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Athens, 29 November-20 December 1967
Provisional agenda, item 2

SECTORAL STUDIES PREPARED FOR THE SYMPOSIUM:

CHEMICAL INDUSTRY

Presented by the Executive Director
of the United Nations Industrial
Development Organization

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Corrigendum

Page 5, paragraph 3:

Change the first part of the second sentence to read as follows:

"These figures contain a margin of about $700 million (1960) to about $3,000 million (1965) ..... "

Page 26, paragraph 78:

In the first sentence, change "dodecene" to read "dodecanes".

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Introduction

1. The chemical industry is one of the dynamic sectors of a modern industrial economy; on the average, it has a growth rate about two-thirds higher than that of the national economy. The dynamic nature of the industry is also manifest in the rapid pace of technological change, which is one of the outstanding characteristics of this industry. The nature of its processes and products is in continuous transition, and the amount of expenditures on research and development, as well as the role which these activities play in management decisions, places it among the most "research-minded" of the industrial sectors.

2. The chemical industry occupies an important place in the framework of industry as a whole. It converts raw materials provided by other sectors of the economy, e.g., mining, oils, agriculture etc., into products used by other industries such as textiles, automotive industries and the chemical industry itself. In fact, nearly all industries producing consumer goods need, directly or indirectly, the products of the chemical industry. In recent years, some direct products of the chemical industry have also become consumer goods, such as plastics, synthetic fibres and rubbers. As the chemical industry becomes more versatile, this tendency is likely to be accentuated. Furthermore, some products of the chemical industry, such as fertilizers and pesticides, have a direct bearing on the efficiency of agriculture, which remains the primary sector of the economy in many developing countries.

I. RECENT TRENDS AND FUTURE DEVELOPMENTS

World production of chemicals[1/]

3. The world production of chemicals is estimated at about $73,000 million in 1960 and at about $115,000 million in 1965. These figures contain a margin of over $700,000 million (1960) to $2,000 million (1965) when compared to the total sums obtained in table I (see annex). This margin comprises all countries not listed in the table, especially China (mainland), for which an estimate of the production value of the chemical industry was not possible for lack of statistical data.

4. As sufficient statistical data are available in the countries which account for about 90 per cent of the world production of chemicals any errors in the estimate are considered to be small. The conversion into US dollars was based chiefly on the official rates of exchange and, in some cases, equivalent to the purchasing power of the currency concerned.

5. The definition of the "chemical industry" is based on the following Standard International Trade Classification (SITC) groups:

Group 5	Chemistry
Completed by	
Groups 266.651.611-23.651.711.211	Man-made fibres
895.241-290 895-911-970	Office supplies
862.300 862.4-5	Photochemical equipment
899.310-339	Candles, inflammables etc.
411.341-43, 431.100-319	Fatty acids etc.
671.4-5	Ferroalloys
231.-2	Synthetic rubber

1/ Three basic difficulties exist in presenting the world production values, namely, lack of or insufficient statistical data on some countries, the necessity of converting various national monetary data into one uniform currency, and different definitions of the chemical industry by various national and international organizations.

As far as possible, the official data on the production values of the chemical industry were taken from national statistics, reports of federations, chambers of commerce, etc. Where these values were missing, the quantities of all chemical products, as far as statistically available, were multiplied by the average world market prices. The rest of the production which was deemed probable was estimated, on the basis of knowledge of the structure of production in the various countries.

Per capita production and industrial development

6. The table below shows the per capita production of the various economic areas in 1960 and 1964.

Table 1

Per capita production, 1960 and 1964

	1960	1964
	(US dollars)	
World[a/]	30.6	40.3
Africa	2.3	3.1
Developing countries	1.3	1.8
America	81.0	96.7
Latin America	9.9	13.6
North America	157.0	189.8
United States of America	166.2	199.4
Asia[a/]	5.1	8.1
Japan	44.1	73.3
Developing countries	1.2	1.8
Europe	50.7	72.1
Western Europe	73.6	98.5
EEC countries[b/]	83.7	113.3
EFTA countries[c/]	85.1	106.3
Eastern Europe	29.7	47.5
Union of Soviet Socialist Republics	26.6	44.3
Oceania	43.2	52.9

a/ Excluding China (mainland).

b/ Belgium, France, Federal Republic of Germany, Italy, Luxembourg, Netherlands.

c/ Austria, Denmark, Norway, Portugal, Sweden, Switzerland, United Kingdom.

Table 2

Production of chemicals per capita and per year (1964) in developing countries

	Up to $5	$	Up to $10	$	Up to $20	$	Up to $30	$
Region								
Asia	Rest[a/b/]	0.3	Philippines	5.4	Taiwan	12.8		
	Burma	0.5						
	Indonesia	0.5						
	Pakistan	0.6						
	Thailand	0.6						
	Iran	1.4						
	Korea, Rep. of	1.7						
	India	1.9						
	Viet-Nam, Rep. of	2.0						
	Turkey	2.8						
Region								
Latin America	Rest[a/]	3.0	Colombia	7.3	Peru	10.2	Argentina	21.8
			Uruguay	8.5	Brazil	15.1	Mexico	22.8
			Chile	9.4			Venezuela	26.8
Region								
Africa	Rest[a/]	0.6			United Arab Republic	12.5		

a/ The rest includes all developing countries of the region in question except the countries mentioned specifically.

b/ Excluding Israel. In 1960, Israel's per capita production of chemicals amounted to $42.9, in 1964 to $60.0. It is thus only slightly below that of Japan ($44.1 and $73.3) and cannot, therefore, be classed with the developing countries listed in table 5.

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7. All developing countries of the three regions - with the single exception of Israel - had a production of chemicals of less than $20 per capita of the population per year in 1960 and less than $30 per capita per year in 1964. Some of the European countries also belong in that category.

8. In 1964, most of the developing countries showed a per capita production of less than $10; only four developing countries figured between $10 and $20, only three between $20 and $30. These figures show the different stages of development of the chemical industry in the developing countries in relation to their population (cf. table 2). They also indicate the problems encountered during the industrialization in the chemical sector of the various countries.

Production, foreign trade and consumption of chemicals

9. The table below summarizes the production, foreign trade and consumption of chemicals in developing countries. It can be seen from the table that in 1960, the imports of chemicals of developing countries amounted to $2,096 million, corresponding to 59.7 per cent of the total production of these countries, namely, $3,513 million. In 1964, the imports of chemicals increased to $2,877 million, but the percentage decreased to 52.2 of the total production of chemicals ($5,511 million).

10. In the same period, the exports of developing countries rose from $350 million to $478 million, an increase of 36.6 per cent. The import surplus over export increased from $1,746 million to $2,399 million, that is, by 37.4 per cent. Hence, the net consumption of chemical products rose from $5,259 million to $7,910 million, that is, by 50.4 per cent. In 1960, the imports of chemicals had a share of 39.9 per cent of the consumption, and in 1964 a share of 36.4 per cent.

11. Tables 3 and 4 show marked differences in imports and exports in the various regions. Imports differed not only significantly in value, but also in their ratios to production and consumption.

Table 3

Production, foreign trade and consumption of chemicals in developing countries

	Imports	Exports	Import surplus	Production	Consumption	Unit
1960						
Africa	359	26	333	330	663	million $
Asia	831	80	751	1,073	1,824	million $
Latin America	906	244	662	2,110	2,772	million $
Total	2,096	350	1,746	3,513	5,259	million $
Share of Africa	17.1	7.4	19.1	9.4	12.6	per cent
Share of Asia	39.7	22.9	43.0	30.5	34.7	per cent
Share of Latin America	43.2	69.7	37.9	60.1	52.7	per cent
1964						
Africa	520	47	473	505	978	million $
Asia	1,095	127	968	1,776	2,744	million $
Latin America	1,262	304	958	3,230	4,188	million $
Total	2,877	478	2,399	5,511	7,910	million $
Share of Africa	18.1	9.8	19.7	9.2	12.4	per cent
Share of Asia	38.1	26.6	40.4	32.2	34.7	per cent
Share of Latin America	43.8	63.6	39.9	58.6	52.9	per cent
Increase 1960/1964						
Africa	44.8	80.8	42.0	53.0	47.5	per cent
Asia	31.8	58.8	28.9	65.5	50.4	per cent
Latin America	39.3	24.6	44.7	53.1	51.1	per cent
Total	37.3	36.6	37.4	56.9	50.4	per cent

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Table 4

Ratio of imports in production and consumption in the three regions

	ratio of imports to production	share of imports in consumption	ratio of imports to production	share of imports in consumption
	1960		1964	
Africa	108.8	54.1	103.0	53.2
Asia	77.4	45.6	61.7	39.9
Latin America	42.9	32.7	39.1	30.1
Total	59.7	39.9	52.2	36.4

Changes in structure of chemical industry

12. The most important products of the chemical industry in the industrialized countries are:

Inorganic and organic basic chemicals

Fertilizers

Plastics

Man-made fibres

Pharmaceuticals

Paints, varnishes, mineral colours, pigments, soaps, detergents, cosmetics.

They comprise more than 80 per cent of the total chemicals.

13. Production values of the various branches are available for most industrialized countries, but not always for the same years. Basic changes in the structure of branches always extend over a longer period than is dealt with in this study (1960-1965). In order to give a survey of such changes, the mean values of the early fifties (1950-1953) have been compared to the mean values of the early sixties. During this period, there occurred the most radical changes in the development of the chemical industry of the last two decades, such as, with regard to raw materials, the transition from coal to oil and natural gas; and, with regard to production, the enormous progress in plastics and synthetic fibres, the new development of numerous insecticides and pesticides, the advance of synthetic detergents, basic changes in the pharmaceutical sector etc.

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14. Average values for period I (early 1950's) and period II (early 1960's) have been ascertained for the countries of the European Economic Community (EEC),[2/] Great Britain, Norway, Sweden, Poland, the Soviet Union (on the basis of estimated values), Japan and the United States (see table 5). In period I, these countries had an average share of 87.5 per cent in world chemical production and in period II, 84.2 per cent. They are considered representative of the structure of the chemical industry in the world.

