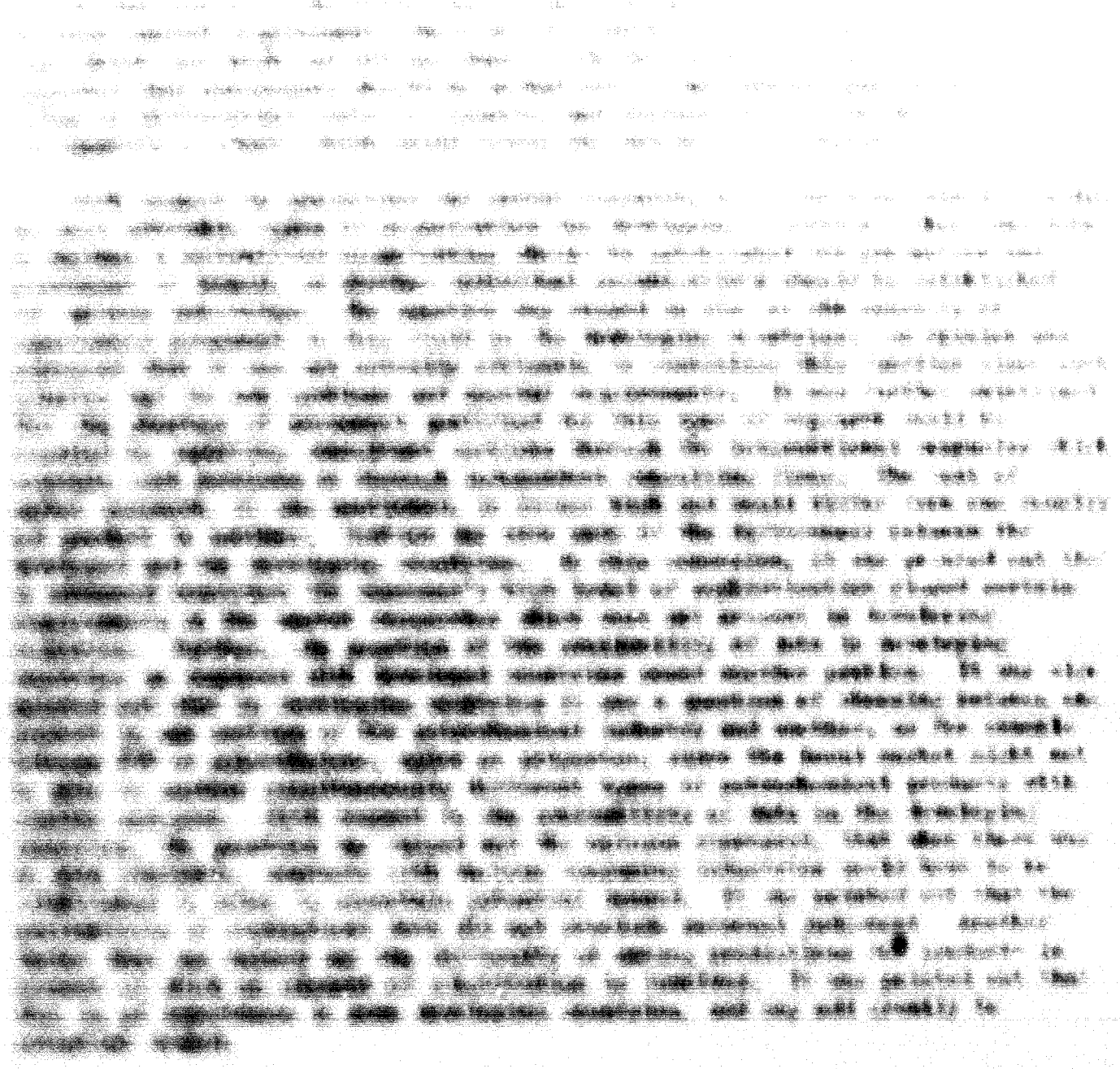












III. RECENT TRENDS IN RESEARCH AND TECHNOLOGY IN THE PETROCHEMICAL INDUSTRY

(Agenda item III)

Scientific research has played a very significant role in the petrochemical industry in recent years, providing the basis from which many successful technological developments have originated, and contributing to the spectacular growth achieved by the industry in the last decade.

Research and development activities in the petrochemical industry have led to the discovery of new, and the improvement of existing, products, and the development, from petroleum or natural gas, of new or improved methods for the synthesis of petrochemicals hitherto available only from other sources. This phase, generally called petrochemicals product research, is normally followed by the stages of petrochemical process development, in which experimental laboratory productions are scaled up to pilot-plant and, finally, to full-plant manufacturing.

Within these broad lines, special areas of research activity may exist according to the specific needs of each particular industrial organization.

The papers presented in this portion of the Conference were designed to develop a summary of recent research and development achievements which might have a bearing on petrochemical industrialization in developing countries, to emphasize the need for investment in effective training programmes for research and development personnel, and to describe a novel utilization of petroleum in the production of proteins.

Petrochemical research and development in the main product lines

Within the above-mentioned framework, recent accomplishments in the general area of industrial and academic petrochemical research and development were reviewed. 1/ They may be summarized as follows:

In the field of raw materials emphasis was placed on the significance of the liquefaction methods developed for natural gas, as well as the utilization of light paraffins in the production of acetylene by controlled oxidation.

Among the olefins, ethylene is by far the most important, being the basis for many petrochemicals, such as polyethylene, ethylene oxide, styrene, EPR rubber, ethylene dichloride, etc. Mention was made of advances in ethylene technology, especially high severity cracking of naphtha feedstocks, giving high yields with a minimum of coke formation. Reference was also made to the development of new routes based on ethylene for the production of such products as: long-chain alcohols, acetaldehyde through direct oxidation, vinyl-acetate, chlorinated solvents, etc.

1/ Recent Trends in Research and Development in the Petrochemical Industry (PET.CHEM.CONF.(.).

With regard to propylene, some new trends include: the increasing demand for high purity propylene monomer for polypropylene production, and the production of several products, such as isopropyl alcohol, hydrogen peroxide, acrolein, allyl alcohol, acetone and glycerine, in an integrated petrochemical complex based on propylene.

Among the diolefins, recent developments in the production of butadiene and isoprene were reviewed. Concerning butadiene, emphasis was placed on the trend towards utilization of normal butane - instead of butene - as feedstock in the dehydrogenation process. The main reason for this shift is the present price differential between butane and butene feeds.

Interest in isoprene has greatly increased recently owing to the development of "cis" polyisoprene rubbers on a commercial scale. Among the available processes, three were singled out as offering the possibility of using relatively inexpensive starting materials and requiring less capital investment than other processes for the production of synthetic rubbers. These are: the Goodyear-Scientific Design process consisting of propylene dimerization, isomerization and pyrolysis; the process developed by the Institut Français du Pétrole, whereby isoprene is produced from isobutylene contained in C_4 refinery streams; and the SNAM process based on the reaction of acetylene and acetone. These two raw materials are becoming more abundantly available and their price is declining.

In this connexion, new trends in the production of acetylene were mentioned including the partial oxidation processes and a new process consisting of the decomposition of hydrocarbon feedstocks, under high temperature, in an electric plasma jet reactor.

With reference to so-called petrochemical end-products, special attention was paid to the recent development of small size - "package" - ammonia plants and their significance in the field of nitrogenous fertilizers, especially for developing countries.

Petrochemical research in organic intermediates[2/]

The main body of this paper was divided into two parts. In the first, a few major developments in petrochemical research which either have been or are soon to be commercialized were outlined. Among these were: (a) new routes to phenol, based on toluene rather than benzene, requiring the oxidation to benzoic acid, followed by oxygenation using catalytic amounts of copper; (b) oxidative amination of propylene to acrylonitrile (in place of more conventional synthesis from acetylene); (c) new routes to raw materials for conventional nylon-66, as well as the preparation of other nylons from caprolactam, aminoheptanoic acid, and cyclooctanone oxime, (d) new oxidation processes for converting alkyl benzenes to aromatic acids, primarily for ultimate use in polyester fibres, among them the liquid phase air oxidation using acetic acid as the solvent, and a manganese or cobalt catalyst containing added bromine; (e) new methods for synthesizing isoprene for use in synthetic rubber.

2/ Recent Trends in Petrochemical Research and Development (ST/CHO/CONF.7).

The paper demonstrated how almost every discovery in organic chemistry has some influence on the petrochemical industry, and in its second part a few of the major recent developments in organic chemistry which are now affecting petrochemical research were mentioned briefly. These include: (a) hydroboration of olefins and other unsaturates, for the synthesis of terminal alcohols, aldehydes, cyclopropane, etc.; (b) the use of carbenes, either in addition or insertion reactions; (c) research on organic molecules containing elements other than the more common ones (CHONS), organic compounds containing fluorine, silicon, phosphorous, boron and the transition elements being of special importance; (d) valence tautomerism, to synthesize new olefins and related compounds; and (e) use of new energy sources and new uses for older energy sources, as for example light.

Petrochemical chemistry research in the macromolecular field[3/]

A large number of valuable products are obtained by the various treatments to which petroleum is subjected in the refineries. However, volatile fractions containing unsaturated hydrocarbons are often also obtained, which can be used as raw materials for chemical synthesis. Moreover, the fractions that find less demand on the market can be subjected to cracking treatments to obtain large amounts of volatile unsaturated hydrocarbons. These compounds, such as ethylene, propylene, butenes, butadiene, can be suitably transformed into different monomers, which, by polymerization or polycondensation, yield high polymers fit for the production of plastics, textile fibres and synthetic rubbers.

By limiting the field of these materials to the hydrocarbon polymers only, it is possible to obtain a fairly wide series of products that are of interest for the area mentioned above. In this case, olefins and diolefins, obtained directly by cracking, after the necessary distillation and purification processes, are polymerized or copolymerized to products having a wide field of application.

Polyethylene is obtained by polymerization of ethylene; in the last few years, its consumption has increased enormously, because of its properties and low cost. Other hydrocarbon polymers and copolymers of wide use consist of polyisobutene and butyl rubber (isobutene-isoprene copolymers) and butadiene-styrene rubbers. These last are widely used as general purpose rubbers and can be produced on a commercial scale under advantageous price conditions, starting from raw materials derived from petroleum. The complete use of unsaturated hydrocarbons obtained from cracking was made possible only ten years ago by the discovery of the anionic co-ordinated polymerization processes. In particular, it was possible to exploit propylene, for which, prior to the discovery, it had been difficult to find valuable applications.

It was thus possible to produce isotactic polypropylene with a high regularity in steric structure and crystallinity, having good mechanical properties and high melting temperature. This polymer is already produced on a commercial scale and is employed for the production of plastics, films and textile fibres.

The copolymerization of propylene with ethylene, under suitable conditions, can yield a new type of synthetic rubber having good mechanical and [illegible]

[illegible]

properties along with an excellent resistance to degradation agents. These new elastomers, the commercial production of which has started recently, are expected to become, in due course, rubbers of wide commercial use.

In the field of diolefins, the new polymerization process allowed the creation of polymers having identical physical and chemical properties to those of natural rubber and of guttapercha. Moreover, a synthetic rubber obtained from butadiene has elastic properties and abrasion resistance higher than those of natural rubber. The field of anionic co-ordinated polymerization has already opened new possibilities to the polymers derived from petroleum, while the research work in progress will, in due course, give rise to new and important developments.

Research and development in the petrochemical industry of the USSR[4]

The oil refining industry of the USSR is the second largest in the world and continues to develop rapidly, particularly by expanding secondary methods of refining. All methods of petroleum refining give abundant sources of raw material for petrochemistry. The production of olefins can be more effective if liquid oil products instead of gaseous hydrocarbons are used as a basis. The main trends of technical progress in this line are in the improvement of pyrolysis ovens - both of the pipe type and of new designs - and in the creation of effective separation systems.

In many cases, several methods of synthesizing identical or substitute materials are being developed and perfected simultaneously. However, along with this process there is a permanent creation and introduction of new synthesis as well. Special mention should be made of higher demands on the purity of monomers, which provides for high quality new materials.

Solid petroleum paraffins, and lately liquid ones also, become a basis for an entire line of synthetic surface-active substances. New synthesis and new products permit considerable reductions in capital and operating expenses.

Proteins from petroleum[5]

A large number of micro-organisms, rich in proteins, can grow upon and draw their carbon from hydrocarbons. The research workers of the Société Française des Pétroles BP at Lavera, near Marseilles, have studied the biosynthesis of proteins from petroleum fractions. The laboratory study made it possible to find the culture conditions most favourable for the microbic species selected, which consume the normal paraffins present in certain fractions of petroleum. This has led to the discovery of microbiological dewaxing. A semi-commercial unit has since been constructed.

The nitrogen necessary for the formation of the proteins is supplied by ammonia, which the petroleum industry produces in very considerable quantities.

4/ New trends in Research and Development of the USSR Petrochemical Industry (Pet/CHE/[illegible]).

5/ Biosynthesis of Proteins from Petroleum (Pet/CHE/[illegible]).

The semi-commercial unit [illegible] the elements necessary [illegible] projected industrial installation [illegible] of protein concentrate necessary [illegible] figures already obtained in the laboratory [illegible] consumed produce up to 1 kilogramme [illegible] of pure protein. This has been [illegible]

Whether in the vegetable or in the animal [illegible] is dependent upon climate, water, soils and [illegible] fermentation is independent of these factors [illegible] order to increase production rapidly.

Petroleum fermentation produces [illegible] 50 per cent protein, in the form of [illegible] or smell. The first form of utilisation [illegible] protein supplementation of cereals in the [illegible] animals, and in meals.

It is, however, also possible to [illegible] more elaborate proteins up to the [illegible] can have flavours similar to meat and fish [illegible] for direct human feeding; however, [illegible] continue for a long time before the various [illegible] are finally accepted as completely [illegible]

The protein production potential of [illegible] at 20 million tons per annum expressed in [illegible] contribution to world nutrition, in view of the [illegible] through protein deficiency among a large part [illegible] its importance, this potential contribution [illegible] world's requirements; half in 1970, and [illegible] population increase.

Research and technology and training [illegible]

The thesis was developed that the [illegible] developing countries must be accompanied by [illegible] the building of research laboratories.

In this connexion, a statement [illegible] its role in the training of [illegible] in the developing countries. It was [illegible] technological training of personnel [illegible] plans for petroleum institutes. The [illegible] of manpower training in developing [illegible] also outlined.

Concerning the interests [illegible] countries, it was stated that [illegible] therefore so that their [illegible]

[illegible]

[illegible] depend heavily on technological borrowing [illegible] stagnate. Such continued dependence upon [illegible] the development of local ideas, processes and [illegible] dependence can easily lead to [illegible] in the [illegible].

[illegible]

[illegible] discussion, participants asked for details about small ammonia [illegible] It was pointed out by the speakers that conventional ammonia plants [illegible] special pieces of equipment able to withstand the high [illegible] and pressures required in the ammonia synthesis process. Such plants [illegible] parts which may lead to maintenance delays and replacement [illegible] in developing countries. By introducing drastic innovations in the design [illegible] and the maximum use of standardized parts, some equipment [illegible] in the United States claim to be capable of offering small ammonia [illegible] of 50-100 tons per day of ammonia) which can compete economically [illegible] large plants. In a conventional plant, the converter consists [illegible] vessel containing several beds of catalyst and a heat exchanger. [illegible] require elaborate cranes for the vertical removal of the converter [illegible] of its height (about sixty-five feet). Catalyst replacement [illegible] is costly and time-consuming. In the new design, this unit [illegible] into five vessels: a heat exchanger and four units containing [illegible]

[illegible] cranes and rigging, as the spent catalyst can be removed by [illegible] removing the internal parts. The new vessels are only from [illegible] high and all work can be done from ordinary portable scaffolds. [illegible] and the additional savings afforded by the use of standard parts [illegible] equipment, evoked great interest.

[illegible] from developing countries inquired in what manner the United [illegible] assist them in the process of choosing among the alternative [illegible] available for their local conditions. It was stated, in reply, that [illegible] Industrial Development, in co-operation with other United Nations [illegible] prepared to act as an adviser or clearing house for authorities in [illegible] on substantive technological matters pertinent to the [illegible] of petrochemical industries in the developing countries.

[illegible] Research and Development in the Petrochemical Industry [illegible]).

[illegible] Fertilizers as a Petrochemical Operation (PET/CHEM/CONF.[illegible]).

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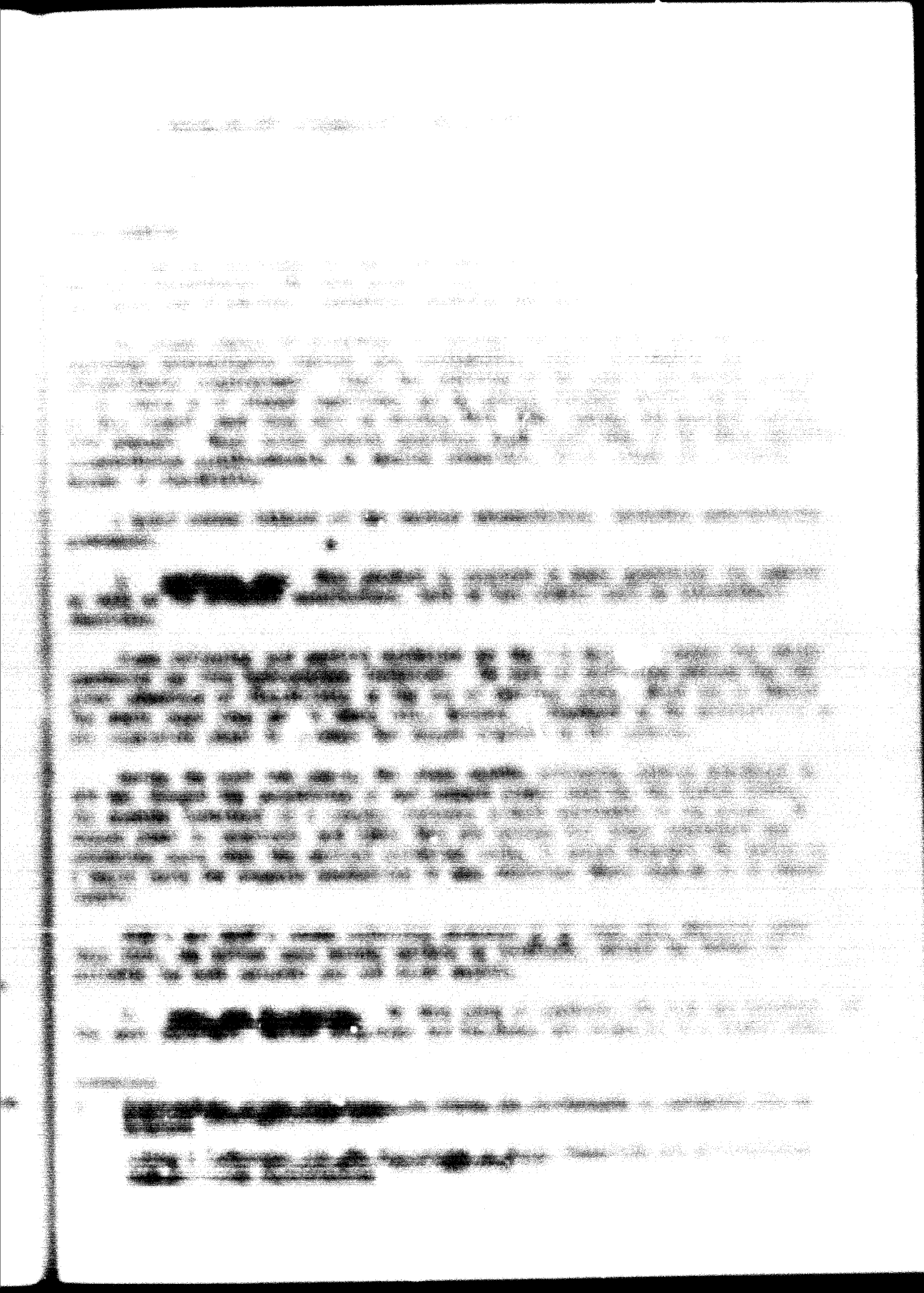

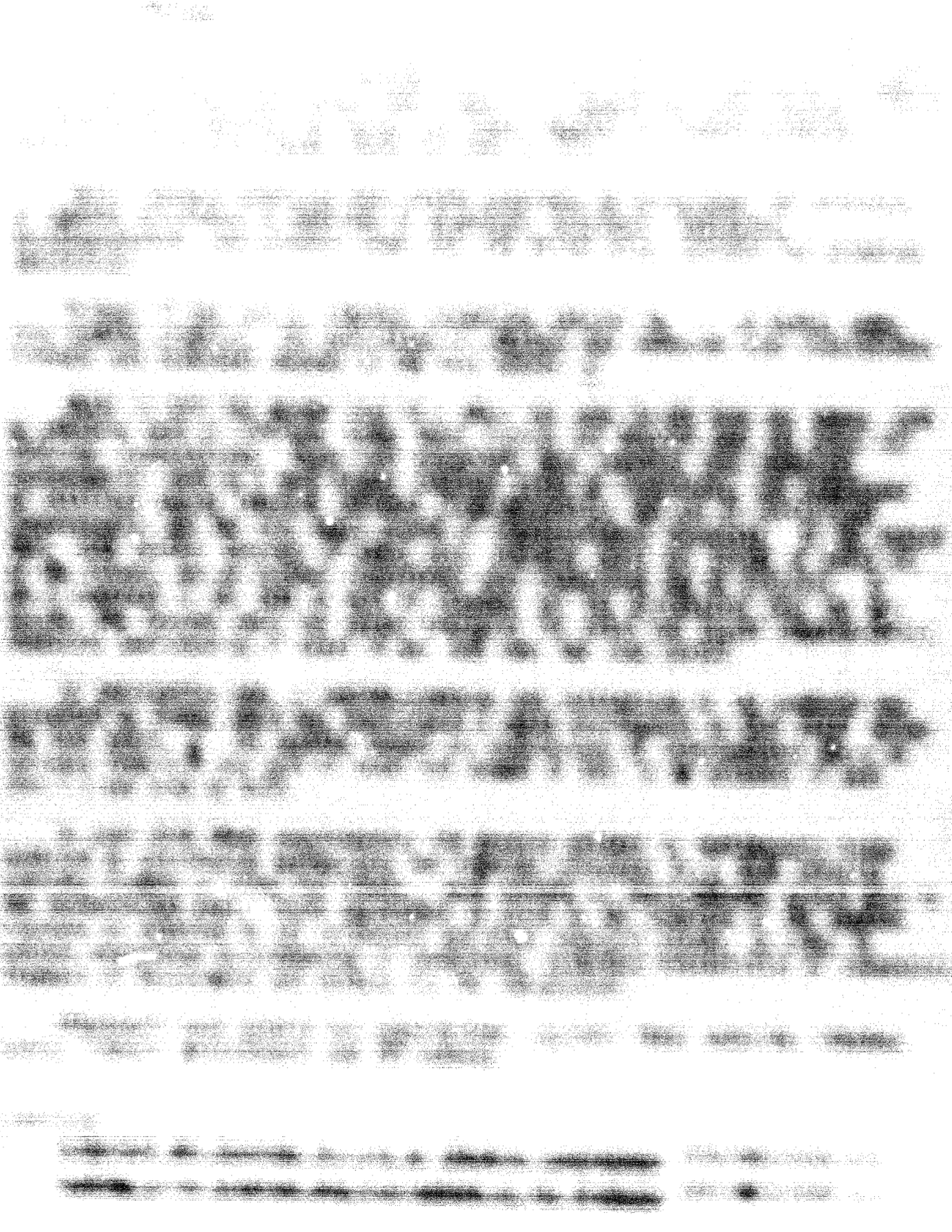

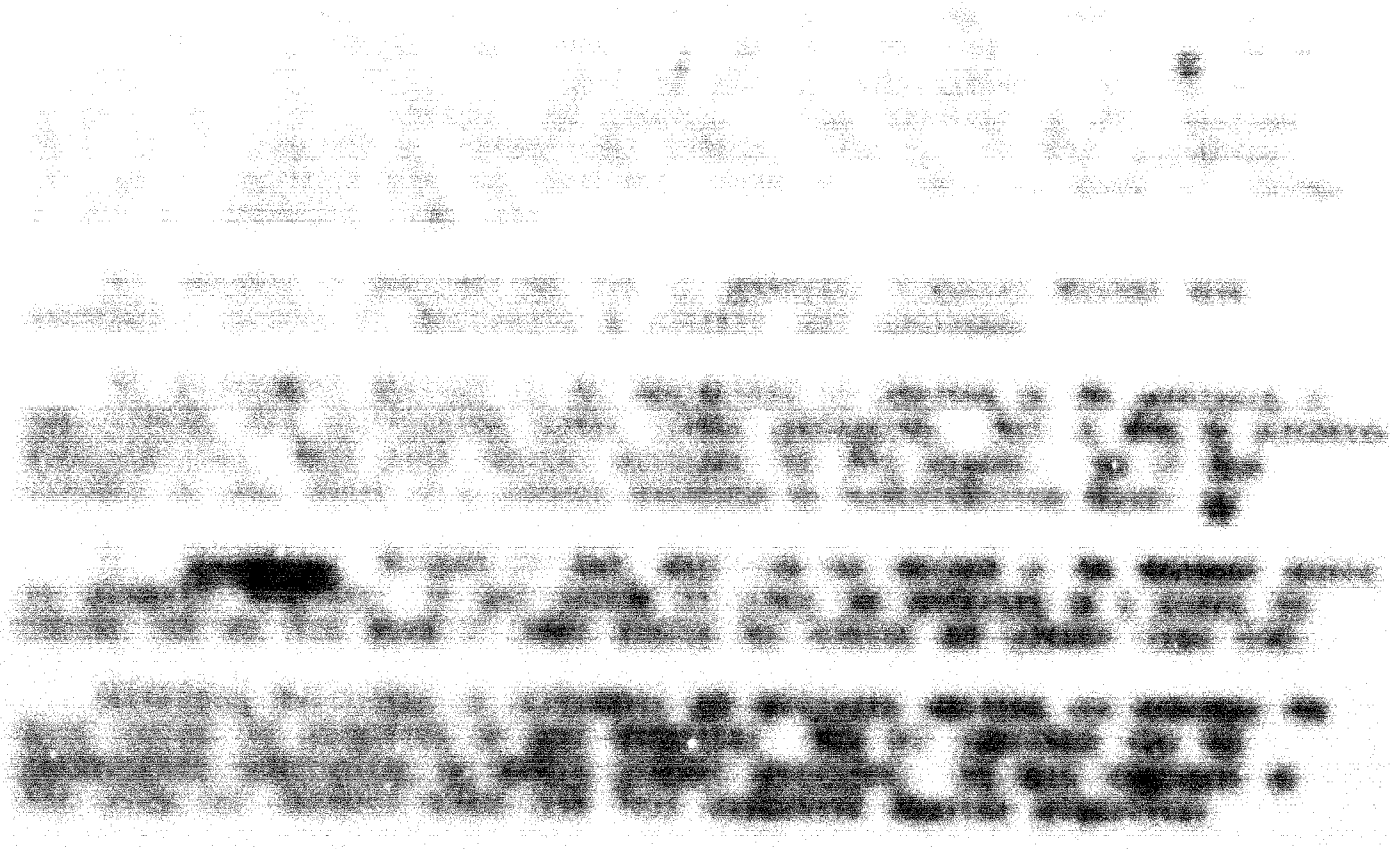

[redacted]

Detol process by Houdry 15/ claims to give the purest benzene grade. This process converts, by hydrodealkylation, higher carbon to lower carbon aromatics [illegible] one or two benzene rings. Communications were presented on the use of a variety of processes (Unifining, UOP Platforming, Sulfolane and Hydeal) in various combinations to bring BTX-aromatics production to the required proportions, including the influence of the chemical composition of the hydrocarbon feedstock upon aromatic yield. 16/ It can be seen that aromatic yields and concomitant economics vary widely, depending upon the naphtha source and plant capacity; lower feed naphtha prices and freight can offset the economic effects of a large difference in plant capacities. A practical example of balancing aromatics production from petroleum is given in a communication from Japan. 17/ Since not enough aromatic or naphthenic crude oils are available on the Japanese market for production of aromatics by the conventional UOP Platforming-Udex combination, the petrochemical industry had to resort to ethylene by-product light oil by introducing the UOP two-stage Unifining-Udex combination units. The economics involved in this scheme were discussed.