15. There is no general rule for the structure of the chemical industry which can be applied to all developing countries. Each country has to develop its industry according to its specific conditions, rather than to aim for a complete range of chemical products.

16. In order to illustrate the diversified structure of the chemical industry in the countries mentioned, table 5 shows not only the average values, but also the minimum and maximum values of the shares attributed to the branches in the two periods. This shows the far-reaching development potentials of the chemical industry.

2/ The EEC countries are Belgium, France, the Federal Republic of Germany, Italy, Luxembourg and the Netherlands.

Table 5

Shares attributed to the main chemical branches (in percentages)

	Period I[a/]			Period II[b/]		
	Average share	Minimum share	Maximum share	Average share	Minimum share	Maximum share
Inorganic industrial chemicals	14.4	7.0	42.6	16.4	9.4	26.3
Organic industrial chemicals	12.8	0.7	14.9	15.0	5.6	24.5
Fertilizers	6.3	4.1	27.5	5.5	4.3	21.8
Plastics	4.9	0.7	7.1	9.9	4.1	12.3
Man-made fibres	7.1	2.0	10.6	7.3	3.9	15.0
Varnishes, paints, printing inks, mineral colours, pigments etc.	6.5	3.0	15.3	8.4	2.9	11.5
Pharmaceuticals	9.2	2.0	13.0	10.5	2.5	13.0
Soaps, detergents, cosmetics	12.0	2.3	20.8	10.1	2.5	12.5

a/ Early 1950's.

b/ Early 1960's.

17. In developing countries, it is possible only in a few cases to ascertain the structure of the chemical industry. For the Latin American countries, the data of the shares attributed to these branches are based on the figures of 1959, which were extrapolated to 1965 and 1970 (cf. La industria química en America Latina).[3/]

18. In table 6 below, the average values of Argentina, Brazil, Colombia, Chile, Mexico, Peru and Venezuela are presented with the corresponding minimum and maximum values for the three years.

3/ La Industria Química en America Latina. Economic Commission for Latin America, document E/CN.12/628/Rev.1, United Nations publication, Sales No.: 64.II.G.7.

Table 6

Shares attributed to the main chemical branches in Latin America
(in percentages)

	1959			1965			1970		
	Average	Minimum share	Maximum share	Average	Minimum share	Maximum share	Average	Minimum share	Maximum share
Inorganic industrial chemicals	4.2	1.8	5.6	6.8	4.2	10.6	7.2	4.8	9.4
Organic industrial chemicals	5.9	1.4	10.4	7.8	2.0	11.3	8.0	4.8	10.4
Fertilizers	7.0	5.0	11.1	6.9	4.1	10.0	6.7	3.8	9.4
Plastics	5.3	2.6	9.0	6.4	5.6	6.8	8.5	7.4	8.9
Man-made fibres	7.5	6.1	9.0	13.1	9.9	15.1	15.2	10.5	18.5
Varnishes, paints, printing inks etc.	8.7	7.2	11.8	7.9	6.5	12.3	7.3	5.8	11.9
Pharmaceuticals	17.5	15.4	24.2	13.4	11.4	17.4	11.9	9.7	16.1
Soaps and detergents	21.3	15.6	25.8	15.9	13.5	18.7	13.6	12.1	15.6

19. The year 1959 of table 6 corresponds to period I of table 5. The most striking deviations concern industrial chemicals, which show a considerably smaller average percentage in the Latin American countries than in the industrial countries dealt with in table 5. The differences in other sections are less significant; the percentages in man-made fibres and varnishes etc. are, to a large extent, on a uniform level. Plastics and man-made fibres, which are particularly important as consumer goods, were produced from imported intermediates. The backward integration towards the production of the intermediates had not yet started, and this is reflected by the low percentage of the organic industrial chemicals.

20. Far above the average of the industrialized countries are the percentages of pharmaceuticals and of soaps and detergents. Although the latter group does not comprise cosmetics (as it does in the corresponding group of table 5), its percentage was more than twice as high in the Latin American countries than, on an average, in the industrialized countries listed in table 5.

21. The marked preponderance of pharmacentical and soap production is typical of many developing countries. Soap is produced in almost all of these countries, which are usually rich in vegetable oils and fats. The methods of production of pharmaceuticals based on domestic medicinal herbs, as well as on imported drugs processed by existing formulating plants, are well known in developing countries.

22. A typical example, for which sufficient data are available, is India. In 1962, the share of pharmaceuticals amounted to 29.9 per cent, that of soaps to 34.1 per cent. Together, these two branches reached a percentage of 64. The small share of 0.2 per cent attributed to organic industrial chemicals shows that, in 1962, modern chemical production was still at the beginning.

23. Tables 5 and 6 show a development trend which essentially is expected to continue until 1975 and to influence the development in developing countries. This trend is marked by the following characteristics.

24. The percentage of organic industrial chemicals will rise in all countries that pursue systematic industrialization in the chemical field. This evolution is a necessary result of the expansion of petrochemistry, which is under way or planned in most of the larger countries. Because of regional conditions, the extent of this growth will vary from country to country. It is to be expected, however, that the trend will move towards a share of 7-8 per cent in all countries which are now below this percentage but which are pursuing the expansion of petrochemistry.

25. The share of the inorganic industrial chemicals is expected to rise more slowly than that of organic industrial chemicals.

26. The percentage of plastics will also increase. To a certain extent, their growth will probably run on parallel lines with that of the organic industrial chemicals from which the plastics intermediates are produced.

27. For the Latin American countries, it is expected that until 1970, the average share of plastics in chemical production will amount to 6.5 per cent. Until 1975, an increase to about 9 per cent may be reached.

28. In the Asian developing countries, this percentage will, on average, not be reached until probably 1975. In some of these countries, which pay particular attention to this sector in their planning, it may be possible to reach a similar value at an earlier date, but only under optimum conditions for expansion.

29. In the developing countries of Africa where data on the 1965 plastics production were not yet available for this study, the share attributed to that branch is probably below 3 per cent.

30. In 1965, the share of the developing countries in the world plastics production was below 2 per cent; it is not expected to increase considerably until 1975.

31. The share of man-made fibres is likely to rise. The planning pursued in the Latin American countries is symptomatic of this trend; they show an average share of 15.2 per cent. In 1965, the average share of the Asian developing countries - excluding China (mainland) - amounted to about 7 per cent, that of the African developing countries to nearly 2 per cent.

32. The share attributed to pharmaceutical production will probably show a slight decrease, as the logical consequence of the growth of the other branches. In 1965, the production of pharmaceuticals in the developing countries amounted to 19.6 per cent of the total chemical production. In Latin America, a decrease to 11.9 per cent is expected until 1970, compared with 17.5 per cent in 1959. The decrease expected in the region of Asia is not nearly as sharp, although the high percentage of 24.9 in 1959 will probably not be maintained. In the region of Africa, an increase of the percentage is very probable. The average share of the developing countries is estimated at 16-17 per cent in 1975.

33. It is anticipated that the percentage of the soap production will decrease more sharply. Soap is produced in most of the developing countries for home demand and, therefore, the growth rates are essentially influenced by the size of the population and the standard of living. In 1965, the average share in the production of chemicals of the developing countries amounted to about 23 per cent. A share of about 15-16 per cent in 1975 seems probable.

34. The share of paints and varnishes and similar products may, on an average, rise to a certain extent in the developing countries. In the developing countries of the three regions, the share of this branch amounted, on an over-all average, to about 10 per cent; an increase to about 11.5 per cent until 1965 is considered possible.

35. The share of fertilisers will probably increase, but it is not within the scope of this study to deal with this development.

II. PRODUCTION TRENDS AND SELECTED PROBLEMS IN THE MAIN BRANCHES OF THE CHEMICAL INDUSTRY

Basic chemicals

36. The raw materials of the chemical industry are products which undergo chemical change to produce chemicals. A chemical industry will often use its own products as starting points for further chemical changes. Thus, in the chain of chemical changes, many chemicals can be both products and raw materials at the same time. It is therefore convenient to refer to chemicals used as starting points as "basic chemicals".

37. Basic chemicals are the commodities produced in greatest quantities in the developed countries. They are manufactured in the largest scale and with the maximum economy. Profit margins are narrow. Inherently, therefore, the scope in this field for developing countries may appear at first sight to be relatively small.

38. Developing countries do, however, possess certain natural advantages such as:

(a) The distance from external source of supply and the time-lag in supply may impose heavy charges on goods of foreign origin and, thereby, provide automatic protection to a local industry.

(b) Raw materials are often available at low cost.

(c) The availability of unskilled labour, although less of an advantage than in times past, is still a factor to be considered.

Basic inorganic chemicals

39. The most important inorganic chemicals are:

Acids - sulphuric, hydrochloric, nitric and phosphoric
Alkalis - soda ash, caustic soda
Calcium carbide
Chlorine
Ammonia

40. Sulphur: The sulphur industry has been subjected to wide fluctuations in prices over the past twenty-five years. In September 1964, the export list price for bright sulphur was $25.50 per ton f.o.b. Gulf of Mexico. Prices have risen steadily, until in September 1966, the price was $39.00 per ton. In 1966, 27.8 million tons of sulphur were consumed in the Western countries, 6 per cent more than in 1965. Price increases are unlikely to slow down until 1969.

41. Sulphur sources are: (1) brimstone - sources like Frasch sulphur in Mexico and the United States, sour gas, petroleum oils, native sulphur etc; (2) pyrites - iron, copper, lead, zinc etc.; (3) coal gas; (4) anhydrite and gypsum.

42. Frasch sulphur is manufactured by steaming out subterranean sulphur deposits with superheated steam. Only Mexico and the United States have sufficiently large deposits for this process. Sulphur is recovered from natural gas, mainly in the United States, France and Canada. These three countries produced 67 per cent (1961) and 90 per cent (1964) of the world's production of sulphur from natural gases. The reserves of the oil sands of Canada are estimated to contain 1,000 million tons of sulphur, and there are other quantities of such deposits around the world.

43. The United States, Canada, Mexico and France produced in 1965 about 53.5 per cent of the world's output, with the United States alone producing 30-35 per cent. Total exports of sulphur rose from 5.2 million tons in 1963 to 6.3 million in 1964 and an estimated 7 million tons in 1965.

44. Except for Mexico, no developing country has a substantial production of sulphur, and developing countries must continue to depend on imports even in the future. Most (85 per cent) of the world's sulphur is used for the manufacture of sulphuric acid, and the rest is absorbed by paper, carbon disulphide, pesticides and miscellaneous uses. Table II (see annex) gives the world production of sulphur from 1960 to 1964.

45. Salt: Commercial salt is produced by three methods: mining, solar evaporation of sea water, and evaporation of underground brines. In the developing countries, solar evaporation is of special importance. In 1965, world salt production exceeded 100 million tons, and is growing at the rate of 4.4 per cent (see table III in the annex). Salt is mainly used in the alkali industries.

46. Phosphates: The main primary minerals are chlor-apatite and fluorapatite, containing 40-42 per cent phosphorous pentoxide (P_2O_5). However, more than 95 per cent of the phosphates mined comes from secondary deposits, mainly phosphorite. The main deposits are in the United States, North Africa and Central Asia, but other economically important deposits occur in the Caribbean and some of the Pacific Islands. Recently, extensive deposits have been located in Africa (Congo (Brazzaville), the Sahara, Senegal, South Africa, Togo, Uganda); Latin America (Brazil, Mexico, Venezuela); Asia (China (Taiwan), Israel, Jordan, Siberia,

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Syria, Republic of Viet-Nam). The reserves exceeded 200,000 million tons of phosphate, with content of greater than 60,000 million tons P_2O_5. About 53 per cent of the phosphate reserves occur in Africa, 26 per cent in America and 12.5 per cent in the USSR. World production of phosphate rock in 1965 was 65 million tons (see table IV in the annex). Prices have risen since 1960, but not as sharply as for sulphur. The main producing countries are Morocco, the United States, USSR, Tunisia and Oceania. Morocco alone produces 33 per cent. World exports were 27.7 million tons in 1964 and 29 million tons in 1965.

47. Sulphuric acid: World production was 72 million tons in 1965, and is growing by 9.5 per cent per year, more rapidly than most other chemicals (see table V in annex).

48. The production of sulphuric acids in developing countries is rapidly increasing at a rate of 11.7 per cent. The main raw materials for the manufacture of sulphuric acid are sulphur, pyrites, smelter gas and anhydrite. More than 50 per cent of the manufacture in 1966 was based on elemental sulphur. Metal smelteries are recovering more and more of the sulphuric acid content of their flue gases. Developing countries with large deposits of gypsum or anhydrite may use them for production of sulphuric acid and cement. This gypsum-based process yields the cheapest sulphuric acid of all processes although the initial cost of the plant is highest. Comparative cost data are given in table VI (see annex). Most sulphuric acid was used to make fertilizers, while its use in making fibres is decreasing.

49. Alkalis: In 1965, world production was 17.5 million tons of soda ash, 16.4 million tons of caustic soda and 14 million tons of chlorine. Chlorine has come into prominence recently, and its use is growing very rapidly. The share of developing countries in soda ash production has risen from 2.7 per cent in 1960 to 4.5 per cent in 1965. No significant development in the technology has recently taken place.

50. Caustic soda: The production of caustic soda is increasing three times as fast as soda ash, and this is largely due to the demand for chlorine. Hence, the causticization process of making soda is gradually decreasing. However, where chlorine does not find profitable use, it is better to follow the causticization process (see table 7 below). The share of developing countries has increased from 3.3 per cent in 1960 to 4.5 per cent in 1965. The viscose rayon, pulp and

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aluminium industries are the main customers for caustic soda. The future growth of the caustic soda industry in developing countries is therefore dependent on the development of those industries.

Table 7

World production of caustic soda

(1,000 metric tons)

	1960	1961	1962	1963	1964	1965
World total	11,300	11,700	12,700	13,900	15,200	16,400
America	5,067	5,056	5,623	6,007	6,447	7,034
Latin America	216	239	256	294	308	351
North America	4,851	4,817	5,367	5,713	6,139	6,683
Asia	1,011	1,125	1,186	1,333	1,561	1,673
Europe	4,856	5,050	5,362	5,929	6,486	6,859
Western Europe	3,317	3,355	3,532	3,879	4,256	4,531
Eastern Europe	1,539	1,695	1,830	2,050	2,230	2,328
Australia	49	49	52	61	68	81

51. Chlorine: The use of chlorine has increased thirty-fivefold between 1930 and 1965, and in 1965 the production reached a total of 14.3 million tons, with a growth rate of 10.8 per cent (see table VII in annex). Developing countries produced 3.7 per cent of the world total. Most of the chlorine is manufactured by electrolysis of common salt. A recent technological innovation is the manufacture of chlorine from by-product hydrochloric acid. Of the two electrolytic processes, in Germany 90 per cent is based on the mercury cell, while in the United States, the diaphragm cell is still popular.

52. Hydrochloric acid: Large quantities are being produced as by-product in chlorination reactions, especially organic chemicals. The world production in 1965 was about 3 million tons. Since hydrochloric acid is in large surplus, new processes for using it to make chlorine become valuable. Another valuable use is to pickle steel, for which hydrochloric acid is fast replacing sulphuric acid, not only on the price factor, but also because it gives better results (see table VIII in annex). Nitrogen and phosphoric fertilizers will be covered under fertilizers.

53. Calcium carbide: Historically, this was a very important product, as the parent of acetylene and calcium cyanamide. However, carbide is of decreasing importance, except under special circumstances of cheap water power, limestone and coke in some developed countries. Manufacture of carbide has increased from 7.5 million tons in 1960 to 9.1 million tons in 1965 - an average growth rate of 3.3 per cent (see table IX in annex).

54. Basic organic chemicals: The most important basic organic chemicals are carbon monoxide (in synthesis gas), aliphatic hydrocarbons (ethylene, propylene and the C_4 hydrocarbons, cyclohexane, acetylene, butadiene, isoprene) and aromatic hydrocarbons (benzene, toluene, xylenes and naphthalene).

55. The raw materials for supply of these basic chemicals were based on coal and agricultural products. As the chemical industry has grown rapidly over the years, the demand for organic basic chemicals has exceeded the supply from coal and agricultural products. The industry accordingly has turned to petroleum or natural gas as a source of these materials, which therefore are also known as petrochemicals.

56. Production of basic organic chemicals in Western Europe reached almost 4.6 million tons in terms of carbon content in 1962. Oil and natural gas accounted for 58 per cent of the production. In the United States, 95 per cent or slightly more than 12.0 million tons carbon content were derived from oil and gas.

57. Investment in chemical plants based on petroleum and natural gas has been at a high level throughout the world. The value of new projects announced for 1964 is shown below.

Table 8

Investment in petrochemical plants, 1964

	Number of new projects	$US million	Per cent
Western Europe	97	1,540	36
North America	95	1,110	26
Asia and the Far East[a/]	72	780	18
Africa and the Middle East	22	530	12
South America	25	342	8
Total	311	4,302	100

a/ Excluding China (mainland).

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58. It can be seen that 62 per cent of the total investment is accounted for by the large producing centres in Western Europe and in North America. Asia and the Far East rank third, largely due to investments for India and Japan.

59. The investment pattern in petrochemical plants has undergone a change during the past few years. In North America, the change from coal to petroleum as a source of basic organic chemicals has largely been completed. The development in Western Europe is continuing at a rapid pace. Other areas of the world have only recently begun investment in petroleum-based chemical plants. The changing pattern of new investments is illustrated below.

Table 9

Changing pattern of investments in petrochemical plants, per cent of world total a/

Region	1961	1964
North America	46	26
Western Europe	28	36
Asia and the Far East	15	18
Africa and the Middle East	3	12
Central and South Africa	8	8

a/ Excluding centrally planned economies. The large increase in new investments in Africa and the Middle East is noteworthy.

60. Synthesis gas: Great quantities of synthesis gas are used for production of methanol and ammonia. Statistical data on production and capacities are missing. It is a fact, however, that synthesis gas is one of the chemical raw materials which are produced in largest quantities. Steam reforming and partial oxidation are the two major processes for producing synthesis gas from hydrocarbon feedstocks.

61. Aliphatic hydrocarbons: Among these products, ethylene and butadiene are the most important. Propylene and butylene play a less significant part. Isoprene will probably gain importance in the sector of synthetic rubber. The products of this group belong to the most important basic materials of the modern organic chemical industry.

62. Ethylene: Ethylene is the most important petrochemical basic material. Various raw materials and a great many processes are available for its production. In the United States, most of the ethylene is produced on the basis of ethane by dehydration. In Europe and Japan, the preferred source is naphtha by cracking pyrolysis.

63. These differences are due, on the one hand, to the fact that large quantities of ethane-containing natural gas are available in the United States, quantities which are lacking in Europe and Japan. On the other hand, gasoline consumption in the United States is considerably higher than the gasoline containing fractions in the processed crude oil. Therefore, large quantities of heavy oils are processed into gasoline in the United States. In Europe, and especially in Japan, less gasoline is used than is contained in the processed crude oil. This causes a surplus, which is best used for petrochemical productions.

64. The approximate data of the ethylene production capacities of the various regions and countries in the autumn of 1965 have been listed in table X (see annex) on the basis of the raw materials which were utilized. The table also shows the capacities to be expected by 1970/1972 in accordance with the plans that have become known.

65. The main uses of naphtha as a raw material in Europe and Japan and of refinery gases and natural gas in the United States are obvious. In all probability, naphtha is the preferred raw material also in Eastern Europe. If this share of the European ethylene capacity is added to the sum of the world capacity, the share of naphtha used outside the United States rises to about 86 per cent.

66. The share of developing countries in the ethylene production capacity of the world is still very small. In the autumn of 1965, it amounted to only 1.6 per cent, with the region of Latin America alone accounting for 1.2 per cent and that of Asia for 0.4 per cent. The region of Africa had not yet disposed of an ethylene capacity. Thus, between 1960 and 1965, the petrochemical production - ethylene being considered as the raw material representative of all petrochemical raw materials - developed far more slowly in developing countries than did the chemical industry as a whole. The share of developing countries in the world production of chemicals in 1965 amounted to approximately 5.3 per cent.