There remains the problem of the separation of C_8 aromatics, which presents serious difficulties because of the close boiling points (see table on page 39). All four components are today recovered as chemical feedstocks. Ethyl benzene, purified by superfractionation towers with up to 360 trays and reflux ratio of 1:120, is dehydrogenated to styrene. For the three isomeric xylenes, the principal outlet is oxidation to the corresponding dicarboxylic acids. The least difficulty is encountered in the case of o-xylene which is readily separated by distillation. The recovery of ethyl benzene is effected by superfractionation and is of economic interest only in conjunction with xylene production. However, production continues to be based on alkylation of benzene with ethylene. Para-xylene's importance hinges almost exclusively on its role as intermediate product in the manufacture of terephthalic acid. It is impossible to isolate it by distillation, and fractional crystallization must be used. Meta-xylene is the most important member of C_8 aromatics being used either as petrochemical feedstock for isophthalic acid manufacture or in gasoline blends and solvents. An alternative solution is to isomerize m-xylene to para- and ortho-compounds.

Another process, which allows for flexibility in intermediates procurement, is the H-Oil and Hy-C processes of Hydrocarbon Research Inc., by hydro-cracking using a novel reactor system. High sulphur crude oils, which can generally be purchased at lower prices, can be suitably processed in such plants. Heavy virgin naphtha and H-Oil naphtha can be reformed to yield aromatics after extraction and the light naphtha and raffinate can be pyrolyzed to yield light olefins. Gas from all of these units can then be converted to synthesis gas for manufacture of ammonia and hydrogen (the latter for hydrogenation within the process). In this way it is possible to produce a vast range of chemical intermediates from a heavy, high sulphur, crude oil.

4. Acetylene. The growth rate of acetylene is slow because of competition from lower-priced ethylene and propylene. The major market for acetylene is PVC, and it is likely that acetylene will continue to share this market with ethylene, the choice depending on hydrocarbon availability, price, and the chlorine balance problem.

15/ Benzene by Hydrodealkylation using the Detol Process (PET/CHEM/CONF.6).

16/ Aromatics: Better to Import or to Produce? (PET/CHEM/CONF.28)

17/ Production of Aromatics from Petroleum in Japan (PET/CHEM/CONF.99).

[illegible] to the [illegible] acetylene process has [illegible] less attractive [illegible] acetylene capacity will be based on natural gas [illegible].

The conventional processes, [illegible] hydrocarbons, depend on burning part of the [illegible] with oxygen [illegible] temperature to the required level. The main economic problem [illegible] concentration of acetylene in the gases from the [illegible]. This [illegible] chain of recovery and purification which accounts for about [illegible] capital cost of the plant.

Acetylene from calcium-carbide at a cost of 1[illegible] to 1[illegible] cents per pound is a relatively expensive intermediate, when compared with ethylene at an average cost of 5 cents per pound. The various acetylene processes based on hydrocarbons with costs in the range of 7-8 cents per pound are still not economically sound and research is aiming at cheaper processes. A new process based on plasma jet cracking, which has been developed on pilot plant scale, converts hydrocarbons completely to acetylene plus hydrogen, both of high purity, so that no purification and separation facilities are required. The hydrogen could be used for ammonia synthesis. It is estimated that, with this process, the acetylene cost would go down to 3 cents per pound. A small plant for 10 million pounds per annum is estimated to cost less than $1 million. 18/

5. **Paraffins**. Paraffin wax, a by-product of lube oil-refining, has been in use as raw material for chemical intermediates for several decades. The bulk of these waxes are mainly n-paraffins, which are subject to cracking in order to produce mainly n-olefins in the range of C_6-C_{25}. By redistillation they are split into various fractions of required chain length, the lower chain ranges serving as raw material for oxoalcohols, whilst the longer chain ranges are used for secondary alkyl sulphate detergents and as an alkyl fraction for certain alkylation processes.

In the last years, in view of the more stringent claims on the biodegrading properties of detergents, n-paraffins have gained in importance. They can be separated from petroleum distillates by a modern technique, the so-called "molecular sieves". Synthetic aluminium silicates with exactly defined pore sizes serve as adsorbents; they selectively adsorb paraffin with higher molecular weight. The molecular sieves catch only molecules of a smaller diameter than the pores. The adsorbed material can be recovered from the sieves by heating or by applying vacuum, and also by exposing the sieve to another adsortable but lower boiling hydrocarbon. Thus, the normal C_{10} to C_{17} paraffins can be recovered on a molecular sieve by passing n-hexane over the sieve and recovering a mixture of both n-paraffins. These two fractions can then be split again by distillation.

There are already various commercial processes in operation, such as Isosiv by Linde Company, Selective Finishing process by Texaco, the BP process and the Molex process by UOP. 19/

18/ Olefins vs. Acetylene - Competitive Raw Materials for the Petrochemical Industries in Developing Countries (PET/CHEM/CONF.103).

19/ Modern Methods for the Production of Aromatics, Olefins and Paraffins (PET/CHEM/CONF.31).

As a competitive process to petrochemical routes for the manufacture of acetaldehyde and acetic acid in small capacity plants, the process of the "Groupe Centrale de Dynamite Nobel-Bozel", which uses ethyl alcohol as raw material, either from natural sources or synthetic, was suggested. 20/ It was claimed that such a plant requires much less capital than a petrochemical unit, capacities of [illegible] to [illegible] meters per annum are considered moderate. Under French conditions, the cost of these two products amounts to [illegible] per cent above the price of the intake material. These plants are simple to operate and are well-established processes based on long experience.

Summary of discussion

With regard to the capacity of the Lacq complex, it was stated that the average capacity is [illegible] m^3 of gas per day with a maximum possible capacity of [illegible] m^3/day, and that in general only 10 per cent of the natural gas production is used for petrochemical feedstock, whereas 90 per cent is used as fuel.

A question was raised concerning the values assigned to refinery off-gases and natural gas in Japan in connexion with naphtha steam cracking. It was stated that these are based on the price of residual fuel oil.

Regarding the commercial production of olefins in the Lurgi-Ruhrgas Sand Cracker and in the BASF fluidized bed process, a question was raised as to whether these plants actually operate on crude oil intake. It was stated that although it is technically possible to use crude oil in these units, it is not being done at present, the economic feedstock being naphtha.

It was stated that in evaluating costs relating to naphtha steam cracking, the value given to propylene is important; propylene can be considered partly as LPG and partly as fuel. Higher hydrocarbons can be evaluated as gasoline after deducting hydrogenation costs, actual costs depending on local conditions.

In connexion with the minimum economic size of a naphtha cracker for developing countries, it was stated that this depends on local conditions. In Europe the minimum economic size has been increased to an average of 150,000 tons/year, but under conditions of protection of domestic production against imported material, a lower size may be economically possible.

With reference to the Detol process, it was asked whether hydrodealkylation is still economically justified, when the price of toluene approaches the benzene price. It was stated that, under such circumstances, the process is not economical.

In connexion with the steam reforming process of ONIA, a question was raised whether aromatic extracts can also be used as feedstock. It was stated that, theoretically, any hydrocarbon could be reformed, but it is essential to submit such feedstocks to trial runs in a pilot plant in order to evaluate the economic feasibility.

Finally, it was asked to what degree the ONIA reforming process differs from the conventional naphtha reforming process; the reply was that there are essential differences in the mechanical design of the process, and in the type of catalyst used.

20/ Natural and Synthetic Alcohol as Competitive Raw Materials (PET/CHEM/CONF.125).

2. Nitrogenous fertilizers

(Agenda item IV-2)

The production of chemical fertilizers is a subject of concern to Governments of developing countries throughout the world. The use of various chemical fertilizers, containing appropriate forms of nitrogen, phosphorous and potassium, can substantially increase the yield and quality of agricultural crops. On the basis of rough estimates, one ton of plant nutrients (N-P-K) can produce an average of ten tons of basic food, and in turn one ton of basic food provides approximately 5,000 calories per day for one year. At the present time, only a few countries have achieved a high level of fertilizer application. The world-wide annual consumption of chemical fertilizers is 31.3 million tons of plant nutrients.

It was pointed out that in the developing countries, which together account for more than two thirds of the world's population, the consumption of chemical fertilizers is less than 15 per cent of the world total, whereas the more industrialized countries consume about 85 per cent of this production.

World consumption of nitrogenous fertilizers is expected to double by 1970. Although the growth rate will vary widely among individual countries, the highest rate of grwoth is expected to take place in the developing countries. These higher growth rates for nitrogen fertilizers are due in part to the fact that the volume production of these materials has recently developed more than phosphate and potash fertilizers, and in part to the fact that the crop responses to nitrogen fertilizers are more immediately apparent.

The principal nitrogenous fertilizers are ammonium nitrate and limed ammonium nitrate. These together account for more than one third of the total world production. Ammonium sulphate and ammonium nitrosulphate together account for just under 30 per cent of world production. Urea, the fastest growing fertilizer, still represents a relatively minor portion of production, about 8 per cent of total nitrogen consumption.

The nitrogenous fertilizers are commonly compared on the basis of their equivalent nitrogen content; ammonium sulphate contains 21 per cent nitrogen, pure ammonium nitrate 33.5 per cent nitrogen, and urea 45 per cent nitrogen.

Anhydrous ammonia itself contains 83 per cent nitrogen and has begun to be used increasingly for direct application to the soil. Ammonium nitrate will also continue to grow, but the major growth will take place in urea, ammonium phosphate and anhydrous ammonia. At the present time, the more industrialized countries are also those consuming the most nitrogenous fertilizer per capita. Among these are some of the Western European countries, the United States, Eastern European countries, China (Taiwan), and Japan, where the consumption of nitrogen per capita varies from about 8 to 27 kilogrammes of nitrogen per capita. The consumption of

nitrogen exceeds 100 kilogrammes per hectare of arable land in [illegible] countries: the Netherlands, Japan, China (Taiwan), Belgium and the [illegible] Korea. The individual countries with the greatest total consumption [illegible] fertilizer are:

In North and South America - the United States;

In Europe - the USSR;

In Asia and Oceania - Japan;

In Africa - the United Arab Republic.

The main intermediate in the manufacture of the various nitrogenous fertilizers is synthetic ammonia. Ammonia plants constitute the largest item of capital investment in the manufacture of nitrogenous fertilizers. It is important therefore to examine carefully the various factors involved in the manufacture of anhydrous ammonia as the prime building block of the nitrogenous fertilizer industry.

There are many factors influencing the manufacturing cost of ammonia, largely local in nature. The major items among these are the cost of raw materials which could account for 25 to 50 per cent of the total cost, depending upon the kind of raw material and plant size. Commercially, ammonia is produced by direct combination of hydrogen and nitrogen at high pressures and temperatures, with the aid of a catalyst. The nitrogen required in ammonia synthesis is obtained from the air. In obtaining the hydrogen required for ammonia synthesis there has been wide diversity, both in the processes employed and in the raw materials used. The two main sources of hydrogen are the hydrocarbons and the hydrogen present in water. At the present time, the greater portion of the hydrogen for ammonia synthesis is obtained by reacting hydrocarbons with steam, oxygen or mixtures of the two substances. In a very few cases, ammonia is still produced from coal and water. It is possible to use either a gaseous or a liquid hydrocarbon as a source of hydrogen for ammonia synthesis, according to the local conditions. In the choice of raw material for hydrogen production, the transportation cost must also be taken into account. For this reason, liquefied petroleum gases (LPG) have found only limited use in ammonia production.

Sometimes because of the geographical conditions within a particular country, the cost of transport can rise to an uneconomic level. In this case a small unit will be economical. A small unit permits a developing country to enter this field with a much lower initial investment for covering its fertilizer [illegible]. Thus, the minimum economic size of an ammonia plant varies with local conditions, and it was suggested that mathematical models could prove useful in determining the optimal plant size, location and time phasing. A study of this type was reported in connection with the programming of the nitrogenous fertilizer industry in India. 1/

1/ Plant Size, Location and Time-Phasing - Introduction (PET/CHEM/CONF.102/[illegible]) and Plant Size, Location and Time-Phasing - The Nitrogenous Fertilizer Industry (PET/CHEM/CONF.102).

It was reported that two methods are presently available for the ... hydrogen from petroleum hydrocarbons. One of these is non-catalytic ... catalytic partial oxidation of both gaseous or liquid hydrocarbons ... other method is catalytic steam reforming. ... the recent development ... metal catalysts for this purpose, the use of naphtha in the steam ... process has been made possible. It was also pointed out that the by-product hydrogen from catalytic reforming can be used in the manufacture of ammonia. However, with the development of hydrogen treating processes in petroleum refining, there has arisen an increased demand for this by-product hydrogen.

At the present time, petroleum-based feedstocks are displacing coal in the manufacture of ammonia. It was shown that Japan has already effected a shift from coal to petroleum-based ammonia processes, finding this route more economical, and partial oxidation of crude oil has been used extensively. 2/ The choice between steam reforming and partial oxidation processes is a matter depending on relative cost factors. In the places where low cost electricity is available it may be more economical to use partial oxidation. At the sites where fuel is cheaper, steam reforming appears preferable.

The manufacture of the various nitrogenous fertilizer materials derived from synthetic ammonia requires substantial capital investment. Ammonia may be used for the processes to produce various nitrogenous fertilizers. In turn the nitric acid is obtained from ammonia by catalytic oxidation. Ammonium nitrate may be diluted with varying quantities of limestone to produce limed ammonium nitrate in order to reduce the danger of explosion. Ammonia may also be reacted with phosphoric acid to yield ammonium phosphate, or with carbon dioxide to produce urea. Every product resulting from ammonia has, of course, its particular technology, depending upon the state in which it is to be distributed and ultimately consumed on the farm. It was reported that concentrated complex fertilizers now form an essential part of fertilizer production in Europe and in the United States. These fertilizers are prepared by reacting phosphate rock with nitric, phosphoric or sulphuric acid, followed by ammoniation and blending with potash salts. These fertilizers can be produced in a wide range of formulations in order to obtain the best combination for each particular soil and crop.

In connexion with the expansion of the use of fertilizers in agriculture, the Conference was informed of a scheme announced by the Mexican State Oil Company, the Petróleos Mexicanos, intended to contribute to the wider use of fertilizers in Mexico. 3/ This enterprise proposes to make available ammonia and nitrogenous fertilizers at prices significantly lower than those at present obtaining. This will be achieved by the construction of large ammonia and urea plants with a daily output of 1,000 tons of ammonia and 500 tons of urea respectively.

Summary of discussion

Since ammonia is the principal intermediate in producing all types of nitrogenous fertilizers, the discussion of costs focused primarily upon the manufacture of ammonia. One of the principal cost factors is that of the raw

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2/ Recent Trends in the Ammonia Industry in Japan (PET/CHEM/CONF.5/...).

3/ Natural Gas Reserves in Mexico as a Factor of the Social and Economic Development of the Country by Means of Nitrogenous Compounds (PET/...).

[illegible]

[illegible] 'package' ammonia plants. Such a plant, with a capacity of [illegible] the structure of a number of different assembled units that can be transported to the plant site, connected together and put into operation in a short time. It was shown that each variant has its advantages and disadvantages. A larger plant requires a larger investment per ton of product [illegible] maintenance charges, plant labour, [illegible], local taxes and insurance. The [illegible] costs are substantially lower in the case of large plant sizes. It was claimed that costs might vary from [illegible] per ton of ammonia for a [illegible] ton per day plant, down to [illegible] per ton in the case of the 1,000 ton per day plant. It was noted that the considerations of [illegible] ammonia market and transport [illegible] of this market are of particular importance to a high capacity plant.

Each country must carefully appraise its own economic situation before embarking upon domestic production. The foreign exchange investment and [illegible] as well as the current annual savings on the fertilizers that would otherwise have to be imported.

The participants suggested that a desirable pattern of world trade would be one in which a small number of large-sized ammonia plants were constructed in [illegible] where low-cost natural gas is available. Ammonia could be shipped in bulk from these points, then converted into specific end-products in the consuming countries. A representative of a developing country pointed out that this may be desirable on two grounds: (1) [illegible] foreign exchange savings by the developing country, and (2) [illegible], in some countries, [illegible] the [illegible] capital and other [illegible].

Another participant suggested that for the nitrogen industry an adequate technical environment is quite essential. The construction and maintenance of the plant necessitates the co-operation of a highly developed mechanical and electrical industry. In order to develop a efficient industry, substantial assistance from the government of a developing country would be necessary. Such assistance might be similar to that received by the Japanese nitrogen industry from the Japanese Government.

[redacted]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The types of plastics covered by the paper are as follows.

a) **Polyolefins** – high and low density polyethylene.

b) **Vinyls** – polyvinyl chloride.

c) Styrenes – polystyrene.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

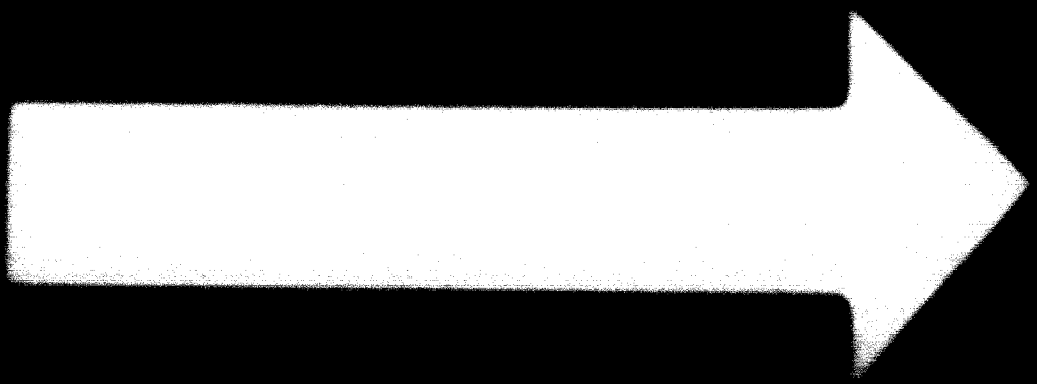
<u>[illegible]</u>

Polyvinyl chloride (PVC) is still the most important plastic today, as shown in the paper "[illegible] and Polyvinyl Chloride". [illegible]

The versatility of polyvinyl chloride, its relatively low capital and operating cost requirements, together with comparatively simple production techniques, place this material in the top position for consideration in a developing country. Polyvinyl chloride's array of properties include excellent water resistance, chemical resistance, good strength, abrasion resistance, and ease of colouring, and when it is compounded with resins it can produce finished products with nearly any degree of flexibility.

[illegible]

[illegible]



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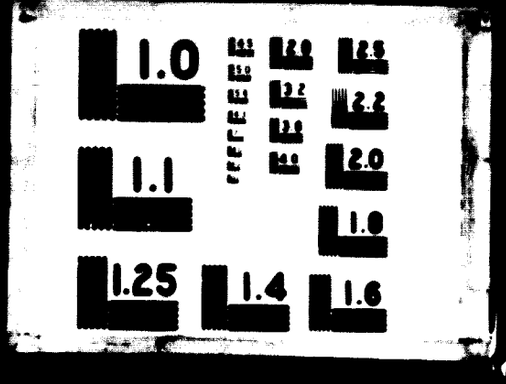

The raw materials needed for vinyl chloride are [illegible] chlorine or hydrogen chloride. The basic routes to vinyl chloride are (a) addition of hydrogen chloride to acetylene, (b) direct chlorination to ethylene dichloride, (c) oxychlorination of ethylene followed by cracking. Two processes thus base on (a) combined facilities - chlorination of ethylene plus hydrochlorination of acetylene - and (b) combined hydrochlorination and chlorination facilities - chlorine, acetylene and ethylene feed.

The acetylene route has the advantage of lowest capital investment. The direct chlorination of ethylene followed by cracking of dichloroethane offers lower raw material costs; the newer oxychlorination process will be of considerable importance, because it combines the use of cheap ethylene with the elimination of by-product hydrogen chloride. The combination routes combine advantages of the various routes for special applications.

Of the three polymerization routes, the suspension polymerization technique offers the lowest investment and the lowest production costs. This process also lends itself readily to the production of copolymers which are used for special applications.

Because the suspension process for producing polyvinyl chloride is a batch process, it is possible for relatively small plants to compete with large installations. As in vinyl chloride production, the main factor in polyvinyl chloride production cost is the raw material, vinyl chloride.

Recently, another process for the manufacture of vinyl chloride has reached industrial status, as shown in the paper "New Vinyl Chloride process" 2/

The process was developed for the exclusive production of vinyl chloride without the need of a multi-million dollar petrochemical complex, and is believed to be the most economical vinyl chloride process. The process is advantageously used to produce low-cost vinyl chloride where carbide acetylene and ethylene are not economically available.

The process consists of a combination of the following steps:

(a) High temperature naphtha cracking, which produces cracked gas containing acetylene and ethylene;

(b) Vinyl chloride synthesis by reaction of cracked gas containing acetylene with hydrogen chloride;

(c) Ethylene dichloride synthesis by reaction of chlorine with cracked gas containing ethylene;

(d) Thermal cracking of ethylene dichloride to vinyl chloride, and separation of hydrogen chloride for reaction in the above step;

(e) Separation and purification of vinyl chloride obtained in the above steps to obtain high purity monomer.

2/ PET/CHEM/CONF.37.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] petroleum [illegible] the paper "[illegible] Chemical Company". [illegible]

[illegible] first operated [illegible] was based on [illegible] of fuel products [illegible] operation of Cosden's facilities [illegible] fuel products. The flow sheet [illegible]

[illegible] from crude oil is processed [illegible] operation as a first step in the [illegible] concentrate produced from this operation [illegible] toluene and xylene. The next step [illegible] fraction by the dehydrogenation of [illegible] production of polystyrene from [illegible] materials.

[illegible]

[illegible] types of general-purpose plastics [illegible] types of plastics materials [illegible] are grouped under the generic name of [illegible] important representative of this family is nylon [illegible] discussed in the paper "Nylon". 10/

[illegible] polyamide resins. Resins of this type [illegible] of a dicarboxylic acid and a diamine [illegible] condensation of lactams [illegible]. [illegible] physical properties of the two broad types of [illegible] identical.

[illegible] synthesis is concerned primarily with the [illegible] hexamethylenediamine for nylon-66 and [illegible] for other nylons is mentioned briefly.

[illegible] commercial processes for the production of adipic [illegible] cyclohexane. The cyclohexane comes largely [illegible] although some is obtained from refinery streams. [illegible] by the hydrogenation of adiponitrile over a [illegible] adiponitrile is produced from adipic acid by [illegible] butadiene. An electrolytic process [illegible] of acrylonitrile to adiponitrile [illegible] conversion of a cyclohexanol-cyclohexanone [illegible] converted to hexamethylenediamine by [illegible]

[illegible]

[redacted] by treatment with hydroxylamine [redacted] lactam by a Beckmann rearrangement.

[redacted] terephthalic and adipic acid to produce [redacted] is the production of nylon-6, caprolactam [redacted] with acid by water and the amino acid is [redacted]. Reduction of monomer and low molecular [redacted] is one of the most serious problems in [redacted]

[redacted] production requires less capital investment and [redacted] is also said to be less costly to [redacted] of caprolactam which have cyclohexanone [redacted] ammonium sulphate as a by-product. This would be [redacted] country because of the use of ammonium [redacted]

[redacted] materials

[redacted] as Construction Materials for Developing [redacted] versatility of plastics applications as construction [redacted] where the housing shortage represents a [redacted]

[redacted] a number of conventional materials in freedom [redacted] and lower, ease of handling, low density and [redacted] corrosion. Available plastics - both [redacted] possess versatility and range of properties [redacted] ranging from paints and coatings to flooring, wall [redacted] and structural members. Present building uses [redacted] of all plastics produced in the United States and [redacted]

[redacted] and this favourable outlook in developed countries, [redacted] promise a bright future for plastics in [redacted] developing countries.

[redacted] requirements and the volume of future demands far [redacted] Petroleum as a raw material is available in [redacted] regions and the shortage of wood and metals [redacted] use of plastics from the naphtha fraction [redacted] product balances in developing countries [redacted] petrochemicals industry in these areas. The [redacted] plastics can go far to fill the void left [redacted] basic needs of construction. Pioneering studies [redacted] feasibility of plastics in meeting the [redacted] countries. Future specific applications based [redacted] all materials, roofing structures, [redacted] facilities - as well as all-round [redacted]

[redacted]

Summary of discussion

During the discussion, the participants posed questions relating to the papers presented.

In answer to a question regarding the most convenient process for polyethylene manufacture in the developing countries, the utilization of high pressure technology was recommended because of the established process knowhow and the greater demand for high pressure polyethylene.

With regard to different types of plastics (i.e. polyethylene and PVC) which can be used for the manufacture of the same end-product, it was stated that different plastic resins can indeed be utilized for the manufacture of the same plastic product and the selection of the resin will depend chiefly on availability and comparison of costs.

Regarding the different processes available for the manufacture of vinyl chloride monomers, it was pointed out specifically that oxychlorination represents a capital cost advantage over the two-step conventional process. The vinyl chloride process, starting with a diluted gas stream containing ethylene, permits the recovery of pure vinyl chloride monomer suitable for polymer manufacture.

In answer to several questions from participants, it was specified that it is economically feasible to recover ethylbenzene from a mixed xylenes stream by superfractionation if the ethylbenzene content is not lower than 7% per cent. The amount will depend only on the types of naphthas that are utilized as feedstock for reforming, as is the present case in some refineries in the United States and Japan.

The question was asked whether the new caprolactam process, based on caprolactone, is suitable for developing countries. It was pointed out that the new process looks promising for those countries that have an established outlet for by-product acetic acid, but in the case of developing countries, the oxime process may perhaps be more desirable since the by-product is ammonium sulphate which can be used as fertilizer.

In answer to several questions from participants, it was pointed out that the use of plastics in rigid pipes and tubes represents a clear advantage over conventional materials, up to a certain diameter. For large pipes subjected to pressures, the utilization of steel was recommended.

As regards the weather-resistance of plastic panels and roofing for houses, in replacement of traditional construction materials, it was indicated that plastic materials can outlast wood if they are properly protected with surface coating such as latex paints or polymer films based on polyesters or vinyls.

If a developing country has petroleum resources for conversion to a petrochemically-based plastic industry, and also a major housing shortage, the most adequate answer to the supply of building materials may be a mass-housing programme which could be integrated with the plastic materials industry.

[redacted]

[redacted]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] [illegible] (continued)

[illegible] Synthetic fibres

([illegible] item [illegible])

To meet the demand for textiles for domestic and industrial purposes, a constant and large expansion of synthetic fibre production is a necessity. At the present time, approximately [illegible] per cent of the total fibre demand in the United States and Western Europe is met by man-made fibres, of which [illegible] per cent are of completely synthetic origin ([illegible] per cent polyamides, [illegible] per cent polyesters, [illegible] per cent acrylics, [illegible] per cent others). In [illegible], the production of synthetic fibres exceeded [illegible] million tons, and the annual growth rate is more than [illegible] per cent. In the industrially advanced countries, the average per capita consumption ranges between [illegible] and [illegible] kilograms per year, compared to an average world consumption of [illegible] kilograms per year.

The production potential of synthetic fibres is determined by many factors: [illegible] of the country, industrial development of the country in general; the [illegible] of the [illegible] textile industry and the fibres used; the [illegible] of the [illegible]; the climate, and last but not least, the degree of [illegible] of the [illegible]. [illegible]

[illegible]

[illegible]

There is no general agreement as to which process for the manufacture of caprolactam is most suited for a developing country. The various methods of producing caprolactam and the side-processes linked with them, show many variations. In all processes a hydrogenation has to be carried out in some stage of the process, and in all processes ammonia is needed. The latter is employed as starting material in the preparation of auxiliary materials (HCN, NH_2OH, $(NH_4)_2SO_4$) and for neutralization of the sulphuric acid used.

The choice of the process will depend on such factors as production capacity, raw material position, special demands for by-products, etc. Also, the quality of the end product may well be a decisive factor. All the processes for the manufacture of caprolactam which have cyclohexanone oxime as an intermediate product produce ammonium sulphate as by-product. This may be desirable in a developing country because of the use of ammonium sulphate as a fertilizer.

As to the lowest capacity limit for a nylon-6 plant for profitable manufacture of nylon-6 textile filament from nylon-6 chips, it is claimed that the minimum daily capacity is 1,000 kilogrammes. From caprolactam the figure would be 1,300 kilogrammes per day and for staple fibre from caprolactam 2,000 kilogrammes per day.

However, these lower capacity limits cannot be taken as a basis if it is intended to export nylon-6 fibres. In this case, the same capacity limits hold good as those existing in an industrially developed country, unless the export is subsidised by the Government. There would only seem to be opportunities for export to the world market if at least 5,000 kilogrammes per day are produced. Comparison of the production costs for plants of different size shows that for small size plants, polymerization of caprolactam is not profitable.

Polyesters now in commercial production for fibre manufacture consist almost exclusively of polyethylene glycol terephthalate. This polymer is formed from the basic monomers or from dimethyl terephthalate and ethylene glycol or ethylene oxide. Such terephthalate fibres differ from polyamide fibres mainly in their elastic properties, and have been accepted primarily for clothing purposes. Polyester fibres are also characterized by their low water absorption. The poor dye affinity of polyester fibres is due to the low water absorption, the low swelling tendency and the high crystallinity of the stretched fibre. Polyester fibres have a tendency to pile in clothing.