67. The comparison between the figures for 1965 and 1970/1972 indicates that the world ethylene capacity will more than double in that period. It may be concluded

from the incomplete production figures for ethylene that in the period between 1960 and 1965, the capacity also doubled. With an average annual growth of about 15 per cent over approximately ten years, ethylene holds first place among the basic materials for the organic chemical industry.

68. The table below gives the share of ethylene production capacity of the various regions in the world and is based on the total sum of production capacities (1970: 17,823 million tons).

Table 10

Share of the regions (per cent) in ethylene production capacity

	1965 (Percentage)	1970/72 (Percentage)
Africa	-	0.3
Developing countries	-	0.1
America	56.8	51.8
Latin America	1.2	3.9
North America	56.6	47.9
United States	52.9	44.9
Asia[a/]	11.3	14.7
Developing countries	0.4	2.4
Japan	10.9	12.3
Europe	30.6	32.4
Western Europe	28.7	29.0
EEC	20.6	19.8
EFTA	8.1	8.2
Eastern Europe	1.9[b/]	3.4
Australia	1.3	0.8

a/ Excluding China (mainland).

b/ Excluding USSR.

69. A study of ethylene expansion in industrialized and in developing countries for the period 1965 to 1970/1972 on the basis of the figures in table X (see annex) shows that the share of the developing countries may grow considerably if their plans are realized (see table below).

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Table 11

Capacities and capacity shares for ethylene in industrial and developing countries

(1,000 tons and percentage)

	1965	Percent	1970/72	Percent
Industrial countries	8,368	98.4	16,659	93.5
Developing countries	135	1.6	1,164	6.5
Africa	-	-	10	-
Asia	33	0.4	425	2.4
Latin America	102	1.2	689	4.1

70. The table above shows that the ethylene capacity of industrialized countries will probably increase by 99.1 per cent from 1965 to 1970/1972. In the same period, the ethylene capacity of developing countries will probably rise by 762 per cent. This growth would still be surpassed by an increase to a level more than twelve times as high, planned in the region of Asia. These growth rates show the great importance attached to the expansion of ethylene capacities in the developing countries. In the capacity of developing countries that is expected for 1970/1972, the region of Africa will probably account for about 4.3 per cent, the region of Asia for about 36.5 per cent and the region of Latin America for about 59.2 per cent.

71. In the field of ethylene production, essential technical improvements were achieved between 1960 and 1965. According to the latest standard of highly industrialized countries such as the United States, plant sizes for ethylene production reach capacities of up to 500,000 metric tons per year. Thus, a plant size which in 1955 amounted to 20,000 metric tons per year increased to a size twenty-five times as large within approximately ten years. At the same time, improvements in process engineering have become effective - such as a much higher ethylene yield on feedstocks, and reduction in utilities inputs through internal steam generation and use of centrifugal compressors.

72. This increase in plant size and output was connected with a trend of considerably decreasing costs. The typical 1955 plant produced ethylene at $220 a ton; by 1961/1962 the typical plant size had increased to 100,000 metric tons per year of ethylene, causing a cost reduction to $100 a ton. According to recent

studies, international quotations for ethylene will come down to $69-70 a ton in the near future.

73. The data available for the world ethylene production, although incomplete, indicate that in 1960, approximately 3.5 million tons were produced. In 1965, this increased to 7 million tons. In 1965, more than 50 per cent of world capacity was accounted for by the United States, whose production amounted to about 4.2 million tons. Of all countries, Japan showed the highest increase during the period dealt with in this study: its production of ethylene rose from 78,000 tons in 1960 to 777,000 tons in 1965.

Propylene

74. Compared to ethylene, propylene at present is still of less importance to the chemical industry; e.g., in the United States, the amount of propylene available is almost four times as high as the consumption; in the case of ethylene, production and consumption are practically identical.

75. As a petrochemical basic material, propylene has an exceptional position. No plants have been erected for production of propylene. It is a typical by-product accruing during the production of ethylene. Therefore, the raw material structure of propylene production is completely analogous to that of ethylene. In the United States, the only raw materials for propylene are refinery gases and natural gas; outside the United States, naphtha represents the main raw material. The total supply of propylene is determined, therefore, by the demand for ethylene and the feedstock used for its production. Propylene produced by refineries in the United States is also consumed by the refineries in the manufacture of alkylates and "polymer-gasoline".

76. According to publications of the chemical industry, at the beginning of 1966, the world capacity for propylene amounted to roughly 4.2 million tons and will increase to about 7.5 million tons by 1970. These figures comprise the production of petrochemical propylene accruing only as a by-product of ethylene. The quantities of propylene available from refinery gases are considerably larger. At the beginning of 1966, these were estimated at 10.3 million tons, of which more than 70 per cent was accounted for by the United States. The share of developing countries corresponds to their refinery capacities.

77. The production figures available for propylene are incomplete. In developing countries, propylene as a petrochemical basic material is still used in extremely small quantities so that it seems justified to assume that industrialized countries use more than 99 per cent of the total quantity of chemically processed propylene. With regard to the expansion of petrochemical production in developing countries, ethylene is expected to continue to precede propylene in playing a decisive part for a long time to come.

78. The high increase in the consumption of propylene for acrylonitrile, popypropylene and butylaldehyde was connected with a decrease in the consumption of dodecene (dodecylbenzene, in particular) and isopropyl alcohol. Among the highest growth rates, acrylonitrile is of primary importance for developing countries: it serves as a basis for the polyacrylonitrile fibres.

79. Butadiene: Butadiene is, by far, the most important C_4-hydrocarbon. Butylene, its precursor, is mainly produced as a by-product during gasoline manufacture and is also manufactured by dehydrogenation of the saturated C_4-hydrocarbons, n-butane and isobutane. Butadiene is also obtained as a by-product of ethylene manufacture.

80. The differences between the United States and other countries with regard to the structure of raw materials used for the production of butadiene are analogous to those existing with regard to ethylene and propylene. While in the United States 50 per cent of the butadiene is produced by dehydrogenation of n-butane (from natural gas), and only 15 per cent by cracking of naphtha, butadiene production in Europe and Japan has been based on refining butylenes and on extraction of butadiene from naphtha steam cracking plants.

81. Because of this variable production of butadiene as a co-product, it is difficult to estimate the world capacity. In the United States, this capacity amounted in 1965 to approximately 1.3 million tons of butadiene; in Japan to about 160,000 tons; in Europe to roughly 400,000 tons. Accordingly, the world capacity does not exceed 2 million tons, the capacities of the east European countries not being included.

82. Of all developing countries, only the region of Latin America (Argentina 32,000 tons, Brazil 26,500 tons, Mexico 45,000 tons) has a butadiene capacity which is to be increased to 136,500 tons by 1970 (Brazil to 33,000 tons). In the region of Asia and the Far East, plans have been made concerning the production of butadiene. In Africa, however, such plans have not become known as yet. Thus, the share of developing countries in the world capacity amounts to less than 5 per cent.

83. The most important field, by far, of application for butadiene is that of elastomers, of which styrene-butadiene rubber occupies first place. In the United States, the share of styrene-butadiene rubber in butadiene consumption shows a declining trend. In 1959, it still amounted to almost 88 per cent and by 1963 it had decreased to 68 per cent. In the same period, the consumption of poly-butadiene rubber increased from zero to almost 12 per cent, that of nitrile rubber (copolymer of butadiene and acrylonitrile) from 3 to about 7 per cent.

84. The consumption of butadiene for plastics is determined by the development of "high-impact" polystyrene, styrene butadiene copolymers, and ABS-plastics. In developing countries, butadiene is gaining importance as a basic material as a result of plans for synthetic rubber production.

Acetylene

85. The main function of acetylene as a basic material for the organic chemical industry has been described in the section dealing with calcium carbide. According to 1965 data, 65 per cent of the carbide is used in this way. On the basis of a world production of 9.1 million tons of carbide, that percentage corresponds to a production of about 1.7 million tons of acetylene for chemical syntheses. It is almost certain that in 1965, approximately 600,000 tons of acetylene were produced by cracking of hydrocarbons. Thus, the world production of acetylene amounted to about 2.3 million tons.

86. As described under calcium carbide, it is characteristic of the development of the past decade that petrochemical ethylene has, to a large extent, entered into competition with acetylene. The high investments, however, that were realized during the same period for the erection of acetylene plants with hydrocarbons as feedstock show that the interest in acetylene has by no means diminished on account of ethylene. From this viewpoint, it seems that it is not so much acetylene as such that is exposed to the pressure of competition of ethylene, but the carbide-based acetylene in particular.

87. Derivatives of acetylene are: vinyl chloride, vinyl acetate, acrylonitrile, chlorine derivatives of hydrocarbons, acetaldehyde, acetic anhydride. In all of these products, ethylene has, to a more or less important extent, appeared as a basic material and in some countries, for instance, in the United States, the acetylene basis for the last two products is no longer of importance.

88. In developing countries, acetylene will probably gain in importance as a chemical raw material in the future (1970 to 1975). This assumption is based on the opinion of experts that the production of carbide for the demand of the chemical industry will increase and that, in the first stages of development of a chemical industry in those countries, carbide-based acetylene may possibly be given preference over petrochemically based materials. This will be the case when the production of a particular product, such as vinyl chloride for the PVC-production, is under consideration, and not the utilization of a broad scale of basic materials as, for instance, that accruing during the cracking of naphtha.

89. In the course of the period 1960-1965, some newly developed processes based on plasma jet cracking were tested, such as the Knapsack-Griesheim WLP Process. All of these processes, some of which yield large quantities of acetylene, are still in the pilot-plant stage. Is is, therefore, hardly expected that processes of this kind will be taken into consideration for acetylene production in developing countries.

90. Aromatic organic chemicals: During the period 1960-1965, it was characteristic of the aromatics (benzene, toluene, xylene etc.) that they were produced, to an increasing extent, on the basis of petroleum instead of coal. Oil derivatives such as reformates and pyrolysate of petroleum are now the major sources for production of pure aromatics.

91. The production of aromatics is connected with the refining of crude oil. Where refineries are available, it is possible in principle to produce aromatics, with the output depending on the type of oil being processed and the processing method used. As aromatics are important basic intermediates, investments for the erection of plants for their production create favourable conditions for developing certain fields of chemical production in developing countries.

92. The production data on aromatics, although incomplete, indicate that in 1965, the world production of benzene amounted to about 6 million tons, and it may be assumed that it has since doubled. Since production data on benzene are available, it is evident that, on the whole, the production in developing countries is still low. In countries where the demand for coke is rising as a result of the erection of big steel plants, there is an increasing output of pit-coal aromatics. The erection of plants for manufacture of aromatics adjacent to existing steel plants

seems advisable within the framework of the projects concerning the establishment of a chemical industry in these countries, particularly if the production of aromatics on the basis of petroleum is not yet possible or planned.

Plastics, synthetic rubbers and man-made fibres

93. Plastics: The term "plastics" in the broader sense covers man-made organic macromolecular or polymeric substances which, at some stage during their manufacture, are capable of being formed into various shapes, usually through the application of heat and/or pressure. In this sense, the term also includes synthetic rubbers and fibres, but the latter are separately discussed in this section. Therefore, "plastics" are understood to be substances which can be worked in solutions, mixtures or dispersions for various fabrications such as moulding, extrusion, laminating and coating.

94. There are more than twenty major families of plastics, which are divided generally into two classes: thermosetting and thermo-plastics materials. Thermosetting materials become set into permanent shape when heat and/or pressure are applied to them during forming; reheating will not soften these materials. Thermoplastic materials become soft when heated and hard when cooled - no matter how often this process is repeated. Examples of the two classes of plastics are:
(a) thermosetting plastics - urea resin, phenolic resins, melamine resins, unsaturated polyesters epoxies, cross-linked polyurethanes and silicones;
(b) thermoplastics - polyethylene, polypropylene, polystyrene, polyvinylchloride (PVC), polyacrylics, cellulosics and polyamides.

95. The scope of application of plastics has broadened to such an extent that there is practically no individual sector in which these products are not used in one form or another. The development has two different trends: one directed towards the manufacture of inexpensive mass-produced materials, the other towards the synthesis of products with specific properties meeting the requirements of specific fields of application.

96. The paint and varnish industry, as well as the adhesive industry, can operate economically with relatively small capacities. This means that a small market also justifies the production of such products. The situation becomes more favourable when there exist branches of industry which have a major demand of these products, such as a wood-processing industry with its requirements of adhesives or a well-developed building trade with its demand of paints and varnishes.

97. The situation is somewhat different in the plastics-processing industry, a very heterogeneous industrial branch. In some of its sectors (production of films, coating, lining, extrusion moulding of tubes and hoses), the plants are now operating fully and continuously. This means a very high output so that a sufficiently large market is necessary.

98. The demand of some of these products in the developing countries will probably increase greatly in the next few years because of the desirable properties of plastics, such as resistance to atmospheric corrosion. The demand of packaging material, for instance, and of films in particular, is expected to rise. Moreover, the developing countries will probably have a continuously increasing demand for plastic tubes, as a result of the development of sewage systems, drinking water supplies and irrigation systems. Thus, there will probably be an increasing number of countries where the requirements of films and tubes justify the production of these products.

99. The other plastics - processing methods are based on piece-work (as, for instance, the pressing of sheets and coating materials, the injection moulding of consumer goods, the blowing of hollow articles, the moulding of plastic foams). In this sector, it depends on the demand of each of the articles.

100. The establishment of a plastics-processing industry does not require a heavy capital investment. Modern processing machines are constructed in such a manner that maintenance and operation costs are low.

101. It must be taken into account, however, that the entire plastics-processing industry, including the production of varnishes and adhesives, requires a great number of auxiliary chemicals, such as pigments and solvents for production of paints and varnishes, and plasticizers, fillers, antioxidants and stabilizers. With the exception of solvents, the quantities required of each substance are so small that, in general, production does not seem justified. Therefore, the import requirements of these chemicals have to be taken into account in the establishment of a plastics-processing industry.

102. Whether a particular plastic material is to be produced depends not only on the demand and processing possibilities but also on the raw materials available. The existence of a petrochemical industry (ethylene, propylene, benzene) is a prerequisite for production of the so-called "bulk-plastics" (polyethylene, polypropylene, polyvinyl chloride, polystyrene). If there is a carbide industry, however, the production of vinyl chloride (PVC) via acetylene may still be profitable.

103. Generally speaking, the production of intermediates for plastics is only practical when there is an integrated chemical industry. Therefore, it follows that the production of plastics is dependent on the import of intermediates until the establishment of a basic chemical industry. This procedure has been successfully practised by small industrial countries and also by some developing countries.

104. In 1965, the production of plastics amounted to about 14.5 million metric tons (compared with approximately 7 million in 1960). This corresponds to an average annual growth rate of about 15.7 per cent. The extraordinary increase in production of plastics is reflected by this extremely high growth rate, which is above that of most of the other groups of products.

105. In 1975, the total demand for plastics is expected to reach 40 million tons and the share of the developing countries will probably be 4 million tons (10 per cent). This forecast is based on the assumption that in the years ahead, economic developments will make great headway in developing countries (which have three quarters of the world population), thus generating considerable new demand for plastics.

106. The production of plastics in developing countries has so far been confined to Latin America (almost two thirds) and Asia (a little more than one third). The main progress in Latin America was made in the period 1960/1961 when production increased to 130 per cent; since 1961, the growth rate has decreased considerably.

107. The table below shows the shares of the regions and economic areas, based on the sums of the production figures.

Table 12

Share of the regions and economic areas in world plastics production

	1960		1965	
	1,000 tons	Percentage	1,000 tons	Percentage
America	3,069	44.4	5,630	39.7
Latin America	59	0.8	170	1.2
North America	3,010	43.6	5,460	38.5
United States	2,849	41.2	5,225	36.8

Table 12 (continued)

	1960		1965	
	1,000 tons	Percentage	1,000 tons	Percentage
Asia[a/]	611	8.8	1,698	12.0
Developing countries	30	0.4	102	0.8
Japan	581	8.4	1,596	11.2
Europe	3,170	45.9	6,735	47.4
Western Europe	2,567	37.2	5,285	37.2
EEC	1,791	25.9	3,886	27.4
EFTA	735	10.6	1,313	9.3
Eastern Europe	603	8.7	1,450	10.2
USSR	332	4.8	821	5.8
Australia	59	0.9	130	0.9

a/ Excluding China (mainland).

108. The extraordinarily high growth rate of some thermoplastics - which hardly finds a parallel in the chemical sector - results from the facts that the properties of these materials offer a great many possibilities of application and that articles made from these thermoplastics can be mass-produced. The plastics are polyvinyl chloride, the polyolefines, polyethylene and polypropylene and, in particular, polystyrene. During the period in question, the share of these plastics rose considerably, from 43.3 per cent to 54.6 per cent.

109. The development of plastics production in developing countries during this period was characterized by concentration on the production of these three products. Table XI (see annex) shows the development of production and the production shares in industrial and developing countries.

110. It can be seen that the expansion of plastics production in developing countries during the period followed an impressive course in spite of the fact that the share in the world production was still below 2 per cent in 1965. This analysis deals only with the developing countries that produce plastics from the basic material to the finished articles; it does not include countries which solely import plastics materials.

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111. Synthetic rubbers: Table XII (see annex) gives a survey of the individual types of synthetic rubbers, their syntheses and main fields of application.

112. The existence of a petrochemical industry is essential to the economical production of bulk materials such as SBR, nitrile rubber, chloroprene rubber, butyl rubber, poly-butadiene and polyisoprene.

113. Major capacities seem justified only when there is a large market for rubber products. As most of the synthetic rubber is still used by the tire industry, only the existence of a highly developed motor industry would guarantee a sufficiently large market for synthetic rubber. The market for other applications is still limited, depending on the degree of industrialization of a country.

114. The production of synthetic rubber is not terminated with the production of polymers. To obtain a workable product, the polymer has to be vulcanized and mixed with fillers, and numerous auxiliaries. Only these finished vulcanized products are used for production of rubber articles.

115. It follows that the prerequisites for establishment of synthetic rubber production (market, raw materials, auxiliaries, technology of production and processing) are considerably more complicated than those required for production of plastics. Therefore, it is not surprising that even today, synthetic rubber is produced in very few countries, as compared to the manufacture of plastics.

115a. In 1965, world production of synthetic rubber - excluding China (mainland) - amounted to about 3.9 million metric tons. Compared to 2.5 million tons in 1960, it rose by 56 per cent. This corresponds to an average annual growth rate of about 9.3 per cent.

116. The table below shows that synthetic rubber has been produced in developing countries only since 1962 and that their share in world production is still very low.

Table 13

Production and production shares of synthetic rubber
(in 1,000 metric tons)

	1960	1961	1962	1963	1964	1965
Industrialized countries	2471.5	2532.7	2883.4	3134.0	3553.6	3817.5
Share in per cent	100.0	100.0	99.4	98.8	98.8	97.8
Developing countries	--	--	16.0	37.0	44.3	86.2
Share in per cent	--	--	0.6	1.2	1.2	2.2
Total (= 100 per cent)	2471.5	2532.7	2899.4	3171.0	3597.9	3903.7

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117. The centre of synthetic rubber production in developing countries is in Latin America: in 1965, it accounted for almost 82 per cent. In Asia, India is the only producer. The African developing countries do not yet have a synthetic rubber industry.

118. It is expected that the synthetic rubber production in developing countries will continue to increase. However, it will, for the time being, be far from reaching the importance attached to other organic derivatives produced on a petrochemical basis. Only in a few exceptional cases may synthetic rubber plants be regarded as economically sound investments in developing countries.