Terephthalic acid is produced by oxidation of p-xylene or by the Henkel process which involves the rearrangement of the potassium salt of benzoic acid to terephthalic acid. The oxidation of p-xylene to terephthalic acid may be by nitric acid or by air. Essentially, all new plant capacity based on p-xylene oxidation has been installed using air oxidation techniques. The Henkel process is claimed to produce a very pure terephthalic acid which eliminates the necessity of purification via the dimethyl ester. The smallest economic size plant for the production of terephthalic acid from p-xylene by the Henkel process was stated to be 4,400 tons per year.

Ethylene glycol comprises less than one half of the weight of the polymer in polyester fibres, and, therefore, very large fibre manufacturing capacities would have to be undertaken to require a glycol supply that would be considered of the economic size plant. The decision of a developing country to make or import ethylene glycol would depend on the availability of by-product ethylene glycol.

Most of the acrylonitrile synthetic fibres are produced from copolymers for the purpose of improving the properties of the fibre. Such fibres spun from copolymers are classified into fibres whose acrylonitrile content is 85 per cent or more (acrylic fibres), and fibres whose acrylonitrile content is less than 85 per cent (modacrylic fibres).

At the present time most acrylonitrile is produced from acetylene and hydrogen cyanide. An alternative route, in which propylene and ammonia serve as raw materials, is becoming important in the production of acrylonitrile. This process has the following advantages: lower cost and investment, greater potential abundance of suitable raw materials, process simplicity, no necessity to handle hydrogen cyanide, and high product quality.

Summary of discussion

As to the comparison between nylon and polyester as staple fibres, it was mentioned that, in general, only polyester was used in large quantities as such. Nylon-6 is also used as staple fibre, but only in very small quantities and in specialized fields, where it is admixed with other fibres to produce textiles for military purposes.

Polyester fibres when admixed with wool in the ratio of 45 per cent: 55 per cent yield good spinning materials with high crease resistant properties. When admixed with cotton, a very high strength clothing material for men's shirting is produced. In this field nylon-6 is competing to some extent.

With respect to the question whether a developing country wishing to produce man-made fibre should make a choice between rayon (cellulosic origin) or petrochemical synthetic fibres, the meeting was undecided, and it was pointed out that this would have to be decided upon for each case individually. By way of illustration, it was mentioned that one developing country had planned to increase its production of rayon, using straw pulp as a starting material; however, because of shortage of straw pulp, the plan had to be abandoned and instead facilities for polyester manufacture are being constructed.

It was pointed out that in developing countries with a hot and humid climate, polyvinyl alcohol might be of potential use as staple fibre because of its resemblance to cotton in respect of moisture absorption, in addition to a number of other desirable properties.

A question was raised relating to the Mid-Century process, and it was pointed out that the various xylene isomers present in the feedstock could be oxidized simultaneously, to give a mixture of benzoic acid, isophthalic acid and terephthalic acid, which could then be separated and refined. Further, in answer to a corollary question as to whether the production of phthalic anhydride can be achieved by the same process, it was stated that the synthesis can be effected and the dibasic acids and the anhydride produced can also be separated.

It was mentioned that in some countries, research was being conducted to develop a new type of nylon using ethylene and carbon tetrachloride as raw materials; however, no information on the progress of the research was disclosed.

A request was made for technical details of the Henkel process for the manufacture of terephthalic acid using toluene as raw material. Owing to the fact that the first Henkel plant based on this process, in the Federal Republic of Germany, was only scheduled to go into operation by the end of 1964, no evaluation of its performance could yet be made.

IV. INDUSTRY STUDIES (continued)

6. Selected end-products

(Agenda item IV-6)

Under this item, various economic and technological aspects of the production of some specific petrochemical end-products, namely sulphur, carbon black, detergents and methanol, were discussed. The importance of multipurpose complexes in the field of petrochemical industries was also mentioned.

Sulphur

The petroleum industry has changed from a net consumer of sulphur in 1950 to a net producer since 1960. It was stated that in 1963, of the nearly 20 million long tons of sulphur consumed in Western Europe and North America, 19 per cent was produced from hydrogen sulphide found in sour natural gas or petroleum refinery gases.

The world-wide sulphur production sources at present were stated to be divided as follows:

Fresh sulphur	30 per cent
Sulphur from pyrites	34 per cent
Native sulphur	2 per cent
Sulphur from natural gas	18 per cent
Miscellaneous	16 per cent

Recovery of sulphur from natural gas is usually carried out in two steps:

- First step: Desulphurization plant unit where H_2S is removed from the gas;

- Second step: Sulphur plant where H_2S is turnt in order to give sulphur.

Industrial separation of H_2S from natural gas can be achieved in several ways all based on selective absorption. The most common processes in this connexion were said to be the amine process and the hot potassium carbonate process.

The acid gases removed from the raw gas stream are regenerated from the absorbing solution by heat and/or pressure differences, then sent to the sulphur plant. In the sulphur plant, part of the H_2S is burned with air to form SO_2. The sulphur dioxide reacts with the remaining hydrogen sulphide, thereby producing sulphur, which is normally referred to as recovered sulphur. This process for the recovery of sulphur is known as the Claus process.

The cost of producing [illegible] sulphur [illegible] such items as (1) the quantity of the gas [illegible] gas in the sour gas, (2) percentage of hydrogen sulphide in the sour gas, (3) percentage of constituents other than carbon dioxide and hydrogen sulphide in the acid gas, and (4) local factors related to the area where the plant is to be established. The unit items will not only affect the [illegible] gas scrubbing plant, but also the sulphur plant. [illegible] it is very difficult to generalize about the [illegible] production and plant capacity.

Generally, the costs of purifying the raw gas and the sulphur plant are not allocated to sulphur alone. This is the case because the purification is normally needed to produce sweet gas, regardless of whether sulphur is recovered or not. If the sweet gas is not needed, it is [illegible] to process the gas merely to recover the sulphur.

Sulphur in general, however, is becoming very important for developing countries which are planning to establish fertilizer plants.

Carbon black

Chemically, carbon black is a pure elementary carbon with a small amount of chemisorbed hydrogen and oxygen and less than 1 per cent of ash. From the point of view of the application properties, quality control, technical service and research required in its production, it must be regarded as a highly [illegible] upgraded material, rather than a basic petrochemical, although it meets the formal requirements of a petrochemical.

The best raw materials for the production of carbon black are natural gas and high aromatic rich fractions obtained from a petroleum refinery.

The various industrial processes for manufacturing carbon black from natural gas and oils are the channel process, thermal [illegible] process and [illegible] process.

The minimum economic size of a conventional carbon black plant [illegible] to be in the order of [illegible] [illegible]/year, requiring a [illegible] as well as the export of a part of its output.[1]

However, carbon black plants may often be constructed in developing countries by private enterprise or governments, before the local demand is large enough to make such an operation profitable. This is done to gain an early market position, looking several years ahead to larger domestic use, and to keep competition out as long as possible. Thus, the development of carbon black production in the developing countries has tended to lead rather than to lag [illegible].

Intermediates[2]

It is estimated that [illegible] per cent of the total demand [illegible] intermediates. The remaining [illegible] per cent [illegible] a wide variety of industrial applications.

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1. Carbon Black Production in Developing Countries [illegible]
2. The Petrochemical Industries [illegible]

[illegible] based on alkyl aryl sulphonate, fatty alcohol [illegible]

[illegible] sulphonates are predominant, accounting for [illegible] The main growth in detergents is presently in the [illegible] formulations.

[illegible] of dodecylbenzene sulphonate may be outlined [illegible] The intermediates used in the preparation are propylene and [illegible] are the steps to be carried in three steps: (i) polymerization of [illegible], (ii) linking tetrapropylene with benzene to form [illegible] and [illegible] sulphonation with oleum and neutralization with sodium [illegible].

[illegible] limits) for a 10,000 tons/year capacity dodecylbenzen[illegible] [illegible] corresponding to a 55,000 tons/year production of commercial [illegible] based on propylene and benzene feedstocks, and including a [illegible] production and benzene alkylation) and a sulphonation [illegible] a million dollars.

[illegible] use of synthetic detergents has emphasized the [illegible]. In several countries, Governments have regulated the [illegible] detergents, which tend to persist in the waste [illegible] being decomposed. Attention has thus been turned [illegible] which will easily degrade under sewage treatment [illegible].

[illegible] detergents are the straight-chain olefins [illegible]. The route from n-paraffins was considered more [illegible] molecular sieve technique for separating n-paraffins [illegible] available at low cost. Conversion of [illegible] on an industrial scale could be effected by chlorination, and the [illegible] obtained may be used directly to obtain alkylate benzene with [illegible] as the catalyst, or they may be dehydrochlorinated to straight-[illegible].

[illegible] HCl by-product of the chlorination of the n-paraffins [illegible] in many countries.

[illegible]

[illegible] of methanol are in the production of formaldehyde, [illegible].

[illegible] by high pressure synthesis from gas composed of [illegible] one of the earliest commercial petrochemical processes.

[illegible] now based on steam reforming processes for [illegible] or natural gas feedstocks. The conversion of [illegible] is carried out in a high pressure reactor like [illegible].

[illegible]

[redacted] million, [redacted]

[redacted]

[redacted] and the demand for petrochemical [redacted] throughout the world, and that [redacted] serve the consumer directly, [redacted] reactors where a variety of [redacted]

[redacted] when there is not sufficient [redacted] The products, in these multipurpose [redacted] of petrochemicals, all of which are [redacted] in an expanded petrochemicals. This type [redacted] and at the same time the cost [redacted]

[redacted] petrochemical

V. COUNTRY STUDIES

(Agenda Item V)

1. Asia and the Far East

Among all the countries in the ECAFE region, Japan is the only one which has developed the petrochemical industry to an international level, and both consumption and production of petrochemical products within the region are largely concentrated in Japan. Some countries of the region have already started to make nitrogenous fertilizers from natural gas or naphtha. Most of the countries have plans to establish naphtha cracker complexes for the production of basic petrochemicals. A summary of their developments and plans follows.

Burma[1/]

Crude oil production in Burma is currently about half a million tons per annum. It has two refineries with a combined capacity of 1.2 million tons per year. Crude oil is imported to supplement the local supply of feedstock to the refineries.

The presence of natural gas was detected at Chauk oil fields during exploratory drilling in 1960. It is expected that firm figures regarding the size of the field will be available during 1965. If the gas reserves are substantial, one 69,000 ton per year urea plant will be installed, using natural gas as raw material.

The consumption of plastic materials and synthetic fibres is expected to increase rapidly in the years to come, but it is unlikely that domestic production could be undertaken before 1970.

Research work is in progress on the manufacture of detergents and pesticides to explore the possibilities of using local raw materials instead of imported intermediates. The Institute of Technology in Rangoon is now giving courses in petroleum engineering.

China (Taiwan)[2/]

Since the discovery of substantial reserves of natural gas in Taiwan in 1960, a fertilizer plant based on natural gas has been built by a joint venture of Chinese Petroleum Corporation, Mobil Chemical Company and Allied Chemical Corporation, with a capacity of 100,000 mt/year of urea and 45,000 mt/year of ammonia. This plant was completed in late 1963 and has now been successfully put into operation.

1/ Petrochemical Country Studies - Burma (PET/CHEM/CONF.48).

2/ Country Studies - China (Taiwan) (PET/CHEM/CONF.66).

[illegible]

1. [illegible]

[illegible]
[illegible]
[illegible]

2. An ethylene-[illegible] plant with a capacity [illegible] per year, using the [illegible] process.

3. Sulphur is produced from crude oil in the [illegible] refinery, which has an installed capacity of [illegible] tons per day and was designed by [illegible], Federal Republic of Germany.

4. A carbon black plant using natural gas as feedstock with an installed capacity of 500 tons per year.

The demand for some petrochemical products in 1968 has been estimated as follows:

Polyester chips	[illegible] mt
Caprolactam	[illegible] mt
Polyethylene	[illegible] mt
Plasticiser	[illegible] mt

Plans for developing the petrochemical industry from 1969 to 1973 include the following:

1. A new ammonia plant of 600 tons per day capacity based on natural gas to be built at Hajipur.

2. A steam cracker capable of cracking 100,000 tons/year of naphtha to produce ethylene, propylene, etc., for the production of plastics and other chemicals.

3. An aromatic extraction plant of 20,000 tons per year capacity to supply the intermediates for plastics and synthetic fibres production. The production of basic intermediates in 1968 is estimated to be:

Benzene	5,000 kl.
Xylenes	6,000 kl.
Ethylene	18,000 tons
Propylene	8,000 tons.

India 3/

The existing organic chemical industry is of non-petroleum origin and is based on traditional raw materials such as alcohol from molasses, acetylene from

3/ Country Study - India (PET/CHEM/CONF.131) and Development of Petroleum-based Organic Chemicals in India (PET/CHEM/CONF.12).

[illegible]

[illegible]

[illegible]

The first two petrochemical complexes under construction in Bombay are expected to start production in [illegible]. The schemes are:

1. [illegible] ton naphtha cracker complex by Union Carbide (India) Ltd. Ethylene capacity is [illegible] tons per year.

2. [illegible] ton naphtha cracker complex by [illegible] and [illegible] Chemical Industries Ltd., in collaboration with [illegible]. Ethylene capacity is [illegible] tons per year. 4/

The total investment in these two complexes is of the order of $[illegible] million.

In order to achieve the targets of the Fourth Five-Year Plan (1966-71), another four petrochemical complexes have been recommended by the planning group for petrochemicals. They are to be located at Koyali (Gujarat), [illegible] and in South India.

The investment for the four petrochemical complexes is of the order of $[illegible] million. This does not include investment in fertilizer plants, which may be another $500 million and also in conversion and fabrication facilities estimated to be of the order of $350-400 million.

The task of achieving the projected scheme is not easy, considering India's limitations, such as scarcity of foreign exchange, trained personnel, marketing and end-use research, and limited facilities for the fabrication of plant equipment.

The Government of India has already taken steps in many directions to overcome these difficulties.

4/ Financing of Petrochemical Ventures in Developing Countries (PET/CHEM/CONF.10) page [illegible]1.

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

Iran 2/

Iran possesses the world's largest proved reserves of natural gas, as well as one of the world's largest reserves of petroleum. The volume of associated natural gas currently being flared in the southern oil fields of Iran is about [illegible] million standard cubic feet a day. This amount is equivalent in heating value to some [illegible] bbls. a day of crude oil. There is, therefore, ample scope for the utilization of gas both as a fuel and as a raw material.

As yet, apart from the nitrogenous fertilizer plant of about [illegible] tons nitrogen annual capacity in Shiraz, based on natural gas from Gach Saran oil field, no other petrochemical plants have been built.

The establishment of a petrochemical complex has been given high priority by the Government. In a general survey for the establishment of a petrochemical industry in Iran, completed by the end of 1963, the establishment of a petrochemical complex was recommended for the manufacture of plastics, synthetic rubbers, synthetic fibres and detergents, in quantities sufficient to satisfy internal demand in 1970. The complex would require an investment of about [illegible] million.

1/ Petrochemical Industry in Indonesia (PET/CHEM/CONF.[illegible]).

2/ The Petrochemical Industry in Iran (PET/CHEM/CONF.[illegible]).

[illegible]

Japan[1]

The plan for the establishment of the petrochemical industry in Japan was begun in [illegible] when the Ministry of International Trade and Industry (MITI) mapped out the programme for bringing the petrochemical industry up to date. In the first stage, four [illegible] cracking complexes were completed between 1957 and [illegible]

As the initial plan advanced, the demand for petrochemical products began to show a steady increase. MITI's second-stage plan was put forward in a document entitled "[illegible] policies towards future petrochemical projects". The basic idea was that petrochemical production was to be raised by all means to an international level. In the second stage, therefore, the stress was laid on the expansion of the existing ethylene unit and the completion of the combinates built in the first stage.

Succeeding the second-stage plan, the third-stage plan was carried out as follows:

1. Expansion of the capacity of existing ethylene from [illegible] tons to [illegible] tons per year.

[illegible]. Promotion of derivatives especially on the basis of propylene.

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[1] Development of Japan's Petrochemical Industry [illegible].

- [illegible] -

[illegible] establishment of [illegible] additional [illegible] having [illegible] tons per year of ethylene, [illegible] were also approved.

In 19[illegible], a plan was worked out raising the capacity of [illegible] to [illegible] tons per year of ethylene, corresponding to the [illegible] demand, and this is now being implemented.

To promote the establishment and expansion of the petrochemical industry, the Japanese Government allowed chemical concerns to introduce foreign capital and technical know-how and engineering, in accordance with the provisions of the law relating to foreign investment.

The Government has adopted various policies of protection and assistance for the approved projects, such as the granting of loans and special arrangements for the depreciation of equipment, exemption from taxes and import duties on imports of equipment and catalysts, etc.

Malaysia[3]

The development of petrochemical industries in Malaysia will be started in the next few years, particularly in Singapore and Malaya. There are five petroleum refineries in Malaysia, each of which is capable of processing [illegible],000 bbls. of crude oil per day. Refinery products and off-gases will be the raw materials for making petrochemicals.

In the early stage, the following petrochemical industries will be developed first:

1. Ammonia. Esso Standard Malaya is constructing an ammonia plant near the Port Dickson refinery. The plant will have an installed annual capacity of [illegible],000 tons of ammonia, which will be converted into ammonium nitrate, and it is expected to go into operation in 19[illegible].

2. Sulphur. The demand for sulphur in Malaysia will exceed 5,000 tons a year in the near future. In view of this and other considerations, it would be economically feasible to establish a sulphur recovery unit from refinery gases.

3. Detergent. The production of detergent in Malaysia is slightly more than 1[illegible],000 tons a year. A new plant is in construction in Singapore having an annual capacity of more than 9 million pounds of detergents.

4. Carbon black. The consumption of carbon black in Malaysia is only about [illegible],000 tons a year, used for tyre manufacture. A new tyre factory in Singapore will start operation by the end of 1964. The consumption of carbon black will increase considerably after the completion of this factory.

The Government of Malaysia, both at the Federal and State levels, is assisting private enterprises in various ways. These include the expansion of infrastructure facilities, development of industrial sites, provision of loans, and tariff protection and concessions.

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[3] Country Studies - Malaysia (PET/CHEM/CONF.[illegible]).

Pakistan[2/]

The search for oil in Pakistan has already disclosed proved deposits of about 20 million cubic feet of natural gas. There are indications that substantial additional reserves will be proved. Indigenous production of oil meets about 20 per cent of the country's requirement. The search for oil is continuing vigorously. The utilization of natural gas for the production of nitrogen fertilizers is only now beginning. During the last six years, the production of fertilizers has risen from zero to 140,000 tons of urea, 70,000 tons of ammonium nitrate, and 50,000 tons of ammonium sulphate.

The minimum additional requirements of nitrogen fertilizers in Pakistan are estimated at 1,400,000 tons in terms of nitrogen. It is proposed to develop the capacity for meeting these requirements in two phases, 450,000 tons by 1960 and the balance of 950,000 tons between 1970 and 1980.

The petroleum refining capacity currently in operation and under installation is of the order of 4.3 million tons per annum and will soon increase to at least 5.3 million tons. Refinery products and off-gases will be used also as petrochemical raw materials.

Two petrochemical complexes will be set up, one in each of the two provinces of the country. Each complex will be achieved in two stages, the first stage by 1970 and the second by 1980. The complex in West Pakistan will use natural gas to the extent of 55 per cent of its feedstock requirements, and the one in East Pakistan to the extent of 67 per cent of its feedstock requirements, the balance in each case being provided by refinery products. The total investment in both complexes is estimated at Rs. 3,500 million by 1980, of which about half will be invested by 1970.

Iran, Turkey and Pakistan are now engaged in mutual consultations with a view to introducing the maximum economies in investment through regional co-operation, and accelerating and enhancing the benefits that will accrue from industrial development in general in these three countries, including the development of petrochemical industries. The consultations now in progress should produce, in the near future, specific projects for implementation as joint ventures.

2. North Africa and Middle East

The potential for petrochemical development in some countries of North Africa and the Middle East is based on the existence of proved and abundant sources of hydrocarbon raw materials which are at present not being utilised to any great extent.

In the discussions that followed the presentation of the country papers, and statements, there were indications that it would be more beneficial to plan petrochemical development on a regional basis, rather than for each country individually. Furthermore, it was evident that in the case of countries with abundant natural gas resources, the question of export markets outside the area loom large in the planning efforts. It was mentioned that regional co-operation is being seriously considered by some of the countries in this area with a view

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2/ Petrochemical Industry in East Pakistan (PET/CHEM/CONF.[illegible]).

developing a common market. The discussions emphasized the need for more trained personnel and for more training institutions, particularly in the field of petroleum and petrochemicals.

Israel[10/]

In 1952, an ammonia plant was installed, and in 1963 polyethylene and carbon black were being produced on the basis of feedstocks from Haifa Refinery. Production of petrochemicals has risen by 14-15 per cent per annum during the period 1958-1963. It is recognized, however, that the industry is still in its first stage of development. Major plans to expand the industry are now under way, with production primarily destined for the domestic market. The source of hydrocarbons for the development plans will be the refinery. Israel claims to be capable of doing the civil engineering and manufacturing a major proportion of the chemical plant equipment needed for the above developments; in fact, there have been significant exports of industrial equipment from Israel in the last few years. One of the significant factors favourably affecting the development of petrochemical industry is the availability of trained personnel, and training and research facilities of high quality.

Kuwait[11/]

About 800 million cubic feet of gas are produced per day. A 400 tons of nitrogen per day fertilizer plant is now under construction as a joint venture of the Kuwait Petrochemical Industries Company with British Petroleum and Gulf Oil (the respective shares are 60, 20 and 20 per cent). A larger ammonia plant of 800 tons of nitrogen per day is being planned primarily to export liquid ammonia. The programme also envisages the construction of a polyethylene plant and other petrochemical units.

Libya[12/]

The recent discovery of associated natural gas with a high content of higher hydrocarbons is of major importance. At the present time, there are no known plans to exploit these resources for petrochemicals as such, but it was stated that studies are under way to evaluate and appraise the feasibility of such projects.

It is anticipated that the associated gas produced, amounting to 190,000 mmcf., will be liquified and transported to Europe. Such schemes are now under consideration and some oil companies have submitted firm proposals to the Government. The establishment of petrochemicals manufacture is considered economically feasible on the basis of joint ventures.

10/ The Development of the Petrochemical Industry in Israel (PET/CHEM/CONF.110).

11/ Natural Gas in Kuwait and its Utilization (PET/CHEM/CONF.120).

12/ The Possibilities for Developing Petrochemicals in Libya (PET/CHEM/CONF.121).

Morocco[13/]

There are some limited sources of natural gas and petroleum hydrocarbons in Morocco, but the reserves are considerably less abundant than in neighbouring Algeria. Plans are being made to establish a petrochemical industry using natural gas from Algeria in conjunction with its use for thermic energy. It is considered that only such conditions will justify the development of a viable petrochemical industry based on natural gas, since only a small fraction of the gas can be used for this purpose. Plans are being contemplated for a petrochemi complex, principally for ammonia synthesis. However, the domestic demand for nitrogen fertilizers is limited. On the other hand, the country is one of the largest sources of phosphate rock and exports it in large quantities. The plans include the upgrading of the rock, possibly into ammonium phosphates, primarily for export. The development of organic chemicals of petrochemical origin is being studied.

Saudi Arabia[14/]

Although Saudi Arabia is stated to have one of the largest hydrocarbon reserves in the world (about 950 mmscfd of natural gas and almost 1,900,000 bbls/day of oil are produced), there are no petrochemical plants in the country at present.

Plans have been already elaborated, under an organization known as "The General Organization of Petroleum and Minerals", to establish several petrochemic entities, preferably on a joint venture basis. The plans also include the settin up of adequate technical training facilities.

Syria[15/]

In 1959, a refinery was established at Homs to process 1 million tons of crude oil per year. Plans are now being prepared to build a nitrogenous fertilizer plant, primarily for local consumption, based on naphtha feedstock. Although the country has supplies of natural gas and crude oil in addition to excess refinery products, the domestic market for petrochemicals is limited; consequently, no detailed planning has been undertaken for this purpose. Some thought is being given, however, to planning within the framework of an Arab common market.

United Arab Republic[16/]

The principal sources of petroleum hydrocarbons for nitrogenous fertilisers, which are the leading petrochemicals produced in the country at the present time, are refinery gas and naphtha from the Suez Refinery. The production of aromatic intermediates and dodecylbenzene will start in March 1965. The development of other petrochemicals based on steam pyrolysis of naphtha is now being undertaken

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13/ Country Study - Morocco (PET/CHEM/CONF.127).

14/ Country Study - Saudi Arabia (PET/CHEM/CONF.129).

15/ Petrochemical Industry - Syria (PET/CHEM/CONF.78).

16/ Country Study - United Arab Republic (PET/CHEM/CONF.128).

by the Government and includes the manufacture of PVC, [illegible] synthetic rubber, synthetic fibres and carbon black, [illegible] be consumed domestically. It is planned to produce [illegible] from petroleum raw materials so that the total production [illegible] 450,000 tons (N) nitrogen per year, of which about [illegible]

3. Europe

With respect to Europe, the experiences of Poland, Romania, [illegible] and Yugoslavia were presented. A review of the petrochemical industry in these countries follows.

Poland[17]

The growing demand for chemical synthetics calls for increased capital investment in the petrochemical industry. This investment [illegible] 2.5 per cent of the annual national income. Production costs of several products have been lowered considerably mainly due to the replacement of [illegible] chemicals by natural gas as hydrocarbon feedstock.

The development plans currently under way cover the period up to about [illegible]. Acetylene from partial oxidation of methane will be the source of [illegible], acetaldehyde, vinyl chloride; and ethylene and propylene from pyrolysis of [illegible] gasoline will be processed into ethylbenzene, ethylene oxide, polyethylene, cumene, phenol and acetone, polypropylene, propylene oxide and [illegible]. Similarly, normal C_4 hydrocarbons will be used as feed for production of [illegible] for about 90,000 tons/year of synthetic rubbers. Benzene, toluene and [illegible] from light oil and coal tar fractions will cover the demand only until [illegible]. Xylenes and additional quantities of benzene will be separated from [illegible] gasoline fractions and from liquid products of [illegible] of the feed to pyrolysis plants. It is expected that the production of [illegible] fibre will be 30,000 tons per year, polyester fibres [illegible] tons per year and acrylic fibres 20,000 tons per year. Caprolactam production is at present based on phenol but will in future be made from benzene via the [illegible] route. Terephthalate will be produced via the nitric acid oxidation of [illegible] and also via benzoic acid. Benzene and naphthalene will continue to remain the source of maleic and phthalic anhydrides and calcium cyanamide the source of [illegible].

Natural gas will be the primary source of synthesis gas to produce [illegible] tons per year of methanol and 1.35 million tons (out of a total of [illegible] million tons) of synthetic ammonia.

Romania[18]

The availability of abundant resources of natural gas and crude oil has stimulated the growth of the petrochemical industry in Romania. In [illegible], the crude oil output was 12.2 million tons and the output of methane was [illegible] million m^3.

17/ Petrochemical and Carbochemical Processes in Poland [illegible] (PET/CHEM/CONF.30).

18/ Country Study - Romania (PET/CHEM/CONF.1[illegible]).

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[illegible] ammonia ([illegible],000 tons in 1963) is obtained from methane, [illegible] total output of ammonia is used for the manufacture of [illegible]. It is expected that in 1965 the total output of [illegible] will be 1.5 million tons, and in 1970, about three times [illegible].

[illegible] methane are produced. Among these are: [illegible], acrylonitrile, vinyl chloride, vinyl acetate, acetic [illegible], etc.

[illegible] these products, a 36,000 ton PVC and a 5,000 ton [illegible] have been put on stream. Besides the existing thermal [illegible] units, a 1 million tons capacity catalytic reforming plant [illegible] with high octane number gasoline, the entire range of aromatic [illegible], xylenes and ethylbenzene, and a pyrolysis plant of 35,000 [illegible] ethylene and [illegible],000 tons/year propylene capacity, will be put on [illegible] by the end of this year. On this basis, plants have been constructed for [illegible] the following products: synthetic rubber (30,000 tons), pheno[illegible] [illegible],000 tons, acetone 11,000 tons), detergents (14,000 tons), [illegible],000 tons), etc.

[illegible]

[illegible] industry has yet been established in Turkey, but the first [illegible] envisages the realization of a petrochemical industry.

[illegible] rates of the petrochemical complex envisaged are:

- [illegible] tons/year - thermoplastic material
- [illegible] tons/year - detergent raw material
- [illegible],000 tons/year - synthetic fibres raw material
- [illegible],000 tons/year - carbon black.

[illegible] the establishment of a petrochemical industry may be [illegible]:

- [illegible] the national petroleum industry into the area of petrochemistry.
- [illegible] the need of foreign currency for petrochemicals by utilizing [illegible], domestic raw materials, etc., and importing only know-how and [illegible] required for the operation.
- [illegible] to the national detergent, textile and plastic industries.

[illegible]

[illegible] investment for the construction of plants in the [illegible] industry, in the period 1959-63, totalled over [illegible]

[illegible] (PET/CHEM/CONF.77).

[illegible] of the Petrochemical Industry in the USSR

[illegible] total invested [illegible] annual rate of [illegible] industry during these five [illegible] growth of capital investment [illegible]

The chemical [illegible] to 25 billion roubles compared with [illegible] chemical fibres is expected to increase [illegible] plastics and synthetic resins seven times.

Petroleum [illegible] for the manufacture of synthetic materials. [illegible] refinery and natural gas sources of hydrocarbon will [illegible] the requirement in the plastic industry. [illegible] Similarly, the output of intermediate petr[illegible] and natural gas raw materials will be increased [illegible] 4.5 times, acetic aldehyde 10 times, and [illegible]

Yugoslavia 2/

In the period [illegible] Yugoslavia grew at a substantially faster rate [illegible] industry as a whole (12.4 per cent).

In 1962, the construct[illegible] unit in Yugoslavia was completed at [illegible], and towards the end of that year a nitrogen fertil[illegible] operation at Pancevo/Banat. In 1964, the construct[illegible], phenol, polystyrene and polyethylene was completed [illegible]

One of the few [illegible] development of the petrochemical industry is the availability [illegible] there are considerable deposits of natural gas and substantial [illegible] petroleum.

Installed capacities [illegible] exceed current domestic demand and surpluses will [illegible]

The long-term development [illegible] industry is still under study and it is most likely that [illegible] of the petrochemical industry in Yugoslavia will be [illegible] construction of new capacities for ethylene, propylene, acetylene [illegible] has been found necessary to organize the plants around [illegible] petrochemical products for which sufficient domestic markets may [illegible], in 1963 Yugoslavia imported about 100,000 tons [illegible], particular attention will be paid to develop[illegible] capacity.

1/ Petrochemical Industry [illegible].

2/ Financing of Petr[illegible] (PET/CHEM/CONF.105) page 62.

4. Latin America

Apparent consumption of chemicals in Latin America was estimated by ECLA to be of the order of $5,000 million in 1959, with imports accounting for about 7 per cent of this total. For 1970, demand was projected to be of the order of $8,000 million.

The share of petrochemicals in the total was rather limited in 1959 but it is expected to increase substantially by 1970. Since the proportion of imports of petrochemicals was much higher than the average 7 per cent for the whole chemical industry, the necessity of a considerable effort towards import substitution is foreseen for petrochemical raw materials and intermediates.

The Latin American countries represented in LAFTA, having realized that

- while petrochemical industries are capital intensive industries, there is a scarcity of domestic capital in the area, also that a high foreign exchange component of investment is required,

- economies of scale prevail in the development of petrochemical industries;

- full utilization of the locally available technology and skills is necessa

- a better allocation of resources and markets is desirable,

consider that the possible solution rests in the concept of complementation and integration of the petrochemical industries in Latin America, sectoral meetings having already recommended this to the Executive Committee of LAFTA in 1963, and 1964.

Positive factors to help in achieving this objective are: the clear understanding prevailing among the countries in the area, that there is need to avoid costly duplication; the pioneering studies in the field of chemical industries done by ECLA; the existence of a state oil industry in these countries which is strong enough to achieve the desired integration by itself or with the cooperation of private industry.

State oil companies have already taken the initiative, and some of them have signed agreements among themselves to study the complementation of their industries in all its aspects, especially in the field of petrochemicals, starting immediately with the exchange of technicians and technical information, the utilization of idle capacities and the exchange of products.

This trend towards integration found expression recently at the meeting held in Buenos Aires under the auspices of Instituto Petrolífero Fueguino (I.P.F.) at which all the Latin American state oil companies were represented, and the basis for joint action was discussed. The establishment of a permanent commission is expected to be achieved during 1965.

Argentina 3/

The petrochemical industry in Argentina started in 1944 with the production of isopropyl-alcohol and several aromatic hydrocarbons. These productions were the first petrochemical activities in Latin America.

However, the real development of this industry has only taken place in the last few years, during which the following plants have been put into operation: carbon black (15,000 tons/year), ethylene, polyethylene ([illegible],000 tons/year of polyethylene in two plants), methanol (11,000 tons/year), carbon sulphide (14,000 tons/year). Other minor plants have been put in operation and there are many other plants under construction. Among these is a petrochemical complex for the production of aromatics, butadiene, SBR rubber, and other products. This complex will represent a total investment of $85 million. 4/ Besides these, there are plants being constructed for the production of methanol, C_3 and C_4 solvents and detergents. Two fertilizer complexes will be built in the near future (urea, ammonium nitrate and ammonium sulphate and mixed fertilizers).

Construction has been announced recently of a new chemical complex for the production of ethylene oxide and propylene oxide, glycols, ethanolamines and several chloride derivatives.

Plans are being prepared for a unit to produce raw materials for nylon-66, which would be complementary to the already existing fibre industries (polyamides, polyester and polypropylene).

As an illustration, some petroleum statistics were mentioned; refinery capacity in Argentina is 18 million m^3 and natural gas reserves amount to [illegible],000 million m^3.

An adequate legal system grants several benefits to the new petrochemical plants and promotes the investment of capital in the country.

Brazil 5/

The petrochemical industry in Brazil had its beginning in [illegible] with a nitrogen fertilizer plant, producing [illegible] tons per day of ammonium calcium nitrate. The legal structure of Brazil's petroleum refining industry is based on state monopoly with the National Petroleum Council as supervisory agency and Petróleo Brasileiro S.A. - PETROBRAS - as executive agency. Even though the petrochemical industry is not included in the state monopoly, PETROBRAS has been until now the only producer of petrochemical raw materials. The National Petroleum Council has recommended, however, that because of its diversification, the petrochemical industry in Brazil should be, as far as possible, set up by private industry.

At present, PETROBRAS has the following petrochemical units in operation:

3/ [illegible]

4/ [illegible]

5/ [illegible]

1. Nitrogen fertilizer plant designed to produce 340 tons per day of ammon calcium nitrate.

2. Ethylene unit designed to produce 57 tons per day.

3. Propylene unit designed to produce 30 tons per day.

4. SBR synthetic rubber plant designed to produce 40,000 tons per year.

From the above list, expansion is planned for the following units:

(a) Ethylene - will be expanded to 100 tons per day.

(b) Propylene - will be expanded to 60 tons per day.

(c) Ammonia unit of the nitrogen fertilizer plant with present capacity of 90 tons per day will be expanded to 140 tons per day.

PETROBRAS has the following petrochemical units under construction:

1. Butadiene - designed to produce 33,000 tons per year.

2. Ammonia - designed to produce 200 tons per day.

3. Aromatic extraction - designed to produce 100 tons per day of benzene.

PETROBRAS's plans call for the construction of the following new petrochemic units by 1967:

1. Ethylbenzene - 33,000 tons per year.

2. Styrene - [illegible],000 tons per year.

3. Propylene tetramer - [illegible] tons per day.

4. Dodecylbenzene - 10,00[illegible] tons per year.

5. Urea - [illegible]0 tons per day.

6. Anti-knocking fluid - 11,5[illegible] tons per year.

Besides petrochemical products, PETROBRAS also furnishes private industry wit raw materials for the following petrochemicals: methanol, formaldehyde, polyethylene, isopropyl-alcohol, carbon black and acetone.

Chile

The expected development of the petrochemical industry in Chile, during the next six years [illegible], is based on the following considerations:

[illegible] E/CN.[illegible].

1. The existence of a growing and sophisticated market for final products of petrochemical origin, owing to the establishment, starting in 1955, of modern process industries.

2. Local availability of raw materials, chiefly light naphthas from refinery by-products and great quantities of natural gas from gasoline plants installed in the Magallanes oil and gas fields, located in the southern part of the American continent.

3. The need for replacing imports and the possibilities opened for some Chilean petrochemical products in LAFTA markets, through sectorial complementation agreements.

There are at present in the course of realization a market study for petrochemical products in the member countries of LAFTA and a technical and economic feasibility study of the most promising petrochemical complexes that could be implemented in Chile during the next six years.

These studies are being made on behalf of the Corporación de Fomento de la Producción (CORFO), a governmental autonomous agency in charge of economic development in Chile, and the Empresa Nacional del Petroleo (ENAP), CORFO's subsidiary in charge of oil production and refining in Chile.

On the basis of the preliminary conclusions of the above-mentioned studies, the implementation of the following petrochemical complexes could be envisaged in Chile between 1956 and 1970:

(a) An ethylene complex, based on light naphtha cracking, whose principal end-products would be high pressure polyethylene, polyvinyl chloride, vinyl acetate, alcohols and solvents.

(b) An aromatic complex, based on refinery reformate, whose end-products would be phthalic anhydride and polyester resins for fibre manufacture.

(c) An ammonia complex, based on natural gas, whose end-product would be anhydrous ammonia.

The total investment in the three complexes will amount to more than $ million, 50 per cent of which will come from local investors (CORFO, ENAP, and private capital), and the rest from foreign loans and investments.

Colombia [7/]

Colombia has begun an ambitious six-year programme of petrochemical development. At present, the petrochemical industry is composed of the following units:

1. Two fertilizer plants with a total capacity of [illegible] tons per year nitrogen, used totally in agriculture.

7/ For a review of petrochemical industry in Colombia [illegible].

1. A plant to produce cyclohexane.

2. Transformation plants for plastics.

Except natural gas for the production of ammonia, the other materials used, such as polyethylene, PVC, caprolactam, etc., are imported. In order to eliminate these imports, the government petroleum company of Colombia (ECOPETROL) has prepared a series of projects for the integration of the petrochemical industry in Colombia and the establishment of a basis for future expansion.

Ecuador[28]

Ecuador offers a typical example of a country faced with the problem of establishing chemical plants of an economical size. The internal demand is small and this fact has precluded the construction of this type of plant. However, the consuming population is growing at the rate of 3 per cent per year and is a good market for chemical products such as paints, detergents, fertilizers, polyethylene and other chemical products. This is the reason why the local authorities are optimistic about the initiation of petrochemical industries in the not too distant future.

It is relevant to mention that the export of fruits such as bananas represent a good market for plastic bags such as polyethylene bags.

Mexico[29]

Mexico is carrying out a very impressive petrochemical programme, with many plants in operation and many others in the construction stage. The success of the petrochemical industry in Mexico is partly attributed to collaboration between the public sector and investors from the private sector. In order to promote and regulate this collaboration, adequate legislation has been established. This legislation can be summarized as follows:

Article 27 of the Mexican Constitution allocates to Petróleos Mexicanos (PEMEX) the performing of the first chemical reaction or physical change of hydrocarbons, or petroleum derivatives. Thus, all the basic petrochemical products or raw materials must be manufactured by this company, operating in the public sector, while the transformation of the basic petrochemical raw materials into finished products for sale to consumers is left to the private sector.

In order to establish policy as far as petrochemical development is concerned and to determine the field of action of the public and the private sectors in the petrochemical industry, the Government has created the National Petrochemical Commission, which is composed of the Secretaría de Patrimonio Nacional, the Secretaría de Industria y Comercio, and Petróleos Mexicanos. The Petrochemical Commission studies the feasibility of petrochemical projects and grants concession for the construction and operation of petrochemical plants.

28/ La Industria Petroquímica en Ecuador (PET/CHEM/CONF.104).

29/ The Mexican Government and the Petrochemical Industry in Mexico (PET/CHEM/CONF.74).

Since its establishment in 1959, the Petrochemical [illegible] approximately forty permits to operate petrochemical plants [illegible]. In these petrochemical plants has been allocated among the public, mixed and private sector as follows:

	Millions of pesos
Petróleos Mexicanos (public sector)	[illegible]
Private investors and Petróleos Mexicanos (mixed sector)	[illegible]
Private investors (private sector)	[illegible]
Total	$3,546.9

The above investments have resulted in plants operating, or in construction for the following products: (1) ammonia and mixed fertilizers, (2) ethylene, (3) polyethylene, (4) ethylene oxide, (5) ethylchloride, (6) ethylene dichloride, (7) vinyl chloride, (8) urea, (9) ammonium sulphide, (10) dodecylbenzene and detergents, (11) butadiene, (12) styrene and polystyrene, (13) aromatics (benzene, ethyl benzene, toluene, xylenes), (14) cyclohexane, (15) carbon black, (16) SBR rubber, (17) acetaldehyde, (18) acetic anhydride, (19) acetic acid, (20) butyl, ethyl, and vinyl acetate, (21) methyl-ethyl-ketone, (22) polyester fibres, (23) nylon-6 and nylon-66, (24) methanol, formaldehyde, (25) acrylic resins, (26) polyamides, (27) phthalic anhydride, (28) ethylene glycols, (29) ethanolamines, (30) caprolactam, (31) epoxy resins, (32) benzoic acid, (33) insecticides, and, (34) phenol.

Peru[30/]

Peru is considering petrochemical development mainly in fertilizer production. There exists at present a fertilizer plant and the Empresa Petrolera Fiscal, a government agency, has projects for the construction of two plants using natural gas as raw material.

These petrochemical plants are being considered within the framework of LAFTA, which could bring about a complementation of markets and permit the operation of large plants as part of a programme of economic integration.

Trinidad and Tobago[31/]

Trinidad and Tobago already possesses a large fertilizer industry dedicated almost exclusively to the export markets. In view of the availability of cheap raw materials, the establishment of further export industries is being promoted by means of incentives such as: the supply of land and services; tax and duty exemptions, etc.

Uruguay[32/]

The production value of the chemical industry, including petrochemistry, was estimated at $US33 million and consumption at $US64 million. Forecasts for the

30/ Petrochemical Industry - Peru (PET/CHEM/CONF.72).

31/ The Petrochemical Industry of Trinidad and Tobago (PET/CHEM/CONF.[illegible]).

32/ Country Study - Uruguay (PET/CHEM/CONF.133).

year 1/ indicate a consumption of chemical products of the order of $150 million.

The consumption of petrochemicals in the main chemicals areas is as follows:

Synthetic resins	15,000 tons/year
Synthetic fibres	1,000 " "
Rubber and carbon black	10,000 " "
Surface active agents	15,000 " "
Ammonia	15,000 " "

Notwithstanding the growth of consumption, the possibility of increasing the national supply is limited owing to the limited internal market. Therefore, the emphasis is on finding export possibilities by means of conventional methods or by utilizing the agreements on industrial complementation and general preference of the LAFTA.

Nevertheless, as far as fertilizers are concerned, there already exists a potential local market. The fertilizer market in Uruguay is as follows:

Nitrogen (N_2)	30,000 tons/year
Phosphorous (P_2O_5)	70,000 " "
Potassium (K_2O)	20,000 " "

This is being partly supplied from local production, and plans are being made for the total supply of fertilizers from domestic production.

Venezuela 2/

Venezuela, the largest producer of oil in Latin America, as yet produces only fertilizers and carbon black among the main petrochemicals. Since raw materials, utilities and capital are available, a large-scale plan is being prepared for the development of an integrated petrochemical industry; as the first step, an olefins complex is being studied for the eventual production of synthetic rubber, plastics, detergents and other derivatives.

Although the basic raw materials will be produced by the Instituto Venezolano de Petroquímica, a government agency, the creation of mixed companies is being promoted for the large variety of possible end-products.

2/ Venezuelan Petrochemical Industry (PET/CHEM/DOC.42).

VI. REGIONAL DEVELOPMENT

(Agenda item VI)

1. Asia and the Far East

In reviewing the development of the petrochemical industry in the ECAFE region, 1/ it was mentioned that the consumption in this region of petrochemical products, such as nitrogen fertilizers, plastics and synthetic resins, non-cellulosic man-made fibres, and synthetic rubbers, has shown high rates of growth. Between 1953-54 and 1960-61, the annual rate of growth for nitrogen fertilizers was 7 per cent. Between 1960-63, the annual rate of growth for plastics and synthetic resins was 21 per cent, that of non-cellulosic man-made fibres 26 per cent, and that of synthetic rubbers 23 per cent.

The production of petrochemical products in the region has also grown at rapid rates. Between 1960 and 1963, the annual rate of growth for nitrogen fertilizers was 14.5 per cent, that of plastic and synthetic resins 34 per cent, that of non-cellulosic man-made fibres 26 per cent, and of synthetic rubbers 63 per cent.

Both the production and consumption of petrochemical products, however, are still mostly concentrated in Japan.

The ECAFE region has been a net importer of nitrogen fertilizers, plastics and synthetic resins, and synthetic rubbers. It was a net exporter of non-cellulosic man-made fibres. Japan is the only exporter of non-cellulosic man-made fibres in the region.

The ECAFE region is characterized by very low levels of consumption and production of petrochemical products, with potentials for expanding both consumption and production. In 1961, the per capita consumption of nitrogen fertilizers in the region was 1.4 kilogrammes compared with 14.9 kilogrammes in the United States, 18.5 kilogrammes in the European Economic Community (EEC), 3.7 kilogrammes in the European Free Trade Association (EFTA), and 3.5 kilogrammes in the Soviet Union, in terms of nitrogen. For plastics and synthetic resins, it was 0.36 kilogrammes in the ECAFE region as against 14.4 kilogrammes in the United States, 3.7 kilogrammes in EEC and 8.86 kilogrammes in EFTA. For non-cellulosic man-made fibres, it was only 0.16 kilogrammes in the ECAFE region, compared with 4.7 kilogrammes in the United States, 1.04 kilogrammes in EFTA, and 0.9 kilogrammes in the EEC.

On the production side, the per capita production of nitrogen fertilizers in the region was 1.3 kilogrammes compared with about 14.9 kilogrammes in the United States, 18.7 kilogrammes in EEC, and 11.7 kilogrammes in EFTA, in terms of nitrogen. For plastics and synthetic resins also, it was only 0.81 kilogrammes in the ECAFE region, compared with 11.5 kilogrammes in EEC, and 9.4 kilogrammes in EFTA. Per capita production of non-cellulosic man-made fibres was

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1/ Development of the Petrochemical Industry in the ECAFE Region (PET/CHEM/CONF.6/1).

0.17 kilogrammes in the ECAFE region, compared with 1.86 kilogrammes in the United States, 1.03 kilogrammes in the EEC, and 0.87 kilogrammes in EFTA.

There are various factors which impede the growth of petrochemical industr in the countries of the ECAFE region. Factors responsible for the slow growth the fertilizer industry were brought out at the recent United Nations Conferenc on the Development of the Fertilizer Industry in Asia and the Far East which wa held at Bombay, India, in 1963. Price relationship between the crops and the fertilizers, non-availability of credit, lack of adequate distribution faciliti and inadequate measures for promotion of fertilizer use were considered to be the factors responsible for the low level of consumption in most countries of the region. The slow growth of the industry is due to the shortage of foreign exchange, lack of know-how, shortage of trained personnel and an under-develope infra-structure.

The basic obstacle to the development of an integrated petrochemical industry is the limited market in most countries of the region for the major petrochemical products, such as plastics and synthetic resins, non-cellulosic man-made fibres and synthetic rubbers.

Although India, Iran and Pakistan are actually to establish petrochemical complexes in their countries, there are at present only two countries in the ECAFE region, namely Japan and Australia, which have developed a petrochemical industry.

The major problem faced by these two countries is the keen competition fro overseas suppliers which have solid advantages of size, technology, access to cheap raw materials, and highly efficient financial and organizational structur

In Australia, with the elimination of import licensing, the local chemical industry, including the petrochemical industry, became vulnerable to dumping by overseas suppliers. Japan, which has attained international level in the petrochemical industry, has its own problems. The small size of production unit and the high price of naphtha, which is the basic material for the petrochemical industry in Japan, were listed as major problems. For example, the capacity of Japan's maximum unit of ethylene in 1964 was 120,000 tons per year, as against 250,000 tons in the United States, 200,000 tons in the United Kingdom, and 150,000 tons in the Federal Republic of Germany.

Price comparison of selected petrochemical products showed that in Japan, in 1962, the domestic price per kilogramme of polyethylene was about 58 cents compared with the imported price of about 51 cents, that of polystyrene about 69 cents compared with 36 cents, and that of SBR about 53 cents compared to about 48 cents for the imported product.

2. Africa

It was stated that the Economic Commission for Africa has been very active in the promotion of industries, including the chemical industry, in Africa. Taking into account the vastness of the African continent, ECA has divided the continent into four sub-regions, namely, North, West, East and Central, and branch offices of ECA have been opened in three of the above sub-regions. In this connexion, it was mentioned that with a view to promoting industrial

[illegible]elopment in the sub-re[illegible] [illegible], [illegible] industrial co-ordinati[illegible] [illegible]. [illegible] development of industries [illegible] basic chemicals, [illegible] petrochemicals, based on imported intermediates. [illegible] [illegible] in East Africa and Central Africa in the [illegible].

Some countries in Africa, especially [illegible] huge reserves of oil and natural gas, have already [illegible] for the development of petrochemical industries in their countries.

3. Europe

In reviewing the development of the petrochemical industry in Europe, [illegible] was stated that growth in Europe immediately after the Second World War was [illegible] than in the United States. The reconstruction problems which [illegible] during that period, the time-lag in technological progress, the policy of the oil companies in locating the refineries near the oil or natural gas reserves [illegible] adding transport costs to the heavy capital cost, and the existence of a [illegible] developed chemicals-from-coal industry which was then [illegible] the existence of rich coal resources, were cited as factors responsible for the slower growth in Europe. At the end of the Second World War, nearly all European countries were still dependent for their organic chemical products on coal and raw materials of vegetable origin. After modest and sporadic beginnings, the petrochemical industry has made great strides in Western Europe in the last decade. Production registered an almost eightfold increase during the period [illegible], and investment has been estimated to reach $3 billion in [illegible]. Increases in the fields of plastics, synthetic rubbers and synthetic fibres were significant.

Although refinery gases and natural gas form the most important source of raw material in the United States, naphtha would be the major raw material for the petrochemical industry in Europe.

From the experience of the European countries, it is evident that there is a close interrelationship between the development of the petrochemical industry and industrial development and technological progress. In fact, the most rapid growth in the petrochemical industry has taken place in the highly industrialized countries and it is only now that less industrialized countries, such as Spain, Portugal and Greece, are beginning to build their petrochemical plants.

As regards the structure of the European petrochemical industry, there is a strong tendency towards vertical integration to provide for [illegible] and to ensure adequate sources of raw materials as well as outlets for sales.

There is also a considerable concentration of capital in the most important producer countries of Europe, to support the heavy investment necessary not only for fixed assets but also for the research required to keep pace with technological progress. In the Federal Republic of Germany, for instance, [illegible] per cent of petrochemical production comes from only five companies, [illegible] oil companies; in the United Kingdom, about [illegible] per cent is in the hands of [illegible] major enterprise; in Italy, the industry is largely [illegible]

_/ Development of the Petrochemical Industry in Europe [illegible] Potentialities (PET/CONF/[illegible]).

[illegible] even in France, where the [illegible] its apparent dispersal, most [illegible] basic [illegible].

[illegible] petrochemical industry has not reached a state [illegible] overcapacity in some areas, investments continue [illegible] present, and construction activity is high, the industry being considered the most promising sector [illegible].

4. Latin America

[illegible] petrochemical plants were already established in the [illegible] many years ago, it was only after the Second World War that the petrochemical industry in Latin America really got started, trying to supply [illegible] markets.

[illegible] the present situation of the petrochemical industry in Latin [illegible] it can be said that because of the limitations in market size and the [illegible] expected, there are relatively few plants in the region.

[illegible] favour the installation of complexes or groups of [illegible] treatment with of production in one site. Examples were [illegible] Argentina and Brazil.

[illegible] of the industry in Latin America is characterized by the [illegible] of products in state enterprises and foreign ventures.

[illegible] the raw materials for the petrochemical industry, in [illegible] the exception of natural gas has been growing steadily [illegible] have been extracted. In other countries of the region, [illegible] sources of natural gas, high proportions of the gas are still being [illegible] according to different patterns of utilization. Oil reserves account for [illegible] and amount to 4.11 billion m^3.

[illegible] capacity of Latin America in 1963 was 2.5 mm bbls per day, of [illegible] per cent [illegible] the refineries existing in seven countries. The [illegible] amount of refinery products in all Latin America is [illegible].

[illegible] oil that is now refined can be considered from the point of view [illegible] raw materials, because of the existence of distilleries of [illegible] in a number of countries, dispersed over wide areas.

[illegible] have taken this into account and a number of countries [illegible] refining [illegible] and bigger units, especially for catalytic cracking [illegible] strong. As in some cases, special steam cracking units will be [illegible], especially where there are no refining facilities or supplies of [illegible]. Steam cracking is already being installed at present in Mexico and [illegible].

[illegible] Latina (PET/CHEM/CONF.120).

Consumption f[illegible] petrochemicals for 1[illegible]. [illegible] to be absorbed by Argentina, Brazil, [illegible] growth will be plastics, [illegible]. Special attention is [illegible] expected that in 1970 Latin [illegible] of nitrogenous fertilizers.

With reference to the petr[illegible], according to ECLA studies, almost two-thirds [illegible] corresponds to sectors of the industry p[illegible] such as paints, cosmetics, f[illegible].

In the last decade an accelerated [illegible] in chemical consumer goods took place, but [illegible] of this stage, emphasis must now be transferred t[illegible] to produce the primary and intermediate materials [illegible] rates of growth.

It is in this respect that the petr[illegible] play a very important role, and it can be expected that [illegible] the main area of development in the chemical [illegible].

Financial aspects

The role of international oil and chemical companies

The petrochemical industry is highly capital-intensive, both in terms of initial outlay and the necessary amount of working capital, and is typically subject to large economies of scale.

International oil and chemical companies constitute the major world producers of petrochemical products. The chemical companies' share in petrochemicals, both from the sales and from the investment points of view, is much higher than the oil companies'. The chemical and the oil industries in the United States are comparatively very profitable. They are financially very powerful and have only limited advantage of credit availability. Long-term indebtedness makes up a predominant portion of total debt, indicating that outside financing is used only when necessary for long-term plans (typically, capital expenditures of a large nature); and, finally, the working capital requirements, although not significantly greater than those for other capital-intensive industries, are at a high absolute level, and are higher than those for labour-intensive industries. 1/

The oil side of petrochemicals is, as a rule, more conservative in its spending plans than the chemical side. For example, petroleum companies in the United States have allotted [illegible] per cent of their [illegible] plant and equipment spending plans to replacement and modernization, while chemical companies have earmarked more than [illegible] per cent of their total capital spending for additional capacity. The gross yearly capital expenditures of the world petroleum industry (excluding exploration expenses) have averaged between [illegible] and [illegible] [illegible] million, [illegible] $1,[illegible] million of which [illegible] per cent has been allotted to investment in refineries and chemical plants.

As in the oil industry, United States chemical firms hold an unchallengeable supremacy as far as financial resources and market penetration potential are concerned, while European firms tend to participate in [illegible] ventures mainly at the commercial and technical level.

As regards the geographical distribution of United States chemical investments overseas, a greater dispersion may be noted than that existing in foreign investment of United States oil companies. [illegible] per cent of total foreign [illegible] in 1965 were in Great Britain, [illegible] per cent in Canada, [illegible] per cent in Western Europe, and [illegible] per cent in the rest of the world. Thus the [illegible]

1/ Financing of Petrochemical Industry in Developing Countries, [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] joint ventures, although [illegible] foreign partners after the new [illegible] companies favourable to joint ventures but prefer [illegible] other industrialized countries.

State companies like ENI in Italy and ERP in France are favourable to entering into joint arrangements with other state enterprises abroad and seek participation by local governments.

As a rule, British and [illegible] German companies are better disposed towards joint ventures than their American counterparts. However, it is the smaller capital exporting countries, notably Japan and Italy, which have the strongest preference for this type of investment. Also they [illegible] are licensing and technical assistance agreements, even those not requiring capital participation by the foreign firms. This is probably a result of having more limited financial resources. The explanation is even more valid in the context of petrochemical investment which implies very heavy capital outlays.

It is possible to identify a recent trend towards an increasing importance of joint ventures in developing countries, coupled with a rising tendency to shift to minority involvement on the part of the foreign investors. Among the developing countries, [illegible] is the area in which joint ventures constitute the [illegible] form of foreign investments. [illegible]

Joint ventures are generally predominant in those fields of manufacturing, especially the newer activities, which require extensive funds and technical know-how; petrochemical industries, in general, would fall within this category. Participation by the local capital market has so far been scanty, owing to the underdeveloped [illegible] of the capital market in developing countries, but the situation has been improving in parallel with the development of financial institutions and capital market mechanisms.