119. Man-made fibres: The man-made fibres show the most dynamic growth of all modern mass-produced products of the chemical industry. These fibres even surpassed plastics in the past decade and, through this development, have continuously increased their share in the world consumption of textile fibres. In 1955, the world production of textile fibres amounted to about 12.6 million metric tons, the share of man-made fibres accounting for 2.5 million tons, or about 20 per cent. In 1965, approximately 18.2 million tons of textile fibres were produced, the man-made fibres accounting for 5.3 million tons, that is, 29.5 per cent. While the world production of textile fibres rose by about 43 per cent in this period, the production of man-made fibres increased by more than 115 per cent.

120. During the period in question, the dominant position of the three most important man-made fibres - polyamide, polyester and polyacrylonitrile fibres - has not changed. New developments have not originated from chemically new materials, but rather from the improvement of the textile qualities of the known fibres, for instance, by texturizing.

121. In 1965, the world production of man-made fibres reached 5.3 million metric tons. Compared to 1960, when it amounted to 3.3 million tons, it rose by 60.6 per cent. This corresponds to an average growth rate of about 10.1 per cent per year. In 1960, cellulosics accounted for about 78.7 per cent and synthetic fibres for 21.3 per cent of the entire production; until 1965, the share of cellulosics went down to 61.9 per cent, and that of synthetic fibres rose to 38.1 per cent.

122. The table below shows the development of the shares of cellulosic and synthetic fibres in industrial and developing countries and in the world.

Table 14

Shares of cellulosic fibres and synthetic fibres
(1,000 metric tons)

	1960	1961	1962	1963	1964	1965
Industrialized countries						
Cellulosic fibres	2433.8	2503.7	2661.1	2841.5	3041.9	3085.1
share per cent	77.8	75.4	71.5	68.5	64.9	61.0
Synthetic fibres	694.0	817.6	1060.3	1305.5	1647.8	1972.6
share per cent	22.2	24.6	28.5	31.5	35.1	39.0
Total (= 100 per cent)	3127.8	3321.3	3721.4	4147.0	4689.7	5057.7
Developing countries						
Cellulosic fibres	156.7	164.9	174.5	182.4	206.3	209.6
share per cent	95.2	93.5	90.6	88.2	84.7	80.0
Synthetic fibres	7.9	11.5	18.1	24.3	37.4	52.4
share per cent	4.8	6.5	9.4	11.8	15.3	20.0
Total (= 100 per cent)	164.6	176.4	192.6	206.7	243.7	262.0
World						
Cellulosic fibres	2590.5	2668.6	2835.6	3023.9	3248.2	3294.7
share per cent	78.7	76.3	72.4	69.5	65.8	61.9
Synthetic fibres	701.9	829.1	1078.4	1329.8	1685.2	2025.0
share per cent	21.3	23.7	27.6	30.5	34.2	38.1
Grand total (= 100 per cent)	3292.4	3497.7	3914.0	4353.7	4933.4	5319.7

This shows that the share of synthetic fibre production is increasing at the expense of cellulosic fibres.

123. Table XIII (see annex) shows the development of the production of man-made fibres in the three regions.

124. During the expansion of the man-made fibre production in developing countries, the question as to which type of fibre should be produced is likely to be raised again and again. No general recommendations can be given in this regard. The

general trend, which shows a considerably higher growth rate in the sector of synthetic fibres than in that of cellulosic fibres, will undoubtedly be significant for the coming period. In each case, the decision in favour of one or the other fibre will depend on the over-all structure of the chemical industry and on other specific conditions prevailing in a particular country.

125. It is to be expected that the relation between the three main groups will not change basically in the near future. Further development will probably be characterized by a trend to modify - chemically or physically - the types that have stood the test, in order to create new qualities and open up new fields of application.

126. The increasing production capacities for fibres and their intermediates all over the world contributed to a decline in average prices during the past few years. In the case of polyamide fibres, this decline was also aggravated by certain surplus capacities. The general opinion is that the prices of synthetic fibres will continue to decline in the coming period. This does not apply to cellulosics, or, if it does, not to the same extent. Since the production of cellulosic fibres is not as expensive as that of synthetic fibres, increased capacity would not cause a significant decline in cost.

Pharmaceutical and pesticides industries

127. Pharmaceuticals: The characteristics of the pharmaceutical industry are as follows:

(a) Small production quantities of any one pharmaceutical product.

(b) Wide variety of different types of products.

(c) Chemicals for pharmaceutical use generally are not used directly, but are formulated by smaller companies specializing in formulation.

(d) The capital cost involved in manufacture of pharmaceutical products from active ingredients is much smaller than that of the chemical industry in general. The capital cost involved in formulating plants is even smaller.

(e) Although the investment cost is relatively small, the research cost is high (see table below for United States figures). Long-term experiments are often necessary after much theoretical study, but even then the research is still much of a gamble.

(f) It appears that the bulk of research work is carried out by manufacturers themselves, but as the majority of pharmaceutical products are manufactured in industrialized countries, the basic research is usually carried out in those countries.

(g) New drugs have only a short market life; thus, 70 per cent of all pharmaceutical products available in 1951 are no longer in the market.

Table 15

Turnover and research expenditures of the United States pharmaceutical industry (in millions of dollars) a/

	Turnover		Research and development expenditures, total pharmaceutical industry	Ethical drugs	Percentage of research and development, total pharmaceutical industry	Ethical drugs
	Total pharmaceutical industry	Ethical drugs				
1961	3,330	1,890	245	200	7.4	10.6
1962	3,579	1,941	276	236	7.7	12.2
1963	3,767	2,047	290	260	7.7	12.7
1964	3,930	2,589	313	298	8.0	11.5
1965	4,130	2,745	351	340	8.5	12.4
Average 1961/65	3,547	2,242	295	267	8.3	11.9

a/ Estimated.

128. In developing countries, the pharmaceutical industry is mainly limited to formulating active principles imported in bulk. However, in some countries, this activity is being integrated backward into producing the active principles from imported intermediates, and eventually manufacturing the intermediates, thus establishing the integral industry from raw material to finished consumer products.

129. This becomes easier if an organic chemicals industry already exists. Where a pattern of industrialization is still being evolved, it would be advisable to ensure that the organic chemicals industry is firmly established before undertaking the manufacture of pharmaceutical products.

130. World production of pharmaceutical products is shown in the table below. Some figures are estimates. The average annual growth rate is 13.2 per cent compared to 9.7 per cent for the entire chemical industry.

Table 16

World production of pharmaceuticals in $US (millions)

	1960	1961	1962	1963	1964	1965
World total	7,800	8,650	9,500	10,750	11,800	12,900
Africa	3	4	15	20	25	30
America	3,636	3,868	4,029	4,466	4,701	4,983
Latin America	320	385	450	520	580	640
North America	3,316	3,483	3,741	3,946	4,121	4,343
Asia[a/]	720	880	1,060	1,350	1,620	1,830
Europe	3,328	3,766	4,226	4,691	5,181	5,733
Western Europe	2,364	2,666	2,996	3,348	3,708	4,123
Oceania	65	76	92	100	107	117

a/ Excluding China (mainland).

131. According to the figures in the above table, developing countries have a greater share in the pharmaceutical industry than in the chemical industry as a whole; the reason for this is that developing countries mainly do formulation from imported active principles. There is very little value added. The actual use of pharmaceutical products per capita is comparatively low in developing countries. It is expected that the share of pharmaceutical production in developing countries will decrease to about 16-17 per cent by 1975 because of the growth of the other branches within the chemical industry.

132. Pesticides: The characteristics of the pesticides industry are similar to those of the pharmaceutical industry. Pesticides are classified as insecticides, fungicides, weed-killers and others (such as rodenticides, plant growth regulators and additives). This group of chemicals is among the most important for developing countries. Pesticides are vital necessities in sanitation, preventive medicine, agricultural production, animal husbandry etc. Many millions of tons of good food are annually consumed or damaged by pests, and much of this waste could be readily saved. Because of the very wide range of pesticides, few people are aware of all of their possibilities. Consequently, several countries use very expensive goods where cheaper chemicals would be equally effective. Many pesticides are manufactured under conditions of trade secrecy, and the prices charged for the pesticides are often high.

133. There are many plants which produce chemicals having pesticidal properties. Pesticides based on plant products such as pyrethrum and derris root have already been commercialized. Many pesticide firms are conducting extensive investigations into new materials of vegetable and animal origin which could have pesticidal properties. Nevertheless, there is still room for a great deal more investigation, and much of it could be done on a regional basis.

134. Quantitative data on the world production of pesticides are necessarily inexact, with effective substances and formulated goods being recorded together. As the content of effective substance in the formulated goods varies widely (from 1 to 100 per cent), it is not possible to give production figures on effective substances. However, as a rough estimate, the world production of pesticides rose by about 60 per cent during the period 1960-1965.

135. Some developing countries are now producers of active ingredients by chemical synthesis. The table below lists the present production capacity of various active ingredients by developing countries.

Table 17

Estimated production capacities of basic insecticides in 1967

(DDT Technical and BHC (13-14 per cent gamma) etc.)

Country	Product	Capacity in tons yearly
Argentina	DDT	3,900
	BHC	3,900
Brazil	DDT	2,000
Mexico	BHC	6,000
	DDT	6,000
	Toxaphene	2,700
India	BHC	2,250
	DDT	3,300 (3,000 additional planned)
	Malathion	600
	Tarathion	900

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Table 17 (continued)

Country	Product	Capacity in tons yearly
Israel	DDT	500
	BHC	200
Philippines	DDT	3,000 (capability 1,500)
	BHC	0
Pakistan	DDT	3,900
	BHC	3,900
China (Taiwan)	BHC	900
	DDT	900
Turkey	DDT	1,500
	BHC	0
United Arab Republic	DDT	700

136. The estimated total value of imports of pesticides (active ingredients and formulated products) by three developing regions in 1964 and the estimated increase in 1970 over those for 1964 are shown in the table below.

Table 18

Estimated total value of imports of pesticides in 1964 and 1970

	Total value imports in 1964 ($US thousands)	Forecast for 1970	Increase due to greater demand assuming no increase in local production
Asia	39,710	74,930	31,220 + 78.6%
Latin America	77,030	106,230	29,200 + 37.9%
Africa	41,410	60,320	19,910 + 49.6%
Total	158,150	241,480	80,330

The estimated increase in demand for pesticides should serve as an indication to developing countries in formulating their future pesticide production programme.