Joint ventures tend to be preferred by developing countries because they permit local capital to participate in the benefits of economic development, promote a faster transmission of technical and managerial know-how, and lessen the danger of foreign economic domination.

It is sometimes argued that these options are, to some extent, in contrast with the goal of maximization of foreign capital inflow in those cases where local savings could have found alternative areas of productive employment and that the requirement of local participation would have the effect of reducing the inflow of foreign capital [illegible] local capital. [illegible]

[illegible] general, the investments of industrial [illegible] with regard to joint ventures abroad [illegible] and host country acceptance of joint ventures [illegible] by the following reasons:

1. The provision of management skills and the [illegible]

2. [illegible] stronger marketing position;

3. The improvement of relations with the Government and the public.

The additional motives of saving capital and reducing business risks are usually valid only for joint ventures in other developed countries.

As for the already mentioned trend towards a shift to minority foreign participation, some companies in industrialized countries feel that majority holding of an enterprise abroad implies the loss of those fiscal and public relations advantages which are derived from a local identification of the venture.

The relative number of joint ventures in petrochemicals is higher than in other industries. Although part of the discrepancy is to be attributed to a recent general shift towards this form of investment, there is little doubt that the explanation also lies in the high degree of suitability of joint arrangements owing to the characteristics of petrochemical projects. Analysis of the forms of ownership of petrochemical projects in developing countries as of [illegible] showed that [illegible] per cent of foreign investments in all groups was in the form of joint local-foreign ventures ([illegible] projects out of [illegible] classified private ones). The percentage was relatively higher in Asia ([illegible] per cent) than in Latin America ([illegible] per cent), and no participation of local capital in foreign enterprises existed in Africa at that time. 1/

Wholly foreign ventures constituted [illegible] per cent of all classified private ventures. They were relatively less important in Asia ([illegible] per cent) than in Latin America ([illegible] per cent). The proportion of wholly local ventures was, instead, similar in both regions: [illegible] per cent in Asia, [illegible] per cent in Latin America. Oil companies sponsored [illegible] out of the sixty [illegible] projects classified ([illegible] per cent) and chemical companies [illegible] projects ([illegible] per cent). Oil companies were relatively more active in Asia than in Latin America.

Government and/or government-associated projects constituted [illegible] per cent of all classified projects. The proportion was relatively much higher in Asia ([illegible] per cent) than in Latin America ([illegible] per cent) despite the extensive activities of [illegible] in the latter [illegible].

The greater frequency of joint international ventures in Asia is not to be explained by a higher preference of foreign investors for this form of venture in Asia; on the contrary, oil companies, generally, [illegible] ventures, sponsor a relatively greater number of projects in Asia. [illegible] explain the finding as a result of national governments' [illegible]. The other [illegible] is taken as [illegible] for the [illegible] number of wholly foreign [illegible] projects in Asia as compared with Latin America.

1/ Analysis of Petrochemical Projects in Developing Countries [illegible]

[illegible] state enterprises and national public intervention in the petrochemical [illegible] developing countries is very significant and there seems to be [illegible] to increase in importance.

[illegible] the distribution of projects has been analysed, not the distribution of the amount of capital invested, since joint arrangements prevail, especially in those projects which require greater capital outlays, the number of joint arrangements may be, if anything, an underestimation of the real importance and growth of the joint venture form of investment in the petrochemical industry.

In general, the ability of a petrochemical concern in a developing country to finance its own expansion out of retained earnings will be greatly influenced by the economic policy of the Government and by the purpose which underlay its establishment. Import substitution carries with it the corollary of the imposition of tariffs on the products previously imported; thus, internal prices will be above world prices of the products, and the concern may have a better chance to finance operations and expansions out of profits. On the other hand, export promotion implies keeping prices at the level of world prices, directly or indirectly, through the granting of easier credit terms to the purchaser, and self-financing will be correspondingly hampered if export subsidies are not granted.

The case of Japan

The Japanese experience was presented as a case study of a country that was able, over a short period, to promote through financial and other measures a fast rate of development in the petrochemical industry. 5/ 6/ The significant growth of Japan's petrochemical industry began in July 1955 with the initiation of development plans by the Ministry of International Trade and Industry. The total investment in chemical industry till that time was only about $90 million, and within a decade the investment in petrochemicals rose to about $900 million; a further $[illegible] million is expected in 1964 and the annual rate of investment has increased significantly during recent years.

The total petrochemical sales represent about [illegible] per cent of all chemical sales [illegible] per cent of the petrochemical producers are engaged exclusively in this activity, the remainder being involved in other producing activities - petroleum refining, integrated organic chemicals, fertilizers and fibres. The petrochemicals output in 1963 was valued at $[illegible] million, with sales turnover relative to fixed assets investment of about 70 per cent.

Fourteen new companies, of which seven entered the field for the first time, were included in the first-term programme for the development of petrochemicals in 1956. In the last five years, twenty-four new enterprises were established, of which six were joint ventures with foreign manufacturers. The total number of joint ventures at the present time is about ten.

5/ [illegible] and Their Problems for Japan's Petrochemical Industry [illegible]

6/ [illegible] Major Issues in the Petrochemical Industry in Japan [illegible]

Of the total investment of $900 million, [illegible] million [illegible] the form of capital and capital surplus and the balance of [illegible] million (80 per cent) was borrowed, mostly in the form of loans. In comparison, the average for manufacturing industries in Japan was 30 per cent capital and 70 per cent borrowings.

The financing of new ventures still tends to rely heavily on current [illegible] although the relative share is declining as more and more internally generated resources become available from the thriving pace of growth of existing enterprises.

The Government of Japan encouraged the implementation of the first [illegible] programme for petrochemicals by providing treasury funds, principally through the Government-sponsored Japan Development Bank. Though this source of funds amounts on the average to only about 6 per cent of total investments, running as high as 10 to 15 per cent in individual cases, it was sufficient stimulus to bring about joint or co-operative financing in the form of loans from financial institutions such as the Industrial Bank of Japan, Long-Term Credit Bank, etc., in combination with commercial banks and trust banks. In addition, sizable investments were made by the Japan Life Insurance Syndicate. Although the relative role of Government-sponsored funds has tended to decrease in recent years, once the initial objective of launching the new industry was more or less achieved, this source of funds is expected to continue to be available on a more strict selection basis.

The raising of funds in overseas capital markets for petrochemical development has assumed increasing importance in recent years, particularly in view of the somewhat tight domestic capital market. The growth potential of the industry, the quality of the available technical resources and the world-wide scope of marketing activities, have tended to attract foreign funds.

Out of the $900 million invested in petrochemicals, $132 million was of foreign origin, most of which was used for facilities and fixed assets. Actual foreign investment was about $50 million, representing $20 million in know-how subscribed as capital, $10 million in cash subscriptions and $20 million in loan form. The structure of investment in the Japanese petrochemical industry is shown in the table below. Joint venture companies with foreign participants who, as shareholders, must hold less than 50 per cent of the voting rights, require governmental approval. Separate government authorization is required for converting know-how into non-cash share subscription, and as in the case of normal fees and royalties, taxes are imposed on all such payments.

Japanese petrochemical industry investment pattern
1955-1963

	$ Million	%
Japanese owned capital	180	20
Financed by Japan Development Bank	50	6
Non-governmental co-operative financing	590	65
Financed by Life Insurance Syndicate	30	3
Foreign investment	50	6
	900	100

In relation to other major industries in Japan, petrochemical development depends less on the securities market, i.e. stocks and bonds, and relies much more on borrowings. The major stockholders are corporations and financial institutions and only a few petrochemical companies offer stocks on the open market. About 30 per cent of all the bond issues in the country are held by financial institutions and these issues are mainly government guaranteed bonds, municipal bonds, power and other utility bonds. Consequently, it has continued to be difficult for petrochemical companies to issue new bonds.

Thus the tendency has been for loans and internally generated resources to provide the principal sources of funds for petrochemical ventures. In order to encourage more utilization of internally generated resources, the petrochemical industry has been allowed liberal depreciation schedules, a fact which also reflects the need to depreciate the assets relatively rapidly in view of the inherent high rate of obsolescence of the technologies involved in petrochemicals.

2. Patents and licences agreements

It is recognized that the available technology in the petrochemical field has been developed almost exclusively in the more industrialized countries and that in the course of implementing such industry in the developing countries, this technology will have to be transferred through one form or another of patent and licensing agreements.

The basis for any such agreements is the mutual recognition of the nature of the exclusive ownership of a new technology and the need to guarantee the owner that the time, money and effort invested in developing it will be protected from competition by initiators as soon as it becomes public knowledge.

The matter of concern to all, and particularly to the recipient developing countries, relates to assurances and measures for avoiding over-exploitation of the almost total technical and financial dependence of the developing countries on the transfer of an exclusive property.

In the transfer of technology by licensing agreements, essentially two forms of technical properties are involved. The first of these is commonly referred to as "patent" - an industrial property right confirmed by individual Governments by deed, for a fixed number of years, for making a product or using a process. This right lies not in the possession of the scientific or technical knowledge incorporated therein, but in the exclusive right to use, and exclude others from using, that knowledge.

The second form of property rights involves "know-how", "technical data" and similar technical knowledge resulting from the accumulated skills and experience of the owner. Such rights, which have commercial value in the adoption of new technology, are not defined by government deed or document as in the case of a patent.

Licensing agreements are concerned with defining the mutual rights and obligations between the licensee and licensor arising out of the proposed transfer of industrial property rights. It must be emphasized that the licensing of patent rights is determined solely by national laws and that these laws vary from country to country in the extent to which certain products or processes are eligible for patenting and the degree to which the patent owner may exercise his monopoly.

The provision of monopolistic power can lead to abuse and misuse of power such as price fixing, patent pooling, compulsory package licensing, which cannot be justified in the public interest. National patent laws are directed at the control of such restrictive practices.

It seems doubtful that the legal strength of patent laws in any particular country affect to any great extent the decision to obtain patents. The available data also seem to indicate that patent owners rarely resort to litigation to enforce their proprietory rights. For example, in the United States, the 500 largest corporations were on the average involved in less than two law suits per corporation during the period 1949-1958. The large disparity between the number of patents granted in developing countries relative to the industrialized countries, can probably be ascribed to the limited economic gains - there appears to be little interest in establishing a patent portfolio in a country where there is little likelihood of developing technical potentials for producing or using a product in the immediate future. This would be particularly applicable in the petrochemical field with its relatively high degree of technical obsolescence.

In any case, it is unlikely that a patent for petrochemical products or processes could be advantagecusly introduced into a developing country without the technical co-operation and collaboration, i.e. proprietary know-how, of the foreign licensor. This supply of know-how, particularly with reference to developing countries, could cover not only the establishment of the plant and putting it on the stream, but also assist in the operation in the initial years in the form of management contracts. The tendency to participate in licensing arrangements covering both the patent and the know-how is prevalent in the petrochemical industry in the industrialized countries. These may often include cross licensing involving third parties, thereby enabling the most up-to-date research and development efforts of competing organizations to be employed within a reasonably short time. Petrochemical technology is subject to rapid changes and there are pressures on the owners of proprietary knowledge to exploit this promptly, or else face the possibility of the process being outmoded and replaced by newer ones.

Although there may be wide variations in the actual format of a licence agreement, there are certain provisions that appear to be common. These include:

(a) Definition of processes, patent rights and proprietary knowledge;

(b) Exclusive or non-exclusive nature of licence;

(c) Provisions for exchange of technical information;

(d) Secrecy;

(e) Time factor;

(f) Royalties and compensations;

(g) Engineering services and assistance;

(h) Guarantees, warranties, liabilities and penalties;

(i) Arbitration, force majeure and assignability.

In the assessment and evaluation of proprietary technical processes, the licensee from the developing country should attempt an evaluation in terms of capital investment, operating requirements, product specification, royalty and compensation, status of process development, commercial application, prior record of licensor, services offered, etc.

The following case was presented as an illustration:

At the end of 1963, a United States company licensed a Japanese manufacturer to use the former's high-pressure polyethylene process. The agreement, essentially technical, is exclusive in character and is scheduled to last for a period of ten years. The mode of payment is as follows: the licensor is to receive a fixed licensing fee of $600,000 plus an engineering fee of $250,000; in addition, the company is to enjoy a continuing royalty of 2.5 per cent of sales on the first 15,000 tons sold, 2 per cent on the next 10,000, 1.75 per cent on the next 25,000 and 1.5 per cent on any amount sold over 50,000 tons. Finally, the licensee will contribute $250,000 annually for the next five years to the licensor's research fund. Since the contract applies to a 40,000 tons/year plant, the three components of total payment, fixed fees (licensing plus engineering), percentage royalty on sales, and research fund contribution have, in this case, about the same financial weight in the compensation of the licensing company.

The above-described case helps to grasp one relevant characteristic of licensing agreements in the petrochemical industry; given the fundamental importance of technology in the industry, such agreements entail a very sizable financial burden on the licensee.

Summary of discussion

It was brought to the attention of the Conference that the dilemma facing the developing countries in their efforts to produce petrochemicals is concerned with the justification of an investment decision and with the factors that affect the evaluation of a particular petrochemical project or group of projects. It is recognized that the yard-stick of commercial profitability is often used as a major guideline in evaluating projects. However, it was pointed out that in many developing countries such a yard-stick is not the only one that should be taken into account. The question is often asked whether the development of a petrochemic industry should be regarded as a self-evident and integral part of the process of industrialization, wherein conventional costs are more or less disregarded, particularly in the initial stages of the development of the industry. The discussion indicated that there were no clear-cut answers to this problem. For example, a simple evaluation on the basis of projected profits in the commercial sense will not take into account problems of a national character such as foreign currency shortages, unemployment, exploitation of natural resources, and the more dynamic consequences which result from the development of an industry, such as the spread of initiative, know-how, industrial skills, etc. On the other hand, profitability cannot be disregarded since losses place an unwanted burden on the economy of a country and, in this sense, it is immaterial how these losses are divided between, say, the producing company, the Government and the consumers.

For comparative purposes of commercial evaluation, the rate of return on total investment is as good a criterion as any other, but as has been pointed out earlier application of this criterion does not assign value to other factors that also contribute to the growth of a national economy and, furthermore, there are the

[illegible] ... feasible to [illegible] ... to be considered together with [illegible] ... the danger lies in the inherently [illegible] ... parisons. The application of a [illegible] ... [illegible] ... suggested by one representative [illegible] ... example, if labour is unemployed then the [illegible] ... lower than existing wage rates. Similarly, [illegible] ... shortages are of major importance, one would [illegible] ... higher exchange rate in the evaluating procedure. This [illegible] ... in terms of the net cost to the economy per unit of foreign exchange [illegible]. This is believed to be a better estimate of the real cost of [illegible] in a project and required to earn the [illegible] foreign exchange. The [illegible] cost, the more profitable the investment both in relation to import savings and export earnings.

It was generally agreed that the development of a petrochemical industry in a country capable of producing natural petroleum hydrocarbons or refinery [illegible] products, is basically a sound idea. For example, at the United Nations Conference on Trade and Development held in Geneva, it was concluded that developing countries must industrialize their economies if they wish to be able to finance imports which are essential for development. In such an event, the most suitable industries would naturally be those based on existing resources, such as crude oil, natural gas and refinery products, in the case of petrochemicals.

The discussion then centred on foreign exchange problems, the shortage of foreign currencies and exchange control. It is clear that investment decisions based solely on the net foreign exchange savings would not be the result of sound economic policies. But, to many developing countries with adverse balance of trade payments, the question of net foreign exchange savings necessarily plays an important role in their investment decisions. The import of finished goods involving an outflow of foreign exchange which many developing countries cannot afford, should be balanced against the possible domestic production of the particular products, even if they are to be produced at a higher local currency cost. One participant, however, had some doubts as to the real [illegible] of the economy of local production at a high cost as a means of saving foreign exchange, particularly in the petrochemical field.

There was some discussion as to whether public international sources of funds could be made available for developing petrochemical industries at lower interest rates than those currently available. In the private sector, the International Finance Corporation is by its charter prevented from providing loan funds at rates lower than those prevailing in the established capital markets. The question was raised whether public international funds should not be looked upon as needed for development of petrochemical industries in the same light as roads, dams, harbours and other infrastructure developments. No answer was possible at the [illegible] and it was suggested that the World Bank should be approached by interested [illegible].

With respect to patent and licensing agreements, one representative [illegible] about the experiences of licensees who were [illegible] petrochemical [illegible], [illegible] a [illegible] of [illegible] that may result [illegible] [illegible] begin, and whether this influenced the [illegible] [illegible]. [illegible], it was indicated that [illegible] [illegible]

[illegible] showed that there was little [illegible] It was also pointed out that there is a [illegible] in the equity of petrochemical ventur[illegible] are more interested in long-term [illegible] advantage.

[illegible] seemed to indicate that joint venture [illegible] in industrialized countries, have proved to be [illegible] countries, and have led to harmonious [illegible] between licensee and licensor.

[illegible] concerning the improvements developed by the [illegible] and the role of the licensee and licensor in any benefits [illegible] as a result of such improvement. It appears that much depends on the [illegible] and terms of the licence agreement. However, most such agreements [illegible] the two-way flow of information and improvements, and in many [illegible] benefits from any improvement effected by other [illegible].

[illegible] was noted as one of the problems faced by developing [illegible], namely the evaluation of the cost of a licence relative to the total [illegible] needed for a plant. While some measure of the relative cost may be [illegible] by comparing the offers of alternative licence vendors, much reliance will [illegible] to be placed on the reputation, prestige, experience and the good faith of a [illegible] vendor. Royalty rates do vary a great deal from process to process. They may be directly based on actual expenditure incurred in the development of the [illegible] technology appropriately amortized over a period of years, or on a [illegible] of the sales price of the products, or may be evaluated in terms of the [illegible] of the projected profits over the life of the licence agreement in the event that the licensor a joint venture partnership.

[illegible] was expressed on the following lines: in most developing [illegible] the agricultural sector, principally food production, plays an important [illegible] in the development plans. Fertilizers are considered necessary to increase [illegible] productivity and the aim of most developing countries is to make fertilizers [illegible] to the farmers at as low a cost as possible. This means that the capital [illegible] of fertilizer projects should be brought down to a minimum, the latter includin[illegible] royalty fees which must be paid to a licensor and should also be minimized. The [illegible] inquired whether the United Nations would be able to initiate the [illegible] of a procedure to evaluate such royalty fees, particularly for [illegible] manufacture. A number of representatives from developing countries [illegible] this view. It was pointed out that licensing is one of the important [illegible] in developing petrochemicals and that the transfer of technology to the [illegible] countries should be made at relatively low cost. It would, in fact, [illegible] a realistic means by which the industrialized countries could help the [illegible] countries.

VIII. LOCATI[illegible]

[illegible]

[illegible]ral aspects

In previous chapters an accou[illegible] lustries in the advanced countries [illegible] such industries in the developing [illegible] vious that a considerable expansion [illegible] ffing. To ensure that this development [illegible] is desirable that location factors [illegible] re established.

The major factors to be considered [illegible] the following:

1. The potential demand, [illegible]
2. The availability of [illegible]
3. The possibility of [illegible]
4. Markets and distribution [illegible]
5. Facilities for transport of [illegible]
6. Availability of facilities [illegible]
7. Prospects of expansion in the [illegible]
8. Availability of skilled [illegible]

In studying the factors determining [illegible] plant, availability of raw materials [illegible] it is preferable to locate the plant [illegible] however, liquid petroleum feedstock is [illegible] units near the principal market or [illegible] of course, would be one where raw material is [illegible] of a large market.

A recent tendency in the advanced [illegible] petrochemical industries near a large [illegible] weight of the product is thereby reduced [illegible] possible to set up units of comparable size [illegible] in a developing country. This is so, because [illegible] nitrogen to the farmer, is more important [illegible] difficulties and costs of transport dictate [illegible] refineries with capacity of the order of 2 [illegible] in a dispersed manner. This would itself [illegible] fertilizer or ethylene production that [illegible]

reason it may not be possible for developing countries to [illegible] synthesis with capacities of the order of [illegible] tons per stream per day [illegible] naphtha crackers for about 200,000 tons of ethylene per year, which are now regarded as the optimum in advanced countries. The actual size and location may have to be decided after drawing up an economic balance of the economies of large-scale operation and the lower delivered cost obtained by decentralization.

One of the most important petrochemical products is synthetic ammonia. The demand for nitrogenous fertilizers is increasing in all countries. There is also a trend in every country to make this basic chemical within the country, to the extent that it possesses the major raw material for the synthesis of ammonia, namely, natural gas or naphtha. One or both of these raw materials are available from natural sources in a number of developing countries, although in some countries petroleum naphtha is derived from refineries operating on imported petroleum crudes.

In selecting a site for a fertilizer factory, it is necessary to ensure that water to the extent of 20,000 gallons per day is available per daily ton of nitrogen capacity. It is also necessary to see that an adequate supply of water will be available when the capacity of the unit is doubled, or trebled, in time. If the steam reforming process is used for the production of synthesis gas for ammonia, the requirement of power from an external source is not large. The use of electrolytic hydrogen may be avoided in ammonia synthesis, unless there are special reasons for doing so. This is because, in the first place, electrolytic hydrogen is more expensive than hydrogen obtained from other sources. Also, a fertilizer factory based on electrolytic hydrogen ties up a large block of power, which is far more valuable for other industrial purposes, particularly in a developing country. The effluent from a fertilizer factory using hydrocarbon feedstocks contains materials that are harmful to human and cattle health. Such effluents must, therefore, be rendered harmless by biological or other treatments before they are discharged into a river stream or an estuary.

Satisfactory provision for water and effluent disposal is therefore essential in selecting a site for a fertilizer factory; the relative cost of transport of raw materials or finished products would be the other important factor that would have to be taken into account.

Among other petrochemicals, plastics, synthetic rubber and synthetic fibres are the most important for developing countries. In many of these countries some demand for plastics already exists. It is possible that such demand would increase considerably if local production was available, particularly in countries where, for instance, packing materials such as paperboard and tin-plate are not available locally. The three main plastics: polyethylene, PVC and polystyrene, require ethylene for their production. At the present time, units for the production of these plastics have been set up in some developing countries, with capacity as low as 5,000 tons a year. However, the ethylene is generally obtained from alcohol or other raw material rather than from a petrochemical source. If ethylene is derived from a petroleum source, it is much cheaper, particularly in the case of large-scale production. Some developing countries might find it profitable to make reciprocal arrangements whereby only one plastic is produced in each country to supply all others taking part in the agreement. Whenever a cracking plant is set up for production of ethylene from petroleum feedstocks, propylene, as well as higher olefins, are produced at the same time, and where the amount of propylene available is substantial and ammonia is also available in the same location,

[illegible] ... with its [illegible] it is possible [illegible] ... in the advanced countries, [illegible] ... by [illegible] ... would have to be [illegible] ... [illegible] of the case of synthetic rubber.

As far as labour is concerned, the fertilizer and other [illegible] industries are capital-intensive and require a high [illegible]. However, the number required is not large, and usually it is possible [illegible] personnel from existing industries such as [illegible] fabrication or [illegible] and train them for their new responsibilities by organizing [illegible] courses. It [illegible] be desirable to depute some engineers abroad for training in similar [illegible] during the period of fabrication and erection of imported and local plant and equipment. Machinery manufacturers are usually able to assist in making the necessary arrangements.

[illegible] Transportation techniques

Two of the papers read described the transport of liquid ammonia and ethylene produced in large units. 1/ 2/ It was mentioned that in Trinidad a unit for production of anhydrous ammonia has already been set up with a production capacity of the order of 250,000 tons and that very soon this capacity will be raised to [illegible],000 tons of ammonia per year. This large unit is being set up first in order to produce ammonia at a very low price for export. The ammonia is stored in tankers at atmospheric pressure and a temperature of minus 28° F. Special ships, as well as receiving terminals in the importing countries, are provided to ensure that individual shipments of 9,000 tons of ammonia can be made. It is claimed that this system will assist the developing countries to produce nitrogen fertilizers in a shorter time by importing ammonia and then using it either as ammonia or in the form of fertilizer compounds. The position is similar with respect to transport of liquid ethylene. It was stated that the transport cost of liquid ethylene decreases considerably when the total amount of ethylene transported to a single point increases from 10,000 to 50,000 tons a year. At the latter figure, the cost of handling per ton of ethylene is as low as $4 per ton. While in the case of such larger demand it would be more economic to produce such ethylene in a naphtha cracker, in the initial stages, where the requirement in a developing country is for small amounts of ethylene, it might be useful for such countries to import liquid ethylene. It was also mentioned that the advantage of transport of liquid ethylene increases with the distance that the liquid ethylene is transported.

Gas-based ammonia plants

In accordance with the above, it was suggested in one paper that gases associated with petroleum crudes that are now being flared in countries like Iran could be used for establishing an ammonia unit with a capacity of 1[illegible],000 tons or

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1/ The Economics of International Distribution of Anhydrous Ammonia (PET/CHEM/CONF.67).

2/ Ocean Transportation of Ethylene and Other Basic Intermediates for Petrochemicals (PET/CHEM/CONF.22).

[illegible] it would then be [illegible] to transport such ammonia to places like India at a delivered price lower than the cost of production in the importing countries. 3/ While it was considered that this would not provide an outlet for the entire volume of gases that are flared today in a single country like Iran, it might be one method of utilizing the gas. It was also claimed that not only would the cost of ammonia transported in this way be lower, but that there would be a foreign exchange saving on such imports. Against this view, it was pointed out that in a country like India, petroleum crudes are imported in order to feed refineries that are set up mainly for the production of kerosene, diesel oil and furnace oil with a light fraction that serves to supply motor gasoline as well as surplus naphtha. If kerosene, diesel oil and furnace oil were imported separately, they would cost much more than the crude from which they are produced in a refinery. Under such circumstances, the surplus naphtha has no foreign exchange cost. Therefore, any calculation which tended to show that it is cheaper in foreign exchange to import ammonia rather than make it from locally available surplus naphtha, is based on an erroneous assumption and it is therefore unlikely that a country which has a surplus of naphtha would be interested in importing ammonia, and thereby simultaneously increasing its problem of disposal of surplus naphtha.

Petrochemical complexes

The Conference had before it two papers which described petrochemical complexes developed in Japan and Mexico respectively. 4/ 5/ In the case of Japan, it was indicated how a unit started with a very low capacity for ethylene and was gradually converted into a unit with capacities comparable to those of the present day in advanced countries. It was also stated that although on looking back it would appear that the original unit was too small and therefore uneconomic in size, it had created the necessary preconditions for the subsequent building up of a larger petrochemical complex. The units established in Mexico also indicated how local requirements had been met by establishing these complexes. The general conclusion drawn from a study of these papers was that the concentration of several producing units in a well-planned petrochemical complex, sharing raw materials, infra-structure and overhead facilities, as well as the utilization of resulting by-products, tended to counteract the necessity of very large-scale capacity for economic production in a single petrochemical unit. Also, that the requirements for each country must be thoroughly evaluated before deciding on the size and the complexity of a petrochemical unit to be set up in a particular location.

Summary of discussion

Considerable discussion took place in the Conference about the possibility of establishing units with large capacity for production of ammonia at locations where natural gas or associated gas are available at a very low cost. In this respect, reference was made to the case of Trinidad where anhydrous ammonia plants

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3/ Developing the Petrochemical Potentials of North Africa and the Persian Gulf (PET/CHEM/CONF.64).

4/ Characteristics and Prospects of Petrochemical Industry - with an emphasis on the Yokkaichi Complex in Japan (PET/CHEM/CONF.98).

5/ Structure of Petrochemical Development in Mexico - Reynosa and Pajaritos Developments (PET/CHEM/CONF.76).

[illegible] been set up essentially for export. It is possible, however, that the [illegible] Trinidad and Kuwait will not be applicable generally. The success of ammonia manufacture in Trinidad is due largely to its location near a very large [illegible] consuming market of the United States. If similar [illegible] available elsewhere, or if it were possible to make [illegible] importing and exporting countries, ammonia units of large size could be [illegible] locations where low-priced hydrocarbon gas is available. However, it [illegible] in many developing countries foreign exchange requirements would be higher in the case of imported ammonia as against ammonia obtained from domestic production, where only a small portion of the cost of production would require foreign exchange. In some developing countries, there would be an additional problem since the existence of substantial refinery capacity set up to meet local needs for petroleum products, gives rise to a substantial naphtha surplus. In these circumstances, imports of ammonia would not only create a problem of disposal of the naphtha surplus but would also add to the problem of foreign exchange.

It was also stated that since the production of ammonia does not really provide an outlet for a large proportion of gases that are flared today in the Middle East and North Africa, some other solution must be found for the utilization of such gases. One such solution would be to use them to produce power at low cost and then to use the power for energy-intensive industries.

Another suggestion for establishing a petrochemical industry was made with respect to carbon black. Channel type carbon black is a product which requires large volumes of methane. Because of the wasteful use of methane in the production of carbon black, as well as constantly rising prices of natural gas in the United States, efforts are being made to substitute furnace black for carbon black. The flared gases could then be used for the production of channel black for export to other countries. Another possibility arises from the fact that in large refineries, such as Abadan in Iran, it is possible to recover sufficient amounts of o-xylene as well as isopentane from the refinery to justify the production of about 40,000 tons per year of polyisoprene synthetic rubber. It would probably be more profitable to establish petrochemical industries based on such raw materials in the first instance, rather than to consider the use of the methane fraction of flared gases.

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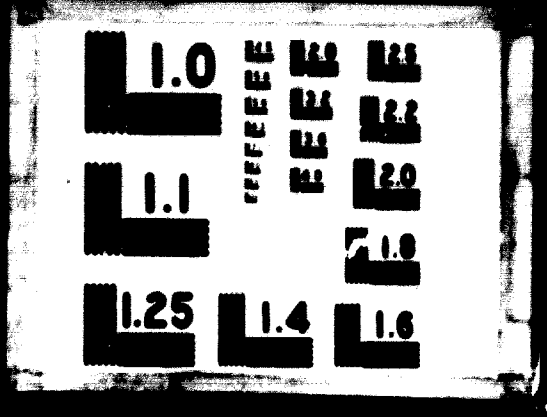

ANNEXES

ANNEX I

PROGRAMME OF THE CONFERENCE

Monday, 16 November 1964

10.00 Opening of the Conference

1. Conference declared open by Mr. S. Lurié, United Nations, Director of the Conference.
2. Message from His Imperial Majesty, Mohammad Reza Shah Pahlavi.
3. Opening address by His Excellency the Prime Minister of Iran, Mr. Hassam Ali Mansour.
4. Election of the Chairman of the Conference.
5. Address by the Chairman of the Conference, Dr. M. Eghbal.
6. Message from Dr. Victor Hoo, United Nations Commissioner for Technical Assistance.
7. Message from Mr. I.H. Abdel-Rahman, United Nations Commissioner for Industrial Development.
8. Address by Mr. S. Lurié, United Nations, Director of the Conference.

12.30 Adjournment

15.00 Item I. Characteristics of the petrochemical industry and prospects for its development

Conference Chairman: Dr. M. Eghbal, Iran

Discussion Leader: S. Teitel, United Nations Centre for Industrial Development

- Opening remarks

Rapporteur: Paulo Vieira Belotti, Brazil

Working papers:
PET/CHEM/CONF.

115.	General Characteristics of Petrochemical Industries and Factors Conditioning their Development	Centre for Industrial Development
85.	Petrochemical Industries - Section I	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole

33. Problems of Technology and Obsolescence in Petrochemical Industries for Developing Countries — R. Landau, Halcon International Inc.

Information Paper:

109. Petrochemical Developments — J.W. Woolcock, Imperial Chemical Industries Ltd.

Discussion

18.00 Adjournment

Tuesday, 17 November 1964

9.00 **Item II. Aspects of demand and supply of petrochemical products**

Chairman: Ahmed Abdul-Rahman Rifai, Kuwait

Discussion Leader: R. Abu El-Haj, United Nations Centre for Industrial Development

- Opening remarks

Rapporteur: Doddridge Henry Alleyne, Trinidad and Tobago

Working Papers:
PET/CHEM/CONF.

90. Recent Trends in Production, Consumption, Trade and End-Uses in Selected Petrochemical Products — United Nations Centre for Industrial Development

107. The Role of the Domestic Market in the Development of Petrochemical Industries and the Need for Exports in relation to Economies of Scale — United Nations Centre for Industrial Development

11. Recent Trends in the World Petrochemical Industry — F.N. Baumgartner, P.L. Richards, Esso Chemical Company Inc.

10. Market Research - Essential to Petrochemical Development — F.O. Kaupp, R.F. Neu, Esso Chemical Company Inc.

49. Synthetic Substitutes of Natural Materials through Petroleum Feedstocks — D.M. Trivedi, Synthetics and Chemicals Ltd.

Discussion

12.30 Adjournment

15.00 Item III. Recent trends in research and technology in the petrochemical industry

Chairman: Ranjit Rai Pahl, India

Discussion Leader: N. Beredjick, United Nations Centre for Industrial Development

- Opening remarks

Rapporteur: Abdul Rahman, Pakistan

Working Papers:
PET/CHEM/CONF.

60.	Recent Trends in Research and Development in the Petrochemical Industry	N. Beredjick, United Nations Centre for Industrial Development
7.	Recent Trends in Petrochemical Research and Development	Harold Hart Michigan State University
39.	Recent Trends of Petrochemistry in the Macromolecular Field	G. Natta, G. Crespi Industrial Chemistry Institute Polytechnic Institute of Milan
87.	New Trends in Research and Development of the USSR Petrochemical Industry	V.A. Khodakhovskaia Specialist on the Petrochemical Industry
18.	The Biosynthesis of Proteins from Petroleum	Alfred Champagnat Société Internationale de Recherches BP
134.	Training of Manpower	A.E. Laurence UNESCO

Information Paper:

82.	Petrochemistry and Polymer Production	S.M. Atlas, H.F. Mark Polytechnic Institute of Brooklyn

Discussion

18.00 Adjournment

Wednesday, 18 November 1964

Item IV. Industry studies

9.00 **IV-1. Raw materials and basic intermediates**

Chairman: Vojno Dizdar, Yugoslavia

Discussion Leader: Harold Hart, United Nations Consultant

- Opening remarks

Rapporteur: Mehmet Hayrettin Bezmen, Turkey

Working Papers:
PET/CHEM/CONF.

38.	Natural Gas as a Raw Material for Petrochemicals	F.B. Korsmeyer Mobil Chemical Company

19.	Petrochemicals from Natural Gas - the Lacq Experience	Pierre M. Husson Société Nationale des Pétroles d'Aquitaine
41.	Use of Natural Gas and Natural Gas Petrochemical Feedstock	B.L. Bates, R.G. Boatright Phillips Petroleum Co.
15.	Naphtha Steam Cracking and Utilization of Products	S. Hayashi and Y. Hirakawa Nippon Petrochemicals Co. Ltd.
73.	Production of Basic Petrochemicals from Heavy Oils via the H-Oil Process	A.R. Johnson, S.W. Ehrlich Hydrocarbon Research Inc.
119.	The Economics of Coal-Chemistry vs. Petrochemistry	E.W. Nagelstein United Nations Special Fund

Information Papers:

	Utilization of Natural Gas in Petrochemical and Other Industries	United Nations Centre for Industrial Development
126.	Natural Gas in Kuwait and its Utilization	Feisal Mazidi Kuwait Chemical Fertilizer Co.

Discussion

12.30 Adjournment

15.00 Working Papers (continued):

86.	Basic Products or First-Generation Petrochemicals (I.F.P. Section II, Chapters I, II, III, IV.1 to IV.4.3)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
31.	Modern Methods for the Production of Paraffins, Olefins and Aromatics	K.H. Eisenlohr Lurgi Gesellschaft für Mineralölteknik mbH
91.	Application of Advanced Technology to Developing Countries for Basic Petrochemical Intermediates	H.R. Shawk, L.L. Caldwell The Lummus Company
5.	Economics of Olefin and Diolefin Production	R.G. Craig, L.C. Doelp, A.K. Logwinuk Houdry Process and Chemical Co.
111.	Production of Ethylenic Hydrocarbons by Cyclic Cracking	A. Roche Office National Industriel de l'Azote
35.	Technical and Economic Changes in Ethylene Manufacture	P. Braber Bataafse Internationale Chemie Mij, N.V. (Royal Dutch/Shell Group)

Information Paper:

103.	Olefins vs. Acetylene - Competitive Raw Materials for the Petrochemical Industries in Developing Countries	D.F. Othmer Polytechnic Institute of Brooklyn

Discussion

18.00 Adjournment

Thursday, 19 November 1964

9.00 Item IV-1. Raw materials and basic intermediates (continued)

Chairman: Mustapha Tala, Morocco

Discussion Leader: A. Brodowski, United Nations Consultant

- Opening remarks

Rapporteur: Fernando Sanchez, Mexico

Working Papers:
PET/CHEM/CONF.

28.	Aromatics: Better to Import or to Produce	J.W. Andrews, R.E. Conser Universal Oil Products
6.	Benzene by Hydrodealkylation using the Detol Process	R.G. Craig, L.C. Doelp, A.K. Logwinuk Houdry Process and Chemical Co.
99.	Production of Aromatics from Petroleum in Japan	Isaburo Watanabo Japan Gasoline Co. Ltd.
89.	Optimum Combination of Petroleum Refining and Petroleum Chemistry Processes	R.G. Ismailov Azerbaijan Academy of Sciences
112.	Hydrocarbous Steam Reforming in Tubes, for Production of Synthesis Gas or Hydrogen	M. Roche Office National Industriel de l'Azote
125.	Natural and Synthetic Alcohol as Competitive Raw Materials (an example of a Low Capacity Outlet)	M. Magnat Groupe Centrale de Dynamite Nobel-Bozel
4.	Selected Processes for the Production of Basic Chemicals and Intermediates from Petroleum Hydrocarbons	H. Sönksen, BASF H.K. Kamptner, Farbwerke Hoescht J.P. Pelizaeus, Bayer S.A.H. Wetter, Chemische Werke Hüls W. Munde, Verband der Chemischen Industrie

Discussion

12.30 Adjournment

- No Afternoon Session

Saturday, 21 November 1964

9.00 **Item IV-2. Nitrogenous fertilizers**

Chairman: Carlos Vanrell, Uruguay

Discussion Leader: Alan S. Manne, United Nations Consultant
- Opening remarks

Rapporteur: Ion Ghejan, Romania

Working Papers:
PET/CHEM/CONF.

86.	**Nitrogen Fertilizers (I.F.P. Section II, Chap. V.5)**	**Prepared** for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
93.	**Ammonia Manufacture from Petroleum Feedstocks**	A. de Picciotto, D.C. Sweeney Jr. Arthur D. Little, Inc.
37.	**Nitrogenous Fertilizers as a Petrochemical Operation**	R.M. Reed, C.R. Sloan Girdler Corporation
3.	**Economics of Ammonia Production in the Developing Countries**	S. Strelzoff Chemical Construction Corp.

Information Paper:

80.	**Processes for the Production of Concentrated Fertilizers**	H. Banthien Hoechst-Uhde International GmbH

Discussion

12.30 **Adjournment**

15.00 **Working Papers (continued):**

102.	**Plant Size, Location and Time Phasing - The Nitrogenous Fertilizer Industry**	P.N. Radha Krishnan, Perspective Planning Division T.V.S. Rama Mohan Rao, Indian Statistical Institute Alan S. Manne, M.I.T. Centre for International Studies
56.	**Recent Trends of Ammonia Industry in Japan**	S. Kodama Sumitomo Chemical Co. Ltd.
63.	**Realization of Fertilizer Production in a Developing Country**	J. Ayllon V., J. Otero R. Y.P.F.B. La Paz L.C. Axelrod, L.E. Postwick, B.G. Mandelil. The M.W. Kellogg Company
75.	**Natural Gas Reserves in Mexico as a Factor of the Social and Economic Development of the Country by means of Nitrogenous Compounds**	Petróleos Mexicanos

Information Papers:

	Nitrogenous Fertilizers based on Natural Gas. (ST/ECA/75 - Sales No. 63.II.B.3)	United Nations Centre for Industrial Development
50.	Technical and Economic Aspects of the Fertilizer Industry in Pakistan	Y.N. Kanaan Chemical Engineer

Discussion

18.00 Adjournment

Sunday, 22 November 1964

9.00 **Item IV-3. Plastic materials**

Chairman: Ranjit Rai Bahl, India

Discussion Leader: N. Beredjick, United Nations Centre for Industrial Development

- Opening remarks

Rapporteur: Juan Tampier, Chile

Working Papers:
PET/CHEM/CONF.

86.	Polyethylene and other Polyolefins, PVC and other Vinyl Polymers - Polystyrene (I.F.P. Section II, Chapters: III.1, V.1 to V.1.3.D, VI.1. to VI.4.2)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
20.	Low Density Polyethylene - The World Market	K.E. Cosslett U.S. Industrial Chemicals Co.
53.	Mono and Polyvinyl Chloride	R.A. Brown, H.A. Huckins Scientific Design Co. Inc.
97.	New Vinyl Chloride Process	S. Gomi Kureha Chemical Industry Co. Ltd.
17.	Styrene Resins for Petrochemical Growth	P. Sherwood R.G. Edmonds, The Badger Company
58.	Acrylonitrile-Butadiene-Styrene Copolymers	T.E. Ronay Marbon Chemical Co. Division of Borg Warner Corp.
14.	Refining and Petrochemical Production by the Cosden Oil and Chemical Company	Jerry G. Jenkins Cosden Oil and Chemical Company

Discussion

12.30 Adjournment

15.00 Working Papers (continued):

34.	Nylon	Lewis F. Hatch University of Texas
59.	Growth of Plastics in Developing Countries	B.S. Garud, S.K. Subbaroyan, F. Vachani Delhi Cloth and General Mills Co. Ltd.
81.	Plastics Progress	J.M. Goppel Shell International Research Mij, N.V.
40.	Plastics as Construction Materials for Developing Countries	Arthur P. Lien Battelle Memorial Institute

Information Paper:

88.	Applications of Petrochemical Based Plastics in Developing Countries	A. Griff Edicon Technical Services Inc.

Discussion

Item IV-4. Synthetic rubbers

Chairman: Ranjit Rai Bahl, India

Discussion Leader: Nicky Beredjick, United Nations Centre for Industrial Development

Rapporteur: Edno Oliveira Maia Brandão, Brazil

Working Papers:
PET/CHEM/CONF.

86.	Synthetic Rubbers: SBR, Butyl-Rubber, Stereo-Rubbers: Poly-isoprene, Polybutadiene (I.F.P. Section II, Chapters: III.3, V.3 to V.3.2.E)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
52.	The Newer Synthetic Rubbers	Tuhin K. Roy Scientific Design Co.

Information Paper:

71.	Synthetic Rubber - as related to Petrochemical Production in Developing Countries	D.F. Othmer Polytechnic Institute of Brooklyn

Discussion

18.00 Adjournment

Monday, 23 November 1964

9.00 Item IV-5. Synthetic fibres

Chairman: Vojno Dizdar, Yugoslavia

Discussion Leader: Lewis F. Hatch, University of Texas

- Opening remarks

Rapporteur: Lim Ho-Pheng, Malaysia

Working Papers:
PET/CHEM/CONF.

86.	Synthetic Fibres: Nylon, Acrylics, Polyesters (I.F.P. Section II, Chapters: III.2., V.2 to V.2.5.C)	Prepared by the United Nations Centre for Industrial Development by the Institut Français du Pétrole
13.	The Production of Synthetic Fibres on a Petrochemical Basis	P. Seifert Inventa AG
57.	Polyester Synthetic Fibre Materials for Developing Countries	David Brown Halcon International Inc.
113.	Contribution to the Manufacture of Polyester Fibres	Antar - Pétroles de l'Atlantique
27.	From Crude Oil to Synthetic Fibres with special consideration of Process Sequence for Polyester Type Fibres	D. Natus Lurgi Gesellschaft für Mineralöl-technik mbH
54.	Development of a Synthetic Fibre Industry, as for example Nylon-6, in Developing Countries	F. Thormann Hoechst-Uhde International GmbH

Discussion

12.30 Adjournment

15.00 Working Papers (continued):

84.	Synthetic Fibres of Polyamides	J. Laub Hans J. Zimmer AG
16.	Methods for the Preparation of Caprolactam and the Synthesis of Lysine from Caprolactam	L.J. Revallier Central Laboratory of Staatsmijnen
51.	Acrylic Fibres	Y. Tsunoda Asahi Chemical Industry Co. Ltd.
43.	Experiences Acquired during a Study for an Acrylonitrile Plant	Mario Galán-Gómez Empresa Colombiana de Petróleos (Ecopetrol)

Discussion

Item IV-6. Selected end-products

Chairman: Vojno Dizdar, Yugoslavia

Discussion Leader: A.P. Lien, Battelle Memorial Institute

- Opening remarks

Rapporteur: Issa Ibrahim Habbash, Saudi Arabia

Working Papers:

86.	Sulphur Production (I.F.P. Section II, Chapter IV.8)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
83.	Petroleum - A Major Source of Sulphur	Gino P. Giusti Texas Gulf Sulphur Co.
86.	Carbon Black Production (I.F.P. Section II, Chapter IV.7)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
36.	Carbon Black Production in Developing Countries	C.A. Polachi, C.A. Stokes, K.A. Burgess Columbian Carbon Company
86.	Detergents (I.F.P. Section II, Chapters III.4; V.4 to V.4.3.C)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
86.	Methanol Production (I.F.P. Section II, Chapter IV.6)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
114.	Contribution of Petrochemistry to Protection of Cultivated Lands	A. Charlet Société Progil

Information Paper:

9.	Multipurpose Reactor for the Production of Selected Petrochemical Intermediates and End-Products	John B. Sproull Wica Chemicals Inc.

Discussion

18.00 Adjournment

Tuesday, 24 November 1964

9.00 Item V. Country studies

North Africa and Middle East

Chairman: Ahmed Abdul-Rahman Rifai, Kuwait

Discussion Leader: H.K. Nieuwenhuis, United Nations Consultant

- Opening remarks

Rapporteur: Abdul Aziz Shnaber, Saudi Arabia

Working Papers:
PET/CHEM/CONF.

121.	Libya	B. Mangush

127.	Morocco	Mustapha Tala
128.	United Arab Republic	Mohamed El-Halfawy
129.	Saudi Arabia	Issa I. Habbash
78.	Syria	Yassine Tabaa, Hicham El-Aass

Europe

Chairman: Mustapha Tala, Morocco

Discussion Leader: N.P. Fedorenko, United Nations Consultant

Rapporteur: Rossana Gattoni-Celli, Economic Commission for Europe

Working Papers:

77.	Turkey	Hayrettin Bezmen
110.	Israel	J.C. Löbel, B. Toren
92.	Yugoslavia	V. Dizdar, C. Jenic, K. Mirkov
61.	USSR	N.P. Fedorenko
30.	Poland	K. Laidler
130.	Romania	I. Marinescu

Information Paper:

32.	The Petrochemical Industry as a Key Tool of Economic Development. A Case History: Southern Italy	Società Edison

Discussion

12.30 Adjournment

15.00 Asia and Far East

Chairman: Carlos Vanrell, Uruguay

Discussion Leader: A.G. Menon, Economic Commission for Asia and the Far East

Rapporteur: U Tin Maung Aye, Burma

Working Papers:

48.	Burma	U Tin Maung Aye, U Kyaw Sein
66.	China (Taiwan)	Te-Lin Yu, Shu-Hsun Ting
131.	India	Ranjit Rai Bahl
120.	Indonesia	Sukasimir
116.	Iran	National Iranian Oil Co.
62.	Malaysia	Lim Ho-Pheng
55.	Pakistan	S.A. Momen
12.	Development of Petroleum-Based Organic Chemicals in India	H.C. Bijawat Union Carbide India Ltd.
132.	Development of Japan's Petrochemical Industry	Hideo Addchi, Hisotoshi Yonaga

Discussion

13.00 Adjournment

Wednesday, 25 November 1964

9.00 Latin America

Chairman: Ranjit Rai Bahl, India

Discussion Leader: Alejandro Torres, Mexico

Rapporteur: G. Otero Rusanova, Venezuela

Working Papers:
PET/CHEM/CONF.

47.	Argentina	Oscar Gatti, E.A. Pasquinelli R.F. Beltramino
100.	Brazil	Edno O.M. Brandão
45.	Chile	Juan Tempier
44.	Colombia	Mario Galán-Gómez
104.	Ecuador	Galo H. Salvador G.
74.	Mexico	Fernando Sanchez, Alejandro Torres
72.	Peru	Héctor de Souza Reategui
65.	Trinidad and Tobago	D.H.N. Alleyne, E.L. Bertrand
133.	Uruguay	C. Vanrell, M. Cratzmar
42.	Venezuela	German Otero Rusanova

Information Paper:

24.	A Review of the Development of the Petrochemical Industry in the United States and Argentina	PASA Petroquímica Argentina, S.A.

Discussion

Item VI. Regional development

Chairman: Vojno Dizdar, Yugoslavia

Discussion Leader: A.G. Menon, Economic Commission for Africa and the Far East

Rapporteur: Roberto Beltramino, Argentina

Working Papers:

69.	Development of the Petrochemical Industry in the ECAFE Region	Economic Commission for Asia and the Far East (ECAFE)
70.	Development of the Petrochemical Industry in Europe: Its Problems and Potentialities	Economic Commission for Europe (ECE)
120.	La Industria Petroquímica en América Latina	The secretariat of the Economic Commission for Latin America (ECLA). Presented by the United Nations Centre for Industrial Development

Information Paper:

La Industria Química en América Latina (E/CN.12/672 - Sales No: 63.II.G.7)	ECLA - United Nations

Discussion

13.00 Adjournment

- No Afternoon Session

Saturday, 28 November 1964

9.00 **Item VII. Financial and legal aspects of the petrochemical industry**

Chairman: Ahmed Abdul-Rahman Rifai, Kuwait

Discussion Leader: Mario Galán-Gómez, United Nations Consultant

- Opening remarks

Rapporteur: Jayarajan Chanmugam, IFC - IBRD

Working Papers:
PET/CHEM/CONF.

105.	Financing of Petrochemical Ventures in Developing Countries	United Nations Centre for Industrial Development
21.	Financial and other Problems for Japan's Petrochemical Industry	T. Hirayama Mitsui Petrochemical Industries Ltd.
79.	The Pattern of Raising Funds in the Petrochemical Industry in Japan	S. Irie, T. Kotera The Industrial Bank of Japan Ltd.
94.	The Role of Foreign Investment in Petrochemical Manufacture	Business and Industry Advisory Committee to the Organization for Economic Co-operation and Development (BIAC)

Discussion

12.30 Adjournment

15.00 Working Papers (continued):

23.	Patents and licensing in the Petrochemical Industry	S. Kahn Engelhard Industries Inc.
29.	Licence Agreements in the Petrochemical Industry	G.M. Brooner, O.D. Edwards Phillips Petroleum Company
8.	Licensing of Process Know-How	Jerry G. Jenkins Cosden Oil and Chemical Co.
118.	The Role of the International Finance Corporation in Promoting Industrial Ventures in Developing Countries	J. Chanmugam IFC - IBRD

Information Papers:

	Financing of Economic Development - Promotion of the International Flow of Private Capital to Developing Countries (E/3905)	United Nations Secretariat
	Transfer and Adaptation of Technology Patents and the Economics of Under-Developed Countries - Interim Report by the Secretariat on the Role of Patents in the Transfer of Technology to Under-Developed Countries (E/C.5/35, E/C.5/52, E/C.5/52/Add.1)	United Nations Secretariat
26.	Some Aspects of Finding and Financing Petrochemical Projects	S.H. Chafkin Checchi and Co.

Discussion

18.00 Adjournment

Sunday, 29 November 1964

9.00 **Item VIII. Location factors in the petrochemical industry**

Chairman: Mustapha Tala, Morocco

Discussion Leader: G.P. Kane, United Nations Consultant

Rapporteur: Luis Prieto Oliveira, Venezuela

Working Papers:
PET/CHEM/CONF.

25.	Location Factors for the Chemical Industries in Developing Countries	L. Nordenson Scientific Design Co. Inc.
68.	Factors Influencing the Location of a Petrochemical Plant	P.C. Livesay American Oil International Co.
108.	The Evolving Pattern of Petrochemical Industry in India with particular reference to Gujarat and Bombay Regions	B. Sreenivasan, Sarabhai Group of Industries H.T. Bhavanani, Calico Mills
64.	Developing the Petrochemical Potentials of North Africa and the Persian Gulf	H.K. Nieuwenhuis, United Nations Consultant
96.	Prospects of Development of Petrochemical Industries in India and other countries of Asia and the Far East	G.P. Kane United Nations Consultant

Information Paper:

95.	Planning of the Chemical Industries at the National Level	Prepared for the United Nations Centre for Industrial Development by T. Vietorisz

Discussion

12.30 Adjournment

15.00 Working Papers (continued):

67.	The Economics of International Distribution of Anhydrous Ammonia	A.G. Bruno W.R. Grace and Company
22.	Ocean Transportation of Ethylene and other Basic Intermediates for Petrochemicals	R. Boudet, Société Gazocéan M.H. Gertz, Purvin and Gertz Inc.
98.	Characteristics and Prospects of Petrochemical Industry, with an emphasis on the Yokkaichi Complex in Japan	Tadao Yano Mitsubishi Petrochemical Co. Ltd.
86.	An Integrated Petrochemical Complex (I.F.P. Section II, Chapter VII)	Prepared for the United Nations Centre for Industrial Development by the Institut Français du Pétrole
76.	Structure of Petrochemical Development in Mexico - Reynosa and Pajaritos Developments	Petróleos Mexicanos

Information Papers

101.	Plant Size, Location and Time Phasing - Introduction	Alan S. Manne M.I.T. Centre for International Studies
117.	Planning of the Calvo Sotelo Integrated Oil Refinery and Petrochemical Complex	Arthur L. Dowling, Thomas E. O'Hare The M.W. Kellogg Company

Discussion

18.00 Adjournment

Monday, 30 November 1964

9.00 Closure of the Conference

Chairman: Dr. M. Eghbal

Presentation and Adoption of Conference Report and Recommendations

Statement by Members of the Conference

Address by Chairman of the Conference

12.30 Adjournment

ANNEX II

LIST OF PARTICIPANTS

1. Participants nominated by Governments

Country	Name	Company
Argentina	BELTRAMINO, Roberto F.R.	Secretaria de Industria y Minería
	GATTI, Oscar Osvaldo	Dirección General de Fabricaciones Militares
	PASQUINELLI, Eduardo Augusto	Yacimientos Petrolíferos Fiscales
Brazil	BELOTTI, Paulo Vieira	Banco Nacional de Desenvolvimento Econômico
	BRANDÃO, Edno Oliveira Maia	Petróleo Brasileiro S.A.
Burma	U KYAW SEIN	People's Oil Industry
	U TIN MAUNG AYE	People's Oil Industry
Chile	TAMPIER, Juan	Corporación de Fomento de la Producción (CORFO) y la Empresa Nacional del Petróleo
China	TING, Shu-Hsun	Chinese Petroleum Corporation
	YU, Te-Lin	Chinese Petroleum Corporation
Colombia	GALAN-GOMEZ, Mario	Empresa Colombiana de Petróleos (Ecopetrol)
	TAMAYO RESTREPO, Pablo	Empresa Colombiana de Petróleos
Ecuador	SALVADOR, Galo	Junta Nacional de Planificación y Coordinación Económica
India	BAHL, Ranjit Rai	Ministry of Petroleum and Chemicals
Indonesia	SUKARMIR	Department of Basic Industry and Mining
Iran	ABEDI, Rahim	University of Teheran
	AKHAVAIN, Mohammad Mehdi	Chamber of Industries and Mines
	AMERI, Mozaffar	Plan Organization
	AZARIAN, H.M.	National Iranian Oil Company
	BAKHTIAR, Abbas Quli	National Iranian Oil Company
	EGHBAL, Manouchehr	National Iranian Oil Company
	IRAVANI, Khan Baba	Ministry of Economy
	IZADI, Hassan	National Iranian Oil Company
	JALALI NOURI, Fazlollah	Member of Parliament
	KAMALI, Jaffar	Petrochemical Plant
	MAHDAVI, Rashid	Petrochemical Institute
	MAZDA, Abbas	National Iranian Oil Company
	MERAT, Parviz	Petrochemical Institute
	MINA, Parviz	National Iranian Oil Company
	MOAZED, Mahmoud	Chamber of Industries and Mines
	RAFI, Mustafa	Petrochemical Institute
	RAZAVIPOUR, Mohammad	National Iranian Oil Company