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137. The following points emerge for developing countries to consider in the initial stages of establishing or developing their pesticides industry:

(a) Priority should be given to establishing formulation plants, using imported technical grade materials. Having established these plants, the countries should consider manufacturing the less sophisticated pesticides.

(b) Some of the newer varieties of pesticides will have to be imported for some time to come. It would not be practicable to make them locally from imported intermediates; moreover, each country has its particular problems and preference for certain products. Highly trained technologists are required to supervise the initial operation of such plants. Provision should be made to instruct farmers in handling pesticides and using them in such a way as to derive the maximum benefit.

(c) Adequate equipment for the application of pesticides should be secured by establishing the production of simpler types wherever possible. These include manually - and power - operated spraying equipment, fixed wing aircraft and seed dressing equipment.

III. SELECTED PROBLEMS OF THE DEVELOPMENT OF THE CHEMICAL INDUSTRY

Capital intensity and need for skilled personnel

138. Like many other industries, the establishment of chemical industries in developing countries involves consideration of factors such as training, the social life of the community, capital structure, national and international finance, industrial location and communications.

139. All of these problems of the industrialization process apply particularly to the chemical industry. This is mainly due to two factors inherent in the chemical industry: its capital intensity and great demand for highly trained personnel.

140. The capital intensity characteristic of the chemical industry makes the financing of investments one of the main problems of its development and growth. The highly industrialized nations show an annual investment index of the chemical industry that corresponds to 8-10 per cent of its turnover. As the total production value of the three developing regions in the year 1965 was almost one third less than the production value of the chemical industry of Japan, it is evident that the development plans for this branch of industry cannot be fulfilled on the basis of the limited financial resources of the countries concerned.

141. Generally speaking, the labour requirements in the chemical industry are rather low as far as unskilled workers are concerned, while a high proportion of engineers, technicians and skilled operators is required. As a consequence, the chemical industry could absorb a large part of the skilled labour in developing countries.

A new stage in development

142. The investment plans in many developing countries are now following a trend towards complicated production processes and larger units, which require greater investments. A characteristic of this development is, for example, the trend towards investments in the field of petrochemical production, which, through its especially wide range of products, encourages the growth of the entire economy and raises hopes of satisfying the demand of the population of developing countries for consumer goods.

Foreign aid and foreign participation

143. Industrialization in general, and especially in the chemical industry, has so far depended on substantial outside help, and it is expected to depend on outside help in the foreseeable future. In this connexion, a larger number of chemical companies in industrialized nations may play an important role in the industrialization of developing countries.

144. The type of participation of such chemical companies in the industrialization of developing countries varies. This may include the transfer of licences and know-how, and the planning and construction of industrial units, undertaken on the initiative of Governments of developing countries but where the size of the project often necessitates a national or international group effort.

145. Furthermore, there are many cases of joint ventures in which companies of a developing country participate, with a varying degree of capital, in the formation of a company together with one or more companies of industrialized nations. Joint ventures are generally undertaken in the field of manufactures, mainly in areas that require extensive funds and technical know-how.

146. Co-operation with a company of an industrialized country in a joint venture often facilitates more efficient technical and economic planning, earlier completion of projects, and a smoother production process.

Training of personnel

147. The experience of chemical companies shows that, generally speaking, it is easier to find personnel for key positions at the lower and middle levels than to find key personnel who are able to run installations, after their completion, without further aid from foreign experts.

148. Hiring and training key personnel for the lower and middle levels are often accomplished in individual developing countries during the period when a plant is being erected by experts of the foreign companies concerned in the project. Such tasks are generally carried out with the aid of key personnel trained in advance in a similar production plant of the industrialized country which is involved in the installation.

149. Local personnel who are in charge of production management and plant engineering frequently lack adequate practical experience. This may lead to unsatisfactory operation of the plant or to production setbacks, since emergency

repair work cannot be executed at short notice. In a number of cases, foreign experts have had to stay for a considerable period after the opening of a plant in order to guarantee its smooth functioning.

150. Plants to be built in the near future may use more complicated processes than in the past, and this will require a high degree of automation and a well-trained staff. In this respect, the success of industrialization of the chemical sector in developing countries will increasingly depend on improvements in, and broadening of, the training of personnel.

Regional and sub-regional co-operation and integration

151. Regional and sub-regional co-operation and integration in the fields of production and marketing cannot develop without the existence of certain political conditions.

152. Of the three regions under consideration, Latin America and Asia show indications of successful efforts towards regional and sub-regional co-operation and integration in the future. The economic community of the ALALC[4/] has recently made remarkably good progress in the development of the chemical industry. Also in Asia and the Far East, co-operation between certain States in chemical production is being developed. The most advanced co-operative arrangement is the one between Iran, Pakistan and Turkey. In Africa, regional and sub-regional co-operation and integration in regard to production and marketing have not yet been developed.

153. However, co-operation in this field is still insufficient. This is due to political factors, but it is not within the scope of this study to discuss them. However, when the factors that favour and promote industrialization in the various regions are examined, it is evident that regional and sub-regional co-operation and integration in the field of production of the chemical industry constitute an indispensable prerequisite for its successful development.

154. Regional co-operation may assume various forms, for example, exchange of technical information, the joint use of common research installations, agreements on production capacities and on obligations to purchase certain products. Investments for chemical plants are of particular importance for regional co-operation and integration.

4/ Asociación Latino-Americana de Libre Comercio (Latin American Free Trade Association).

155. As stated before, the chemical industry is very capital-intensive. This means that from the techno-economic viewpoint, the costs for a bigger plant do not rise in proportion to the size of the installations, but much more slowly. Under these circumstances, it is appropriate to decide on the size of a plant, not in accordance with the volume of the existing national market - which is of special importance for investments in relatively small countries - but from the aspect of a plant which works efficiently and whose dimensions are in accord with economic requirements.

156. Supranational agreements may provide an appropriate solution to this problem. A suitable starting-point is to agree on production aiming at a distribution of manufactures in such a way that the product ranges of the individual countries are complementary to one another.

157. In establishing a chemical industry in a developing country, the close interrelation of this industry with the entire economy as supplier and purchaser must always be kept in mind. The development of the economic consumption structure at the end of a planning period must serve as a guideline for priority decisions in the chemical sector. Furthermore, supraregional co-operation can facilitate decisions and give the investments a higher economic efficiency.

158. Regional co-operation and integration are also desirable because of a special characteristic of chemical production: only as an exception does a production process yield nothing but the desired product. As a rule, several products are produced simultaneously. Frequently, it is only through economic exploitation of by-products that the entire process becomes profitable, since the calculable credit items for the by-products lower the costs of the main product.

159. Experience has shown that the high production costs of certain chemical plants in developing countries are mainly due to the fact that there is no possibility of using the by-products.

160. Construction of such a plant on the basis of common planning for an integrated production - possibly beyond the national borders - offers a favourable starting-point for the efficiency of this plant.

161. It follows that the national planning of a country should run on parallel lines with consultations on a regional and possibly on a sub-regional basis. It is understandable that in this respect, the term "region" rarely has a continental scope. The ideal starting-points for such co-operation are the geographically

adjacent areas of a region. Favourable location with regard to transportation of bulk commodities (for instance, rich deposits of raw materials), favourable conditions of power supply (a factor of particular importance for the chemical industry, which is to some extent characterized by a high consumption of electricity) and, above all, the possibility of opening up new markets - these are factors that play an important part when the possibility of co-operation is taken into account.

162. The example of Pakistan, Iran and Turkey shows how expert groups from the countries concerned are trying to co-ordinate the national plans with regard to a complementary development of the production structure of the chemical industry in the sub-region concerned, as well as with regard to the interrelation of the chemical industry and the entire economy of the area.

163. These expert groups are studying, for instance, the possibility of joint ventures and of an exchange of technical experience in order to achieve more rapid and more effective progress in the technological development of the chemical industry of their area.

Processes and cost structures

164. During the period covered in this study, improvements made in processing and planning have resulted in a considerable increase of the productivity of the capital employed in the processing industry of industrialized countries. This has been achieved by the constant development of new and improved processes in almost all sectors of chemical production, by the economical operation of auxiliary and subsidiary units, by improved materials, by minimizing the breakdown of units, by large and cost-efficient production capacities and by stressing research.

165. The use of import licences is of fundamental importance in establishing a chemical industry because the acquisition of processes developed elsewhere constitutes one of the most important measures for rapid and efficient industrialization. As a result of acquisition, developing countries need not follow all of the technological stages that have been developed by industrialized nations.

166. The transfer of knowledge of processes requires, in many cases, a special adaptation of an individual process to the particular needs of the developing country as licensee. This, in turn, implies that the licensee must often engage

in additional research and planning to achieve the know-how necessary to minimize the technological risks of adaptation. There are cases where the transfer of a process from the industrialized countries is not directly applicable to the developing countries and, therefore, some additional experimental work may be needed.

167. Lack of capital and foreign exchange in developing countries makes it necessary for the licenser occasionally to demand capital participation in exchange for the transfer of processes. A number of developing countries have expressed some opposition to such capital participation by the licenser.

168. In due consideration of the value of transfer of licences as an important generating factor of the entire process of industrialization, the political measures taken in the administration of the economies of the developing countries should be of such a nature as to encourage the licenser.

169. When processes are being adapted to the specific conditions of a country, the differences in price structure of raw materials, of power supply and of finished products are of great importance. Such factors will often lead to production costs completely different from those of an industrialized country.

Patent protection

170. Patent protection is one of the most important factors in the growth and development of the chemical industry.

171. Beyond the traditional function of fostering research, the patent system influences investment policy and the flow of technical know-how. The position that a developing country takes with regard to patents affects the potential of local industrial growth, as well as the country's partnership with other countries at different stages of industrial development.

172. While there have been a number of justifications for the grant of patents, modern theory maintains that the exclusive privilege, limited to a certain period of time, is given to the patentee by the Government in the public interest, since this is likely to encourage research and inventive activity, to induce inventors rapidly to disclose their inventions instead of guarding them as trade secrets, and to promote investment in promising lines of production.