Country	Name	Company
Iran (cont.)	SADRI, Mansour	National Iranian Oil Company
	SAFFARI, Reza Mohammad	Petrochemical Institute
	SAFINYA, Parviz	Ministry for Foreign Affairs
	SHARIFI, Shapur	National Iranian Oil Company
	YEGANEH, Mohammad	Deputy to the Minister of Economy
	ZAHEDI, Abdul Hossein	Ministry of Economy
Israel	GOTTESMAN, Edward	Haifa Refineries Ltd.
	LOBEL, Joseph Chaim	Ministry of Commerce and Industry
	SHAVIT, Alfred Benjamin	"Delek" Israeli Fuel Corporation Ltd.
	TOREN, Benjamin	Ministry of Commerce and Industry
Kuwait	MAZIDI, Feisal Mansour	Kuwait Chemical Fertilizer Company
	RIFAI, Ahmed Abdul-Rahman	Ministry of Finance and Industry
Libya	MANGUSH, Bashir Abdullah	Ministry of Petroleum Affairs
Malaysia	LIM, Ho-Pheng	Department of Chemistry, F/M
Mexico	SANCHEZ, Fernando	Petróleos Mexicanos (PEMEX)
	TORRES, Alejandro	Petróleos Mexicanos (PEMEX)
Morocco	TALA, Mustapha	S.A.M.I.R.
Pakistan	KURESHI, Nur Nabi Ahmad	Planning Commission
	MOMEN, S.A.	East Pakistan Industrial Development Corp.
	RAHMAN, Abdul	Investment Advisory Centre of Pakistan
	BURGESS, Leslie M.	Harvard Advisory Group (Planning Commission)
Peru	DE SOUZA REATEGUI, Héctor	Empresa Petrolera Fiscal del Perú
Poland	LAIDLER, Konstanty	Ministry of Chemical Industry
Romania	GHEJAN, Ion	L'Institut de Recherches PETROCHIMIE
	MARINESCU, Ion	Ministère de l'Industrie du Pétrole et de la Chimie
Saudi Arabia	BUSHNAK, Zuhdi Ahmed	General Petroleum and Mineral Organization
	HABBASH, Issa Ibrahim	Ministry of Petroleum and Mineral Resources
	SHNABER, Abdul Aziz	Ministry of Petroleum and Mineral Resources
Syria	TABAA, Yassine M.	General Petroleum Authority
Trinidad and Tobago	ALLEYNE, Doddridge Henry	Ministry of Petroleum and Mines
	BERTRAND, Eugene Louis	Ministry of Petroleum and Mines
Turkey	BEZMEN, Mehmet Hayrettin	Türkiye Petrolleri A.O.
	SENGEL, Nevzat Fikret	Turkish Petroleum Corporation
United Arab Republic	EL-HALFAWY, Mohamed	Industrialization Organization
Uruguay	CRATZMAR, Mardoqueo	ANCAP
	VANRELL, Carlos	ANCAP
Venezuela	LEDESMA LANZ, Antonio	Instituto Venezolano de Petroquímica
	OTERO RUSANOVA, German	Instituto Venezolano de Petroquímica
	PRIETO OLIVEIRA, Luis	Instituto Venezolano de Petroquímica

Country	Name	Company
Yugoslavia	DIZDAR, Vojno	Federal Office for Economic Planning
	JENIC, Cedomir	Federal Secretariat of Industry
	MIRKOV, Kornelije	Federal Office for Economic Planning

2. **Participants from Industry, Academic and Research Institutes**

Country	Name	Company
Federal Republic of Germany	HUMMEL, Ulrich	Hans J. Zimmer AG
	KAMPTNER, Herbert Karl	Farbwerke Hoechst AG
	LAUB, Joachim	Hans J. Zimmer AG
	MUNDE, Wolfgang J.T.	Verband der Chemischen Industrie e.V.
	OETKEN, Friedrich A.	Lurgi Gesellschaft für Mineralöltechnik mbH
	PELIZAEUS, Paul J.	Farbenfabriken Bayer AG
	SONKSEN, Hans D.A.	Badische Anilin- und Soda-Fabrik AG
	THORMANN, Friedrich	Hoechst-Uhde International GmbH
	WETTER, Friedrich A.	Chemische Werke Hüls
France	CHAMPAGNAT, Alfred	Société Internationale de Recherches BP
	FAVRE, Jean H.	Institut Français du Pétrole
	HENNY, Victor E.	Institut Français du Pétrole
	HUSSON, Pierre M.	Société Nationale des Pétroles d'Aquitaine
	JOURNU, Henri	Union des Industries Chimiques
	KERMARREC, François J.	Institut Français du Pétrole
	MAGNANT, M.	Groupe Centrale de Dynamite, Nobel-Pozel
	MERCIER, Claude	Institut Français du Pétrole
	ROCHE, André	Office National Industriel de l'Azote
India	BHAVANANI, Hiranand T.	Calico Mills
	BIJAWAT, Harish C.	Union Carbide India Ltd.
	GARUD, B.S.	Delhi Cloth and General Mills Co. Ltd.
	GLADEL, Yves L.	Indian Institute of Petroleum
	KRISHNA, Maddaly G.	Indian Institute of Petroleum
	SREENIVASAN, B.	Sarabhai Group of Industries
	TRIVEDI, Druman M.	Synthetics and Chemicals Ltd.
Italy	BALCONI, Gianfranco	Società Edison
	CRESPI, Giovanni	Istituto di Chimica Industriale del Politecnico Milano
Japan	HAYASHI, Shigeru	Nippon Petrochemicals Company Ltd.
	HIRAKAWA, Yoshihiko	Nippon Petrochemicals Company Ltd.
	HIRAYAMA, Takeshi	Mitsui Petrochemical Industries Ltd.
	IRIE, Sukemitsu	The Industrial Bank of Japan Ltd.
	ISHIGURO, Tadashi	Japan Gasoline Company Ltd.
	KODAMA, Shinjiro	Sumitomo Chemical Company Ltd.
	KOTERA, Teruhiko	The Industrial Bank of Japan Ltd.
	OSUMI, Kazuo	Chiyoda Chemical Engineering and Construction
	TAMAKI, Akiyoshi	Chiyoda Chemical Engineering and Construction
	TAMAKI, Masataka	Mitsui Petrochemical Industries Ltd.

Japan (cont.)	TAKEUCHI, Chisato	Chiyoda Chemical Engineering and Construction
	TOKUHISA, Yoshio	Mitsubishi Petrochemical Company Ltd.
	TSUNODA, Yoshio	Asahi Chemical Industry Company Ltd.
	WATANABE, Isaburo	Japan Gasoline Company Ltd.
	YANO, Tadao	Mitsubishi Petrochemical Company Ltd.
	YONAGA, Hisatoshi	Ministry of International Trade and Industry
Lebanon	KANAAN, Youssef N.	Consultant to Fertilizer Companies
Netherlands	BRABER, Pieter	Bataafse Internationale Chemie Mij, N.V.
	GOPPEL, Johan M.	Shell International Research Mij (Royal Dutch/Shell)
	REVALLIER, Leonardus J.	Staatsmijnen in Limburg
Switzerland	BERTHER, Clau	Emser-Werke
	JAEGER, Peter	Emser-Werke
	WEBER, Jürg F.	Inventa, AG für Forschung und Patentverwertung
Union of Soviet Socialist Republics	ISMAILOV, Rustam G.	Economy Council of Azerbaijan
	KHODAKOVSKAIA, Vera A.	State Committee on Petrochemical Industry
United Kingdom of Great Britain and Northern Ireland	CLOUGH, Harry	Imperial Chemical Industries Ltd.
	GILLIES, Fyfe	British Petroleum
	SMITH, Douglas G.	British Petroleum
	WOOLCOCK, James W.	Imperial Chemical Industries Ltd.
United States of America	ADAMS, Robert R.	Battelle Memorial Institute
	BRUNO, A.J.	W.R. Grace and Company
	CONSER, Richard E.	Universal Oil Products Company
	COSSLETT, Kenneth E.	U.S. Industrial Chemicals Co.
	DE PICCIOTTO, Alexandre	Arthur D. Little, Inc.
	EDWARDS, Oliver D.	Phillips Petroleum Company
	GERTZ, Melvin H.	Purvin and Gertz Inc.
	GIUSTI, Gino P.	Texas Gulf Sulphur Company Inc.
	HAAS, Henry J.	Phillips Petroleum Company
	HATCH, Lewis F.	University of Texas
	JENKINS, Jerry G.	Cosden Oil and Chemical Company
	JOHNSON, Axel R.	Hydrocarbon Research Inc.
	KAHN, Samuel	Engelhard Industries Inc.
	KORSMEYER, Frederick B.	Mobil Chemical Company
	LANDAU, Ralph	Halcon International Inc.
	LIEN, Arthur P.	Battelle Memorial Institute
	LOGWINUK, Alexander	Houdry Process and Chemical Company
	NEU, Robert F.	Esso Chemical Company Inc.
	NORDENSON, Lars	Scientific Design Company Inc.
	O'HARE, Thomas E.	The M.W. Kellogg Company
	PETTY, Donald S.	Universal Oil Products Company
	RICHARDS, Prescott L.	Esso Chemical Company Inc.
	RONAY, Thomas E.	Marbon Chemicals
	SCHAFFEL, Gerson S.	Scientific Design Company Inc.
	SHAWK, Harry R.	The Lummus Company - India
	SHERWOOD, Peter W.	Consultant - The Badger Company
	STRELZOFF, Samuel	Chemical Construction Corp.

3. United Nations regional economic commissions

ALEMAYEHU, Makonnen	Economic Commission for Africa
GATTONI-CELLI, Rossana	Economic Commission for Europe
LI, Ching Yuan	Economic Commission for Asia and the Far East
MENON, Ambady G.	Economic Commission for Asia and the Far East
NYUNT, U Tin	Economic Commission for Asia and the Far East
SHEN, Jin Tai	Economic Commission for Asia and the Far East

4. United Nations consultants

BRODOWSKI, Alexander B.	Chemical and Petroleum Consultant
FEDORENKO, Nikolai P.	Economic-Mathematical Institute of Moscow
GALAN-GOMEZ, Mario	Empresa Colombiana de Petróleos (Ecopetrol)
HART, Harold	Michigan State University
KANE, Govind P.	Ministry of Industry and Supply, New Delhi
MANNE, Alan S.	Stanford University
NIEUWENHUIS, Herman K.	Chemical Projects Associates Inc.

5. Other international and inter-governmental organizations

AL-HASHIMI, Madhat M.	Organization of the Petroleum Exporting Countries (OPEC)
BADAKHSAN, Amir	Organization of the Petroleum Exporting Countries (OPEC)
CHANMUGAM, Jayarajan	International Finance Corporation - International Bank for Reconstruction and Development (IFC-IBRD)
HAMMAD, Fahd	Organization of the Petroleum Exporting Countries (OPEC)
LAURENCE, Alfred	United Nations Educational, Scientific and Cultural Organization (UNESCO)
SHENFIELD, A.A.	Federation of British Industries, representing the Business and Industry Advisory Committee to the Organization for Economic Co-operation and Development (BIAC to OECD)

6. Observers

BOURDILLAT, Felix P.	Ministry of Industry, France
CERNIA, Enrico M.	Società A.B.C.D.
CHAN, Yi-Chen	Chinese Petroleum Corporation
COLIN, Alec	Ministry of Industry, France
COOPER, Roger	Tesco Limited
COOPERMAN, James	Industry Section, United States Embassy, New Delhi
DE CLERCK, Marcel	UNESCO Mission in Iran
DE CORVAL, Gérard	ECAFE Consultant
DE SOUSA, Joseph P.	Chemical Age of India
DOLL-STEINBERG, Alfred	Simon-Carves Ltd.
DUNAWAY, Don Carlos	Consultant, Allied Chemical Company and Pauley Petroleum

6. Observers (continued)

FLENKENTHALLER, Horst M.	Snam Divisione Progetti, E.N.I.
LENNON, Derek	Humphreys and Glasgow Ltd.
MORRIS, Anthony E.L.	Geologist
RAZMARA, Reza	Petrochemical Corporation of Iran
RIFAI, Taki M.	Institut Français du Pétrole
ROBIE, Robert H.	The Atlantic Refining Company
SERSALE, Franco	Humphreys and Glasgow Ltd.
SHAHBANDI, Mike	The Atlantic Refining Company
WEATHERS, Lucien T.	Arabian American Oil Company
WITTRIN. Heine	United Nations Technical Assistance Resident Representative's Office, Teheran
YANG, Yu-Fan	Chinese Petroleum Corporation

ANNEX III

OFFICERS OF THE CONFERENCE

1. Chairman and Vice-Chairmen

EGHBAL, Manouchehr	Iran
BAHL, Ranjit Rai	India
DIZDAR, Vojno	Yugoslavia
RIFAI, Ahmed Abdul-Rahman	Kuwait
TALA, Mustapha	Morocco
VANRELL, Carlos	Uruguay

2. Report Committee

KURESHI, Nur Nabi Ahmad	Pakistan (Chairman)
ALLEYNE, Doddridge H.	Trinidad and Tobago
AYE, U Tin Maung	Burma
BELTRAMINO, Roberto F.R.	Argentina
BEZMEN, Mehmet Hayrettin	Turkey
BRANDÃO, Edno Oliveira Maia	Brazil
CRATZMAR, Mardoqueo	Uruguay
DE SOUZA REATEGUI, Héctor	Peru
EL-HALFAWY, Mohamed	United Arab Republic
HABBASH, Issa Ibrahim	Saudi Arabia
JENIC, Cedomir	Yugoslavia
LAIDLER, Konstanty	Poland
LIM, Ho-Pheng	Malaysia
LOBEL, Joseph Chaim	Israel
MANGUSH, Bashir Abdullah	Libya
MARINESCU, Ion	Romania
OTERO RUSANOVA, German	Venezuela
RIFAI, Ahmed Abdul-Rahman	Kuwait
SALVADOR, Galo	Ecuador
SHARIFI, Shapur	Iran
SUKASIMIR	Indonesia
TABAA, Yassine M.	Syria
TAMAYO RESTREPO, Pablo	Colombia
TALA, Mustapha	Morocco
TAMPIER, Juan	Chile
TORRES, Alejandro	Mexico
TRIVEDI, Druman M.	India
YU, Te-Lin	China

3. Discussion Leaders

ABU EL-HAJ, Ribhi	United Nations Centre for Industrial Development
BEREDJICK, Nicky	United Nations Centre for Industrial Development
BRODOWSKI, Alexander R.	United Nations Consultant
FEDORENKO, Nikolai P.	United Nations Consultant
GALAN-GOMEZ, Mario	United Nations Consultant
HART, Harold	United Nations Consultant
HATCH, Lewis F.	University of Texas
KANE, Govind P.	United Nations Consultant
LIEN, Arthur P.	Battelle Memorial Institute
MANNE, Alan S.	United Nations Consultant
MENON, Ambady G.	Economic Commission for Asia and the Far East
NIEUWENHUIS, Herman K.	United Nations Consultant
TEITEL, Simón	United Nations Centre for Industrial Development
TORRES, Alejandro	Mexico

4. Rapporteurs

ALLEYNE, Doddridge Henry	Trinidad and Tobago
AYE, U Tin Maung	Burma
BELOTTI, Paulo Vieira	Brazil
BELTRAMINO, Roberto F.R.	Argentina
BEZMEN, Mehmet Hayrettin	Turkey
BRANDÃO, Edno Oliveira Maia	Brazil
CHANMUGAM, Jayarajan	International Finance Corporation - International Bank
GATTONI-CELLI, Rossana	Economic Commission for Europe
GHEJAN, Ion	Romania
HABBASH, Issa Ibrahim	Saudi Arabia
LIM, Ho-Pheng	Malaysia
OTERO RUSANOVA, German	Venezuela
PRIETO OLIVEIRA, Luis	Venezuela
RAHMAN, Abdul	Pakistan
SANCHEZ, Fernando	Mexico
SHNABER, Abdul Aziz	Saudi Arabia
TAMPIER, Juan	Chile

5. Iranian Officers

Chairman of the Organization Committee:	MOSTOFI, Haghir
Executive Secretary:	IZADI, Hassan
Deputy Executive Secretary and Liaison Officer:	SADRI, Mansour
Head of Secretariat:	GAFFARY, Abdolalli
Deputy to Secretariat:	SHAIRANI, Kewmars
Head of Reception Committee:	RAHNEMA, M.
Head of Services	SADRI, Fereydoon
Technical Head:	McKELLIP, Spencer
Assistant Technical Head:	VOKHSHOUR, Kooros
Press Officer:	BOZORGMEHR, Benman

6. United Nations Officers

Director of the Conference:	LURIE, S. Inter-Regional Economic Adviser, Department of Economic and Social Affairs, former Director in the Centre for Industrial Development
Co-Director:	MENON, A.G. Economic Commission for Asia and the Far East
Secretary:	TEITEL, S. Centre for Industrial Development
General Rapporteur:	ABU EL-HAJ, R. Centre for Industrial Development
General Technological Rapporteur:	BEREDJICK, N. Centre for Industrial Development

ANNEX IV

MESSAGES AND ADDRESSES

1. Message from His Imperial Majesty, Mohammad Reza Shah Pahlavi

(Read by His Excellency Ghods Nakhai, Minister of the Imperial Court)

For quite a number of years we have been looking forward to the day when the development of petrochemical industries would receive the attention it deserved in the developing countries. It was, therefore, with great enthusiasm that our Government extended its whole-hearted invitation to the United Nations to convene in our capital the first Inter-Regional Conference on the Development of Petrochemical Industries in Developing Countries. It is, indeed, a great privilege for my country to act as your host, and I take pleasure in extending our warmest welcome to such a distinguished group of government officials, experts and industry leaders, coming from all over the globe.

In a way it may be considered natural that this first Petrochemical Conference should be held in Iran. My country is not only among the oldest oil producing countries in the modern world, but also its association with the use of petroleum for various purposes is as old as its civilization.

Petrochemical industries have made phenomenal strides in industrialized countries during the post-war era. Perhaps no other industry has experienced such rapid scientific discoveries and technological innovations as petrochemicals. New processes are being introduced continually, making it possible to manufacture new products which now literally number in thousands. These products which meet innumerable needs have, to a great extent, redeemed the scarcity of traditional raw materials, opening new vistas for the welfare and prosperity of men.

So far, the developing countries have had a very meagre share in the growth of petrochemical industries, although many of them are endowed with great resources for their development. No doubt, the establishment of petrochemical industries in these countries has been hampered by the scarcity of capital and technical know-how as well as their limited markets.

This conference provides the opportunity to identify the problems and seek suitable and practical ways and means for their solution. It is indeed obvious that sporadic efforts here and there are of little avail. The potentials for the development of these industries in the developing countries are so enormous that concerted effort is required to obtain optimum results. I am sure your deliberations will contribute to the fulfilment of this long-felt necessity and I wish you all the best of success.

2. Opening Address by His Excellency Mr. Hassan Ali Mansour, Prime Minister of Iran.

Your Excellencies, Ladies and Gentlemen,

It gives me great pleasure to welcome you to this United Nations Inter-Regional Conference on the Development of Petrochemical Industries in Developing Countries. The rapid development of petrochemicals, which is one of the distinguishing marks of the modern age, has led to petrochemical products establishing themselves within a remarkably short period of time as necessities of every-day life, and has opened up new and great possibilities for the future. This development, however, has taken place mainly in the industrialized countries, and the progress of the developing countries in this field has been hampered by many adverse factors and consequently has not been as rapid as we could have wished.

This Conference, as well as the ECAFE Natural Gas Seminar which is to follow immediately afterwards in Teheran, affords an excellent opportunity to examine various aspects of this situation in order to provide certain guidelines whereby the developing countries will in future be enabled to achieve faster progress in this field. We in Iran have a special interest in the question of petrochemical development on account of our enormous under-utilized reserves of natural gas - amongst the world's largest - as well as of the existence of huge petroleum reserves and an advanced oil industry. The Government has, therefore, devoted particular attention to the development of petrochemicals, has given it high priority in the development plans, and has allocated to it substantial sums of money.

We feel that there are great opportunities in Iran for the establishment of a petrochemical and in particular a fertilizer industry. Here in this country are abundant and cheap supplies of natural gas conveniently located between the Far East, Africa and Europe, and close to the seaboard; here also is a society in which structural changes, land reform measures and other reforms recently initiated by His Imperial Majesty the Shah, have paved the way towards faster economic growth and mass consumption. In this improved environment there is bound to be a healthy market for petrochemical products, particularly fertilizers. Thus there is ample scope for a petrochemical industry based both on the home market and on export. The establishment of such an industry in Iran, and indeed in other countries similarly situated and possessing ample under-utilized reserves of natural gas, will not only render possible the exploitation of great natural resources now being wasted and bring great benefits to the peoples of such countries; it will also benefit other peoples of the world, helping them to raise their agricultural output and their standard of living generally. It will also lead to greater interdependence between the suppliers of capital, the providers of raw materials and the consumers. The more such links that we can forge, the nearer we shall be to world peace.

An economic survey recently conducted in Asia and the Far East indicates that the annual increase in food production in the area has been 0.5 per cent, compared with an annual growth of population of 2.4 per cent, and that per capita food production in 1964 barely equals the 1934 to 1935 level in this part of the world. In our world of continually rising expectations, this is indeed a sorry state of affairs, and its rectification is a great challenge to our energy and initiative. The increase in output of artificial fertilizers affords one of the best hopes of rapidly increasing the living standards of the developing countries, and of attaining one of the United Nations prime objectives - Freedom from Hunger. Such

a development would also play its part in bringing about greater political stability and improved prospects for a secure and lasting peace. A hungry world is indeed a very unsafe world.

Your Excellencies, Ladies and Gentlemen, a large number of the most eminent experts in the field of petrochemicals are assembled here today, and I am confident that their discussions will lead to conclusions of the highest importance for our economic welfare. It is my earnest hope that we shall all leave this Conference richer in knowledge and inspired by new ideas that will bear abundant fruit. I wish you all success, and a happy and enjoyable stay in Iran.

3. Address by His Excellency Dr. Manouchehr Eghbal, Chairman of the Conference

(Chairman and Managing Director of the National Iranian Oil Company and Leader of the Iranian Delegation)

Excellencies, Ladies and Gentlemen,

May I express my thanks at my election as Chairman of this Conference, and my pleasure at having the honour to welcome you to Iran.

All over the world the developing countries are embarking upon a programme of action to accelerate their rates of economic growth in answer to the legitimate aspirations of their peoples. This effort manifests itself especially in the domain of industrialization. In this respect, the petrochemical industries can contribute a great deal to the growth of industrial potential and national income. In fact, not only has important progress been achieved in the scientific and technical aspects of the petrochemical industry, but also the increase in demand and volume of productions have been such that they can only be described as spectacular. The extraordinarily rapid development of the industry in recent years has, to some extent, compensated for the shortage of traditional raw materials. Nowadays it is difficult to find an aspect of modern life where petrochemical products are not used directly or indirectly, and their importance as finished or semi-finished products increasingly manifests itself in all sectors of the economy.

Nevertheless, the development of the petrochemical industry in the developing countries has not been as swift as in the industrialized nations. The purpose of this Conference, convened under the auspices of the United Nations, is precisely to create a medium for the exchange of views on how to accelerate the development of this industry in the developing countries.

In Iran, under the guidance of His Imperial Majesty the Shah, the development programme for the petrochemical industries has received priority, and various projects are being studied or implemented on the basis of such favourable factors as the presence of considerable reserves of gas and the existence of a highly advanced petroleum industry. In order to centralize all efforts made in this direction, the National Iranian Oil Company is about to create a National Petrochemical Company. This company will implement all future projects and will co-ordinate all efforts in the private and public sector.

I hope that in the course of our deliberations, the Iranian delegation will have the opportunity to present to you some of the existing problems on the subject, and that it will profit from the exchange of views and the vast experience of the participants of this Conference.

Excellencies, Ladies and Gentlemen,

Most of the countries represented in this gathering have considerable resources which could serve as a basis for the establishment of new petrochemical industries. To achieve this objective, individual efforts on the basis of national planning are not adequate. What is needed is closer co-operation between developing and industrialized countries on the exchange of scientific and technical data, research, the preparation and implementation of projects, marketing of products and programmes of investment. At the same time, regional or multilateral

collaboration in terms of specialization in certain industries and sub-division of the work involved among the developing countries can also be considered. By the establishment of large petrochemical projects duplication of efforts may be avoided.

Excellencies, Ladies and Gentlemen,

I hope that the work of this Conference will efficiently contribute to the understanding of our common problems and will achieve tangible results for the economic development of our countries.

4. Message from Dr. Victor Hoo, United Nations Commissioner for Technical Assistance

On the opening day of your Conference on the Development of Petrochemical Industries in Developing Countries organized by the United Nations in co-operation with the Government of Iran, I wish to convey to you my greeting and express our gratitude to the Government of Iran and its officials for their efforts and their hospitality.

Several United Nations bodies, especially the Technical Assistance Committee and the Economic and Social Council, in considering the provision of technical assistance to developing countries, singled out industrial development as deserving a particular emphasis. Petrochemical industries are strategic to this development. We therefore are happy that this Conference takes place under the auspices of the United Nations. It is yet another of many examples of true international co-operation of which we in the United Nations who are associated with technical assistance programmes are proud. The international character of the Conference is reflected in the participation in it of more than thirty countries coming from four continents of the world. The United Nations Secretariat, both from Headquarters and from the Regional Economic Commissions, UNESCO, the Special Fund and the World Bank are responsible for a number of studies and papers prepared to assist you in your work. The several consultants serving the Conference came from different parts of the world. Finally, a great number of Governments, through another form of international co-operation, namely contributions made towards United Nations Technical Assistance, made the holding of this Conference possible.

In the course of your deliberations, you will study many aspects of the petrochemical industry. The question of research and technology, location factors, financial and legal aspects, the question of the demand and supply of petrochemical products and many others. The developing countries, whether they have their own petroleum and natural gas resources or have only petroleum refineries, all face an important problem of finding practical ways for expanding, or establishing and running viable petrochemical complexes as a part of their industrial development. I am confident that this exchange of experience and information among the developing countries and with the developed countries will be of great value to all the less advanced countries in finding a proper solution to many economic and technical aspects of this question.

We in the United Nations wish you a successful and productive Conference.

5. Message from Mr. I.H. Abdel-Rahman, United Nations Commissioner for Industrial Development

Your Excellencies, Mr. Chairman, Ladies and Gentlemen,

The holding of a conference on the development of the petrochemical industry in the developing countries is a further manifestation of the accelerating tempo which has marked in recent years the efforts of the United Nations in the field of economic development. It is in line with the drive of the less developed nations to promote and accelerate by every means their industrial development. This drive has been reflected in the programme of action of the United Nations Development Decade, in which industrial development has been singled out as one of the areas of highest priority.

The hopes of the peoples of the less developed areas of the world for a better life consistent with the possibilities of today's technology are based in many countries on the creation of a modern and efficient industrial sector. With this in mind, the United Nations organs have devoted considerable attention in recent years to the need to strengthen and enlarge the Organization's activities in the field of industrial development. The Economic and Social Council established, only a few years ago, a Committee for Industrial Development, one of whose major concerns is to promote the most effective application of modern industrial methods of production and management to the establishment and operation of industries in the developing countries.

The General Assembly, mindful of the need to focus attention on the problems of industrial development, approved last year a resolution concerning the holding, not later than 1966, of an International Symposium on Industrial Development, preceded by appropriate regional and sub-regional meetings. We hope that this undertaking will afford for the first time the opportunity of a full-fledged examination of the broad range of questions related to the industrialization of the less developed countries. In a sense, such broadly conceived undertakings as the proposed International Symposium as well as the specialized meetings such as this Conference on the Petrochemical Industry are all aimed at a further clarification of the basic issues of industrialization with a view to a fuller mobilization of efforts under practical programmes of action.

One of the outstanding problems is the need for making available to the developing countries the fruits of scientific and technological advances as a basic tool in the struggle for development. Scientific and technological research is still, by and large, a privilege of a small number of countries. Until recently, it has been primarily oriented to the resource endowments and the requirements of the already advanced countries.

It has often been thought that industrial development could nowadays be telescoped by applying to the less developed countries all the existing technological knowledge. But it cannot be denied that industry involves more than the technical process of production. It is therefore particularly noteworthy that this Conference is not limited to the purely technological problems. The papers to be presented reveal, on the contrary, a high awareness of the economic and cost aspects.

The fact alone that a meeting such as this is taking place under United Nations auspices and that so many distinguished specialists have responded generously, by

their writing and by their presence, to the call of the United Nations, will be a source of great satisfaction for all those concerned in the less developed countries with the task of accelerating industrial development.

I wish to express my deepest gratitude to the Government of Iran for having so graciously offered its host facilities for holding this Conference.

To all participants, may I extend my best wishes for the fullest success of your work.

6. Address by Mr. S. Lurié, Director of the Conference

It has now become a truism to state that accelerated industrialization is the strategic element in the economic development of the developing countries. In terms of productivity, diversification of output and income effect, the development of industry represents a powerful instrument in achieving higher standards of social and economic welfare among the populations of the less developed countries.

Among the various industries that may come in for consideration in a programme of industrialization, some sectors, because of their particular technical and economic characteristics, the type of resources on which they are based and the nature of their product, are of a particularly dynamic character. The establishment of such industries, in addition to its direct economic effects, creates an impact area which exerts an over-all stimulating effect upon the rest of the economy.

The petrochemical industry is one of such dynamic industries. As could be seen from the figures quoted in the opening speech by the distinguished Chairman of the Conference, His Excellency Dr. Manouchehr Eghbal, the petrochemical industry has been characterized by an extremely high rate of growth during recent years. It has become a source of rapidly growing importance of a wide range of chemical products applied in a variety of uses, ranging from intermediate products consumed in a great number of industries to goods in everyday use by the final consumer. There are now in the world about 1,500 plants in operation, and the number of newly established plants is growing at a rate which will result in the doubling of the existing production capacity within the next four to five years. Most of these plants are located in the highly developed countries, while only modest beginnings have been made in that direction by some of the developing countries.

There are, on the other hand, many developing countries which possess vast resources of oil derivatives from their refineries and of natural gas, which are sources of very low cost or even zero cost raw materials for petrochemical industries. A valorization of those raw materials, with a view to developing industries producing a variety of products for domestic consumption and exports is becoming a major preoccupation of Governments as an important factor in the industrialization of their countries.

It is with this consideration in mind that the United Nations Centre for Industrial Development has convened this conference, upon the recommendation of the Committee for Industrial Development of the United Nations, made at its third session. The Conference has been convened under the programme of work of the Centre geared to assisting Governments of developing countries in their efforts to promote industrial development.

As can be seen from the aide-mémoire of the Conference, the objective of this meeting is twofold. One is to consider the particular economic and technological aspects of the petrochemical industry from the special point of view of the developing countries. The second, equally important if not even more vital, objective is to provide a forum for the discussion of policies to be adopted by developing countries to promote the development of petrochemical industries on the basis of their resources.

In dealing with the first aspect, the intention is not merely to present a survey of the technology and economics of the petrochemical industries established in the highly industrialized countries, but to consider and compare these aspects from the particular point of view of the requirements and resource endowments of the developing countries. Thus, for example, in considering the various technological alternatives, special attention is given to processes which make possible a lower per unit investment or to those which are less subject to the factor of economies of scale which is generally characteristic of chemical process industries. The latter factor in particular is of crucial importance as regards the economics of the petrochemical industries in the developing countries. While many developing countries, in fact practically all countries represented at this Conference, have abundant raw materials which could serve as a point of departure for a petrochemical industry, most of them are facing the problem of limited domestic markets. Since the petrochemical industries are particularly sensitive to economies of size, these countries are faced with the dilemma of establishing either relatively small and uneconomic units or, should they decide to install capacities beyond those of their markets, units with low rates of capacity utilization. In both cases, this implies high costs of production and low yields on the invested capital.

The answer to this dilemma is by no means an easy one and the discussion of this problem should be a major objective of this Conference. In the first place, the potential size of the domestic markets should be gauged, not in terms of present consumption, but in the dynamic sense by taking into account the future growth of demand with the expected over-all rate of growth, the development of other sectors of the economy and the growth of consumer incomes.

The past rates of growth or the past patterns of consumption should be taken only as a starting point which does not necessarily prejudge the rates of future development and in many cases it will be well to bear in mind the well-known adage that supply creates its own demand; the history of industrial development in many countries has shown that the establishment of new industries has often provided a spectacular impulse to the growth of demand for their products.

In the second place, there are the possibilities of supplementing domestic markets by exports. The role of export markets in the industrialization of the raw materials of the resource-endowed developing countries is another area of discussion at this Conference in which we have the good fortune to have many representatives from the petrochemical industry of the highly developed countries. The latter countries possess not only the technical know-how but also extensive markets for the products of the petrochemical industries, particularly the intermediate products which require the existence of a sophisticated industrial structure. The technical, economic and commercial co-operation of highly developed countries with the developing countries in the field of commercialization of the latter's resources of petrochemical raw materials would enable the developing countries to establish viable industries of adequate economic size. While the progress of industrialization in the developing countries will enable them to absorb in due course an increasing proportion of the intermediate products delivered by their petrochemical industries, in the earlier stages of their development these industries will have to rely to a substantial extent on exports. In this way, the vicious circle of uneconomic operation and high costs, limited domestic markets and lack of competitiveness in outside markets because of high costs, would be overcome.

Another way out of the dilemma might be regional industrial integration whereby a pooling of national markets of a given region would provide for an adequate economic size of production. This implies in turn country specialization, each country being engaged in a line of production which is most appropriate to its endowment in resources. Instead of each of the countries producing on its own a wide range of products on an uneconomic scale, regional integration would provide for a sound policy of industrialization of the raw material resources of the region.

May I be allowed to add, as a personal note, that having been detached for some time by the United Nations as Adviser to His Excellency Mr. Ali Khani, Minister of Economy of Iran, I have been in a particularly fortunate position to witness the efforts which are being made by the Government of Iran to further the industrial development of this country and, in particular, the development of a national petrochemical industry based on the oil and gas resources of the country. A number of petrochemical projects are being studied at the present time by the Government in the context of the project of regional economic integration between Iran, Turkey and Pakistan, which is now being actively pursued by the three countries concerned.

Before concluding my statement I should like to convey, on behalf of the United Nations and the Centre for Industrial Development, our sincere thanks to the Government of Iran for its generous co-operation in the organization of this Conference. I would, in particular, like to convey our thanks to the management and staff of the co-sponsoring organization in Iran, the National Iranian Oil Company, whose unstinting co-operation, generosity and highly efficient handling of the arrangements for the Conference it is my duty and pleasure to acknowledge here. I would also like to address our thanks to the members of the Iranian National Committee and other institutions which collaborated in the preparation of the Conference. May I conclude by formulating the hope that the labours of this Conference will contribute materially to the cause of promoting the economic and social development of the poorer countries of the world.

7. Closing Statement by His Excellency Dr. Manouchehr Eghbal, Chairman of the Conference

The Petrochemical Conference convened by the United Nations has just been concluded. Those of us who took part in the meetings during the last fifteen days have had a unique opportunity to exchange, in an atmosphere of free, frank and cordial discussions, our various experience and technical knowledge relating to the establishment and operation of petrochemical industries. I am convinced that all participants from the developing countries have benefited as much as the Iranian delegation from these discussions and that the latter have been of appreciable assistance in the future implementation of the petrochemical projects which they envisage.

The role and the magnitude of the petrochemical industries in the economy of the oil and gas producing countries has been sufficiently underlined in the course of the discussions. Important plans and programmes for the development of petrochemical industries, production of chemical fertilizers and of various by-products of these industries are in the stage of study and implementation in Iran.

I have the hope that this distinguished gathering of heads of industries, of experts and of official representatives of various Governments who have had the opportunity of familiarizing themselves with the problems of the petrochemical industries in the developing countries, will keep up the contacts established so that these countries will benefit from the co-operation of the industrialized countries in the establishment of their industries.

I regret that other commitments have unfortunately prevented me from attending all the sessions of this Conference. However, I followed the deliberations of this Conference with considerable attention. In this connexion, I am happy to be able to express my thanks to our Vice-Chairmen, Messrs. Vojno Dizdar, Carlos Vanrell, Mustapha Tala, Ahmed Abdul-Rahman Rifai and Ranjit Rai Bahl, for the excellent manner in which they have presided and conducted the discussions. I am particularly grateful to Mr. Lurié and other members of the secretariat of the Conference, whose unforgettable services have contributed to the success of this Conference.

I should also like to express the hope that you will have the opportunity of revisiting our country and renewing the friendly contacts which you have so firmly established here.

ANNEX V

DOCUMENTATION OF THE CONFERENCE

PET/CHEM/CONF.	Title	Author	Language*
1	Provisional agenda		E F S
2	Provisional annotated agenda		E F S
3	Economics of Ammonia Production in the Developing Countries	S. Strelzoff Chemical Construction Corp.	E F
4	Selected Processes for the Production of Basic Chemicals and Intermediates from Petroleum Hydrocarbons	H. Sönksen, Badische Anilin- und Soda-Fabrik J.P. Pelizaeus, Bayer H.K. Kamptner, Farbwerke Hoechst F.A. Wetter, Chemische Werke Hüls W. Munde, Verband der Chemischen Industrie	E F S
5	Economics of Olefin and Diolefin Production	R.G. Craig, L.C. Doelp, A.K. Logwinuk Houdry Process and Chemical Co.	E
6	Benzene by Hydrodealkylation using the Detol Process	R.G. Craig, L.C. Doelp, A.K. Logwinuk Houdry Process and Chemical Co.	E
7	Recent trends in Petrochemical Research and Development	Harold Hart Michigan State University	E
8	Licensing of Process Know-How	Jerry G. Jenkins Cosden Oil and Chemical Company	E
9	Multipurpose Reactor for the Production of Selected Petrochemical Intermediates and End-Products	John B. Sproull Wica Chemicals Inc.	E
10	Market Research - Essential to Petrochemical Development	F.O. Kaupp, R.F. Neu Esso Chemical Company Inc.	E F S
11	Recent Trends in the World Petrochemical Industry	F.N. Baumgartner, P.L. Richards Esso Chemical Co. Inc.	E F S

* E - English, F - French, S - Spanish.

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12	Development of Petroleum-Based Organic Chemicals in India	Harish C. Bijawat Union Carbide India Ltd.	E
13	The Production of Synthetic Fibres on a Petrochemical Basis	P. Seifert Inventa	E F
14	Refining and Petrochemicals Production by the Cosden Oil and Chemical Company	Jerry G. Jenkins Cosden Oil and Chemical Company	E
15	Naphtha Steam Cracking and Utilization of its Products	S. Hayashi and Y. Hirakawa Nippon Petrochemicals Company Ltd.	E
16	Methods for the Preparation of Caprolactam and the Synthesis of Lysine from Caprolactam	Dr. Ir. L.J. Revallier Central Laboratory of Staatsmijnen in Limburg	E F S
17	Styrene Resins for Petrochemical Growth	P.W. Sherwood - Consulting Chemical Engineer, and R.G. Edmonds - The Badger Company Inc.	E
18	The Biosynthesis of Proteins from Petroleum	Alfred Champagnat Société Internationale de Recherches BP	E F S
19	Petrochemicals from Natural Gas - The Lacq Experience	Pierre M. Husson Société Nationale des Pétroles d'Aquitaine	E F
20	Low Density Polyethylene - The World Market	K.E. Cosslett U.S. Industrial Chemicals Co.	E F
21	Financial and Other Problems for Japan's Petrochemical Industry	T. Hirayama Mitsui Petrochemical Industries Ltd.	E
22	Ocean Transportation of Ethylene and Other Basic Intermediates for Petrochemicals	R. Boudet - Gazocéan, and M.H. Gertz - Purvin and Gertz, Inc.	E F S
23	Patents and Licensing in the Petrochemical Industry	S. Kahn Engelhard Industries Inc.	E
24	A Review of the Development of the Petrochemical Industry in the United States and Argentina	C.V. Foster - Continental Oil Co., and W.S. Coe - PASA, Petroquímica Argentina S.A.	E S

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25	Location Factors for the Chemical Industries in Developing Countries	L.H. Nordenson Scientific Design Co. Inc.	E
26	Some Aspects of Finding and Financing Petrochemical Projects	S.H. Chafkin Checchi and Company	E
27	From Crude Oil to Synthetic Fibres - with special considerations of process sequences for polyester-type fibres	D. Natus Lurgi Gesellschaft für Mineralöltechnik mbH	E F S
28	Aromatics: Better to Import or to Produce?	J.W. Andrews and R.E. Conser Universal Oil Products Company	E S
29	Licence Agreements on the Petrochemical Industry	G.M. Brooner and O.D. Edwards Phillips Petroleum Company	E
30	Petrochemical and Carbochemical Processes in Poland within the Period of 1955-67	Konstanty Laidler Ministry of the Chemical Industry of Poland	E
31	Modern Methods for the Production of Aromatics, Olefins and Paraffins	K.H. Eisenlohr Lurgi Gesellschaft für Mineralöltechnik mbH	E F S
32	The Petrochemical Industry as a Key Tool of Economic Development. A Case History: Southern Italy	Società Edison S.p.A.	E F S
33	Problems of Technology and Obsolescence in Petrochemical Industries for Developing Countries	R. Landau Halcon International Inc.	E
34	Nylon	Lewis F. Hatch University of Texas	E
35	Technical and Economic Changes in Ethylene Manufacture	P. Braber Bataafse Internationale Chemie Mij N.V. (Royal Dutch/Shell Group)	E F S
36	Carbon Black Production in Developing Countries	C.A. Polachi, C.A. Stokes and K.A. Burgess Columbian Carbon Company	E
37	Nitrogenous Fertilizers as a Petrochemical Operation	R.M. Reed and C.R. Sloan Girdler Corporation	E F S

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38	Natural Gas as a Raw Material for Petrochemicals	F.B. Kaesmeyer Mobil Chemical Company	E
39	Recent Trends of Petrochemistry in the Macromolecular Field	G. Natta and G. Crespi Institute of Industrial Chemistry Polytechnic of Milan	E
40	Plastics as Construction Materials for Developing Countries	Arthur P. Lien Battelle Memorial Institute	E
41	Use of Natural Gas and Natural Gas Liquids as Petrochemical Feedstock	B.L. Bates and R.G. Boatright Phillips Petroleum Company	E
42	Venezuelan Petrochemical Industry	German Otero Rusanova Instituto Venezolano de Petroquímica	E S
43	Experiences Acquired During a Study for an Acrylonitrile Plant	Mario Galán-Gómez Empresa Colombiana de Petroleos	E S
44	The Beginning of Petrochemical Industry in Colombia. The Recovery of Ethylene and Propylene and the Planning of a Polyethylene Plant	Mario Galán-Gómez Empresa Colombiana de Petroleos	E S
45 (46)	Petrochemical Industries in Chile	Juan Tampier Corporación de Fomento de la Producción	E (S)
47	La Industria Petroquímica en la República Argentina	O. Gatti - Dirección General de Fabricaciones Militares R. Beltramino - Secretaria de Industria y Minería E. Pasquinelli - Yacimientos Petrolíferos Fiscales	S
48	Petrochemical Country Studies - Burma	Tin Maung Aye and Kyaw Sein People's Oil Industry	E
49	Synthetic Substitutes of Natural Materials through Petroleum Feedstocks	D.M. Trivedi Synthetics and Chemicals Ltd.	E
50	Technical and Economic Aspects of the Fertilizer Industry in Pakistan	Y.N. Kanaan Chemical Engineer	E

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51	Acrylic Fibres	Y. Tsunoda Asahi Chemical Industry Co. Ltd.	E
52	The Newer Synthetic Rubbers	T.K. Roy Scientific Design Co. Inc.	E
53	Mono and Polyvinyl Chloride	R.M. Brown and H.A. Huckins Scientific Design Co. Inc.	E
54	Development of a Synthetic Fibre Industry, as for example Nylon-6, in Developing Countries	F. Thormann Hoechst-Uhde International GmbH	E
55	Petrochemical Industry in East Pakistan	S.A. Momen East Pakistan Industrial Development Corp.	E
56	Recent Trends in the Ammonia Industry in Japan	S. Kodama Sumitomo Chemical Co. Ltd.	E
57	Polyester Synthetic Fibre Materials for Developing Countries	D. Brown Halcon International Inc.	E
58	Acrylonitrile-Butadiene-Styrene Copolymers	T.E. Ronay Marbon Chemical Company	E
59	Growth of Plastics in Developing Countries	B.S. Garud, S.K. Subbaroyan and P. Vachani Delhi Cloth and General Mills Co. Ltd.	E F
60	Recent Trends in Research and Development in the Petrochemical Industry	N. Beredjick United Nations Centre for Industrial Development	E
61	The Economic Aspects of Development of the Petrochemical Industry in the USSR	N. Fedorenko Central Institute of Mathematical Economics of Moscow	E
62	Country Studies - Malaysia	Lim Ho Pheng Department of Chemistry F/M	E
63	Realization of Fertilizer Production in a Developing Country	Juan Ayllon V. and Jorge Otero R. - YPFB, La Paz L.C. Axelrod, L.E. Bostwick and B.G. Mandelik - The M.W. Kellogg Company	E

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64	Developing the Petrochemical Potentials of North Africa and the Persian Gulf	H.K. Nieuwenhuis Chemical Projects Associates Inc. - United Nations Centre for Industrial Development	E
65	The Petrochemical Industry of Trinidad and Tobago	D.H.N. Alleyne and E.L. Bertrand Ministry of Petroleum and Mines	E
66	Industry Studies - China (Taiwan)	Te-Lin Yu and Shu-Hsun Ting Chinese Petroleum Corporation	E
67	The Economics of International Distribution of Anhydrous Ammonia	A.G. Bruno W.R. Grace and Company	E
68	Factors Influencing the Location of a Petrochemical Plant	P.C. Livesay American Oil International Co.	E F
69	Development of the Petrochemical Industry in the ECAFE Region	The Secretariat of the Economic Commission for Asia and the Far East	E
70	Development of the Petrochemical Industry in Europe: Its Problems and Potentialities	Secretariat of the Economic Commission for Europe	E
71	Synthetic Rubber - as related to Petrochemical Production in Developing Countries	D.F. Othmer Polytechnic Institute of Brooklyn	E
72	Petrochemical Industry - Peru	Héctor de Souza Reategui Empresa Petrolera Fiscal del Perú	S E
73	Production of Basic Petrochemicals from Heavy Oils via the H-Oil Process	A.R. Johnson and S.W. Ehrlich Hydrocarbon Research Inc.	E
74	The Mexican Government and the Petrochemical Industry in Mexico	Petróleos Mexicanos (PEMEX)	E
75	Natural Gas Reserves in Mexico as a Factor of the Social and Economic Development of the Country by Means of Nitrogenous Compounds	Petróleos Mexicanos (PEMEX)	E
76	Structure of Petrochemical Development in Mexico - Reynosa and Pajaritos Developments	Petróleos Mexicanos (PEMEX)	E

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77	Petrochemical Industry - Turkey	H. Bezmen Ministry of Energy and Natural Resources	E
78	Petrochemical Industry - Syrian Arab Republic	Y. Tabaa - General Petroleum Authority H. El-Aass - General Organization for the Implementation of Industrial Projects	E
79	The Pattern of Raising Funds in the Petrochemical Industry in Japan	S. Irie and T. Kotera The Industrial Bank of Japan Ltd.	E
80	Processes for Production of Concentrated Fertilizers	H. Banthien Hoechst-Uhde International GmbH	E F
81	Plastics Progress	J.M. Goppel Shell International Research Mij, N.V.	E F S
82	Petrochemistry and Polymer Production	H.F. Mark - Polytechnic Institute of Brooklyn S.M. Atlas - Bronx Community College, City University of New York	E
83	Petroleum - A Major Source of Sulphur	Gino P. Giusti Texas Gulf Sulphur Company Inc.	E
84	Synthetic Fibres of Polyamides	J. Laub Hans J. Zimmer AG	E
85	The Petrochemical Industries - Section I	Institut Français du Pétrole, for the United Nations Centre for Industrial Development	E
86	The Petrochemical Industries - Section II	Institut Français du Pétrole, for the United Nations Centre for Industrial Development	E
87	New Trends in Research and Development of the USSR Petrochemical Industry	V.A. Khodakovskaia State Committee on Petrochemical Industry	E
88	Applications of Petrochemical-Based Plastics in Developing Countries	A.L. Griff Edison Technical Services Inc.	E

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89	Optimum Combination of Petroleum Refining and Petroleum Chemistry Processes	R.G. Ismailov Azerbaijan Academy of Sciences	
90	Recent Trends in Production, Consumption, Trade and End-Uses in Selected Petrochemical Products	United Nations Centre for Industrial Development	E
91	Application of Advanced Technology to Developing Countries for Basic Petrochemical Intermediates	H.R. Shawk and D.L. Caldwell The Lummus Company	E F S
92	Petrochemical Industry in Yugoslavia	V. Dizdar and K. Mirkov - Federal Office for Economic Planning C. Jenic - Federal Secretariat of Industry	E
93	Ammonia Manufacture from Petroleum Feedstocks	A. de Picciotto and G. Sweeney, Jr. Arthur D. Little Inc.	E
94	The Role of Foreign Investment in Petrochemical Manufacture	Business and Industry Advisory Committee to the Organization for Economic Cooperation and Development	E F S
95	Planning of the Chemical Industries at the National Level	T. Vietorisz International Business Machines and The New School for Social Research	E
96	Prospects of Development of Petrochemical Industries in India and Other Countries of Asia and the Far East	G.P. Kane Ministry of Industry and Supply, New Delhi, for the United Nations Centre for Industrial Development	E
97	New Vinyl Chloride Process	S. Gomi Kureha Chemical Industry Co.	E
98	Characteristics and Prospects of Petrochemical Industry - with an emphasis on the Yokkaichi Complex in Japan	T. Yano Mitsubishi Petrochemical Co. Ltd.	E
99	Production of Aromatics from Petroleum in Japan	I. Watanabe Japan Gasoline Company Ltd.	E F
100	The Petrochemical Industry in Brazil	E.O.M. Brandão, J.B. de Madeiros and O.T. Peckolt Petróleo Brasileiro S.A.	E S

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101	Plant Size, Location and Time-Phasing - Introduction	Alan S. Manne M.I.T. Centre for International Studies	E
102	Plant Size, Location and Time-Phasing - The Nitrogenous Fertilizer Industry	P.N. Radha Krishnan - Perspective Planning Institute T.V.S. Rama Mohan Rao - Indian Statistical Institute Alan S. Manne - M.I.T. Centre for International Studies	E
103	Olefins vs. Acetylene - Competitive Raw Materials for the Petrochemical Industries in Developing Countries	D.F. Othmer Polytechnic Institute of Brooklyn	E
104	La Industria Petroquímica en Ecuador	Galo H. Salvador G. Junta Nacional de Planifacción y Coordinación Económica	S
105	Financing of Petrochemical Ventures in Developing Countries	United Nations Centre for Industrial Development	E
106	Summaries of Working Papers Contributed to the United Nations Inter-Regional Conference on the Development of Petrochemical Industries in Developing Countries		E F S
107	The Role of the Domestic Market in the Development of Petrochemical Industries and the Need for Exports in Relation to Economies of Scale	United Nations Centre for Industrial Development	E
108	The Evolving Pattern of Petrochemical Industry in India with particular reference to Gujarat and Bombay Regions	B. Sreenivasan - Sarabhai Group of Industries, and H.T. Bhavanani - Calico Mills	E
109	Petrochemical Developments	J.W. Woolcock Imperial Chemical Industries Ltd.	E
110	The Development of the Petrochemical Industry in Israel	Joseph C. Löbel and Benjamin Toren Ministry of Commerce and Industry	E

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111	Production of Ethylenic Hydrocarbons by Cyclic Cracking	A. Roche - Office National Industriel de l'Azote J. Lemaire - G.E.G.I. Company	E F
112	Hydrocarbons Steam Reforming, in Tubes, for Production of Synthesis Gas or Hydrogen	A. Roche - Office National Industriel de l'Azote J. Lemaire - G.E.G.I. Company	E F
113	Contribution to the Manufacture of Polyester Fibres and Plasticizers	ANTAR Pétroles de l'Atlantique	E F
114	Contribution de la Pétrochimie à la Defense des Cultures	A. Charlet Société Progil	F
115	General Characteristics of Petrochemical Industries and Factors Conditioning their Development	United Nations Centre for Industrial Development	E
116	The Petrochemical Industry in Iran	National Iranian Oil Company	E
117	Planning of the Calvo Sotelo Integrated Oil Refinery and Petrochemical Complex	A.L. Dowling and T.E. O'Hare The M.W. Kellogg Company	E
118	The Role of the International Finance Corporation in Promoting Industrial Ventures in Developing Countries	J. Chanmugam - on behalf of the International Finance Corporation	E
119	The Economics of Coal-Chemistry vs. Petrochemistry	Special Fund - United Nations	E
120	La Industria Petroquímica en América Latina	Comisión Economica para América Latina	S
121	The Possibilities for Developing Petrochemicals in Libya	B. Mangush Ministry of Petroleum Affairs	E
122	Petrochemical Industry in Indonesia	Sukasimir Department of Basic Industry and Mining	E
123	List of Conference Participants		E
124	List of Conference Documents		E

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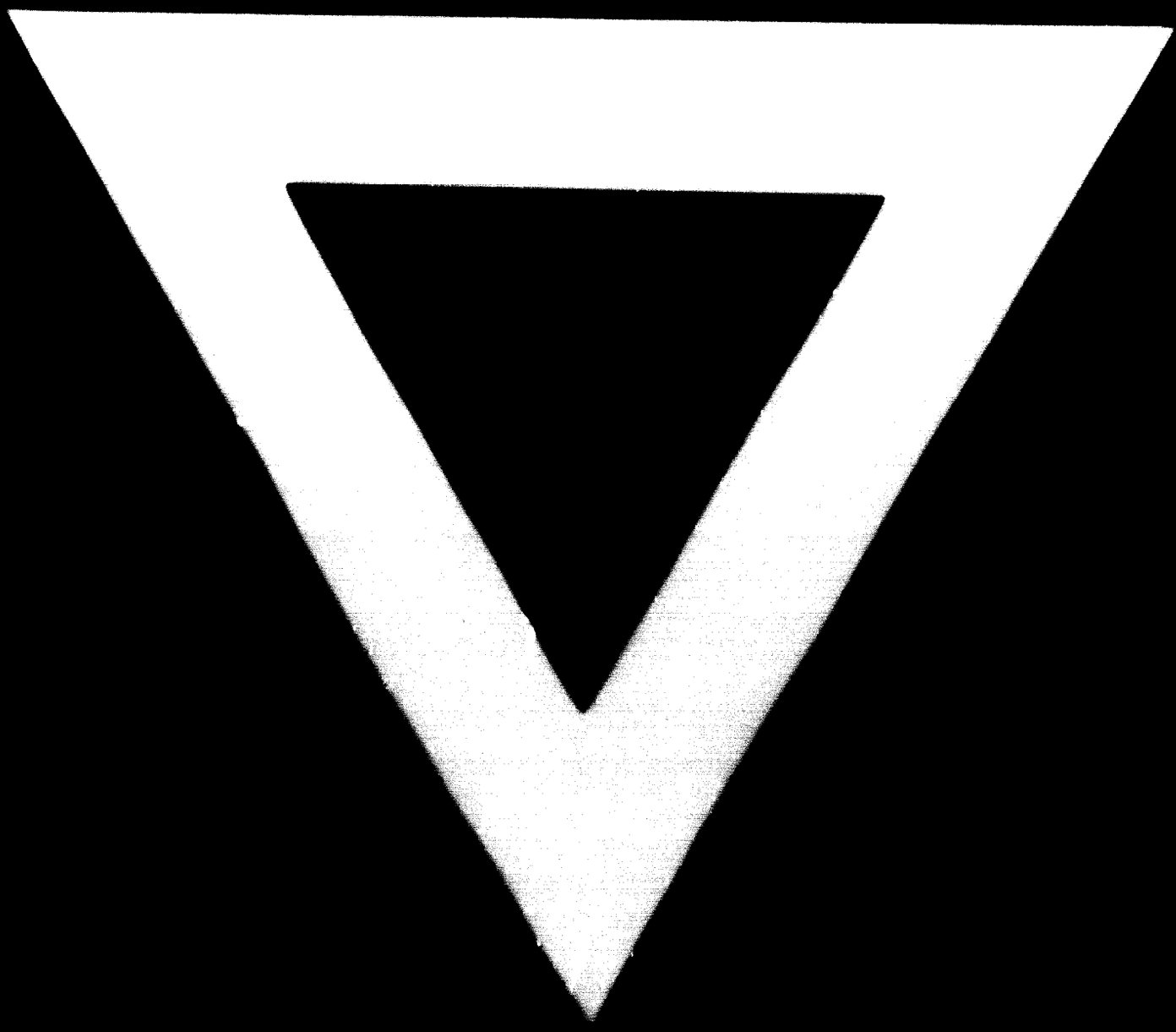
125	Natural and Synthetic Alcohol as Competitive Raw Materials	M. Magnat Groupe Centrale de Dynamite, Nobel-Bozel	E
126	Natural Gas in Kuwait and its Utilization	F. Mazidi Kuwait Chemical Fertilizer Co.	E
127	Country Study - Morocco	M. Tala S.A.M.I.R.	F
128	Country Study - United Arab Republic	M. El-Halfawy Industrialization Organization	E
129	Country Study - Saudi Arabia	I. Habbash Ministry of Petroleum and Mineral Resources	E
130	Country Study - Romania	I. Ghejan - L'Institut de Recherches PETROCHIMIE I. Marinescu - Ministère de l'Industrie du Pétrole et de la Chimie	E
131	Country Study - India	Ranjit Rai Bahl Ministry of Petroleum and Chemicals	E
132	Development of Japan's Petrochemical Industry	H. Adochi and H. Yonaga Ministry of International Trade and Industry	E
133	Country Study - Uruguay	C. Vanrell and M. Cratzmar ANCAP	E
134	Training of Manpower	A.E. Laurence United Nations Educational, Scientific and Cultural Organization	E



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