173. The question has been raised as to whether the particular situation of developing countries necessitates a different approach to patent protection. It has been said that the patent system of industrialized nations will not necessarily yield the same results if applied to the economies of developing countries.

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174. To evaluate the situation, attention is drawn to a report of the Secretary-General of the United Nations on The Role of Patents in the Transfer of Technology to Developing Countries[5/] and to the Model Law on inventions and technical know-how, prepared by the United International Bureaux for the Protection of Intellectual Property (BIRPI).[6/] These documents are described in the following paragraphs.

175. The Secretary-General's report, prepared on request of the General Assembly,[7/] includes, among other things, a survey of national patent legislation; Governments' evaluations of the manner in which access to inventions and know-how had been helped or hindered by the existence or non-existence of a national patent system; and statistical information. The report also deals with the impact of patents on the economies of developing countries, with special reference to the transfer of technology.

176. This report was considered by the 1964 United Nations Conference on Trade and Development (UNCTAD). It adopted a recommendation,[8/] summarized as follows:

(a) Developed countries should encourage the holders of patented and non-patented technology to facilitate the transfer of licences, know-how, technical documentation and new technology in general to developing countries.

(b) Developing countries should undertake appropriate legislative and administrative measures in the field of industrial technology.

(c) Competent international bodies, including those of the United Nations and the Bureau of the International Union for the Protection of Industrial Property, 9/ should explore possibilities for adaptation of legislation concerning the transfer of industrial technology to developing countries, including international agreements in this field.

5/ The Role of Patents in the Transfer of Technology to Developing Countries, Report of the Secretary-General (E/3861/Rev.1) (United Nations publication, Sales No.: 65.II.B.1).

6/ Model Law for Developing Countries on Inventions (BIRPI publication, No.: 801 (E)), Geneva (1965), 124 pp.

7/ General Assembly resolution 1713 (XVI) of 19 December 1961.

8/ Recommendation A.IV.26 in Proceedings of the United Nations Conference on Trade and Development, vol. I, Final Act and Report (United Nations publication, Sales No.: 64.II.B.11), p. 57.

9/ The International Union for the Protection of Industrial Property was founded in 1883 as an inter-governmental organization. It functions in Geneva as part of the United International Bureaux for the Protection of Intellectual Property (BIRPI).

(d) Additional facilities for information on, and for the transfer of, technical documentation and know-how should be organized within the United Nations framework in consultation with appropriate international organizations.

The UNCTAD recommendation was endorsed by the Economic and Social Council (resolution 1013 (XXXVII)) and by the General Assembly (resolution 2091 (XX)). In the latter resolution, the Assembly asked the Secretary-General to continue the studies, and the competent international bodies to give attention to requests of Governments of developing countries for technical assistance in the field of industrial property and administration.

177. On the basis of these developments, it seems reasonable to offer the following analysis.

178. The concentration of technical knowledge and experience, capital and facilities in the industrialized areas presents, undoubtedly, a serious problem for developing countries. To improve this situation, an industrial partnership with more developed countries is a necessity, and the patent system appears to be an important instrument to encourage partnership.

179. Most of the developing countries will depend for a long time, and to a considerable extent, on technical and scientific developments that originate outside their borders. The grant of patents to foreigners should be considered as a necessary means of encouraging the inflow of technology and the development of an indigenous industrial economy.

180. In October 1964, the United International Bureaux for the Protection of Intellectual Property (BIRPI) invited a committee of experts from developing countries to Geneva to draft a Model Law.

181. The Model Law for Developing Countries on Inventions,[10/] as prepared by the expert group, is based on the traditional patent system, but takes into account the special needs of developing countries. In particular, it provides for protection of non-patented secret know-how in licensing agreements.

182. The Model Law may be considered as a possible guideline for developing countries.

183. From the viewpoint of a sectoral study dealing with the evolution of the chemical industry, the following points with regard to the patent system may be emphasized.

10/ Op. cit.

184. The growth of the chemical industry depends a great deal on the quality and intensity of research which, in turn, requires extensive investments. Experience in industrial countries shows that the necessary intensity of research cannot be achieved without adequate patent protection.

185. Beyond basic research expenditures, inventions in the chemical field often call for considerable further investments before a product can be put on the market. Experience in the pharmaceutical field shows that valuable basic inventions which had been voluntarily dedicated to the public by the inventors, without seeking patent protection, were not taken up for a number of years because the lack of monopoly right made it impossible for individual companies to risk the high investments needed to bring the product to the production stage.

186. Inventions in the chemical field often cannot be worked out in the absence of additional know-how. This additional knowledge, which is rarely patentable, forms an essential part of licensing agreements. Even among industrialized nations, there is a high degree of dependence on foreign advances in specific technical fields. The patent system is the basis for the exchange of technology.

ANNEX

Table I

World production of chemical industry

(millions of US dollars)

	1960	1961	1962	1963	1964	1965
World grand total	73,000	79,500	87,500	94,500	104,500	115,000
Africa	650	705	765	835	925	1,030
South Africa	320	345	365	390	420	450
United Arab Republic	230	250	280	310	360	420
Rest of Africa a/	100	110	120	135	145	160
America	33,360	35,970	39,580	40,940	43,360	47,170
Latin America	2,110	2,320	2,600	2,870	3,230	3,360
Argentina	380	390	401	440	480	520
Brazil	780	860	1,000	1,100	1,190	1,146
Chile	71	72	74	76	80	83
Colombia	95	100	105	113	127	140
Mexico	530	607	690	786	904	963
Peru	70	81	91	100	115	133
Uruguay	18	19	21	22	23	24
Venezuela	120	142	163	183	225	250
Rest of Latin America b/	46	49	55	68	86	101
North America	31,250	33,650	36,980	38,070	40,130	43,810
Canada	1,450	1,550	1,680	1,670	1,830	2,010
United States	29,800	32,100	35,300	36,400	38,300	41,800
Asia	5,173	6,000	6,656	7,652	8,876	9,830
Burma	10	10	11	12	12	13
China (Taiwan)	73	85	110	130	155	206
India	573	630	706	782	916	1,050
Indonesia	45	47	48	53	56	60
Iran	20	21	22	28	32	37
Israel	90	105	120	135	150	160
Japan	4,100	4,800	5,290	6,100	7,100	7,800
Korea, Rep. of	24	29	35	42	48	55
Pakistan	20	28	42	53	60	70
Philippines	110	121	132	159	170	180
Thailand	14	14	16	18	18	20
Turkey	55	60	70	78	85	83
Viet-Nam, Rep. of	25	27	28	30	32	35
Rest of Asia c/	14	23	26	32	42	61

(Foot-notes on following page)

Table I (continued)

	1960	1961	1962	1963	1964	1965
Europe	32,419	34,962	38,366	42,592	48,231	53,077
Western Europe	22,769	24,072	25,766	28,212	31,781	34,487
EEC countries	14,220	15,190	16,350	17,860	20,195	21,780
Belgium and Luxembourg	678	735	740	800	864	960
France	3,650	4,000	4,540	5,030	5,500	5,800
Germany, Fed. Rep. of	5,793	6,000	6,330	6,820	7,789	8,500
Italy	3,420	3,720	3,950	4,270	4,800	5,060
Netherlands	679	735	790	940	1,242	1,460
EFTA countries	7,599	7,652	8,116	8,814	9,833	10,751
Austria	300	317	331	354	388	436
Denmark	164	175	215	220	230	250
Norway	285	305	340	340	350	365
Portugal	65	70	70	70	75	80
Sweden	505	525	565	610	670	720
Switzerland	510	550	585	740	820	900
United Kingdom	5,770	5,700	6,010	6,480	7,300	8,000
Greece	115	120	125	125	130	135
Ireland	55	60	65	68	73	81
Spain	600	850	890	1,115	1,310	1,490
Finland	180	200	220	230	240	250
Eastern Europe	9,650	10,890	12,600	14,380	16,450	18,590
Bulgaria	60	70	75	85	95	105
Czechoslovakia	720	810	910	940	1,030	1,100
Germany, Eastern	1,630	1,760	2,040	2,170	2,370	2,550
Hungary	110	130	150	175	195	220
Poland	940	1,030	1,200	1,300	1,550	1,800
Romania	330	410	515	670	830	1,000
USSR	5,700	6,500	7,500	8,800	10,100	11,500
Yugoslavia	160	180	210	240	280	315
Oceania	679	686	734	804	904	985
Australia	584	584	630	695	780	850
New Zealand	94	102	104	109	124	135

a/ All countries of Africa except those listed above.

b/ All countries of Latin America except those listed above.

c/ All countries of Asia, Middle and Far East except China (mainland) and those listed above.

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Table II

World production of sulphur

(1,000 metric tons)

	1960	1961	1962	1963	1964
World total	20,500	22,700	23,800	23,900	25,600
Africa	262	239	230	198	240
America	8,594	9,465	9,554	10,079	11,030
Latin America	1,436	1,337	1,559	1,669	1,828
North America	7,158	8,128	7,995	8,419	9,202
Asia	2,285	2,431	2,532	2,525	2,693
Europe	8,493	8,984	9,663	9,715	9,895
Western Europe	5,216	5,474	5,746	5,668	5,732
Eastern Europe	3,277	3,510	3,917	4,047	4,163
Australia	349	330	317	349	360

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Table III

World production of salt

(1,000 metric tons)

	1959	1960	1961	1962	1963	1964
World total	79,500	84,600	85,500	91,600	95,000	98,700
Africa	1,420	1,704	1,609	1,903	1,736	2,129
Algeria	142	131	131	131	130	130
Ethiopia	141	157	151	198	255	263
South Africa	237	253	208	255	198	300
Tunisia	92	166	161	290	300	214
United Arab Republic	383	522	517	560	392	675
Rest of Africa	425	476	441	469	461	547
America	28,749	29,150	29,529	33,527	34,790	36,425
Latin America	2,912	3,030	3,211	4,068	3,608	4,200
Argentina	519	549	581	494	169	373
Brazil	854	923	889	1,243	1,193	754
British West Indies	245	235	239	223	276	349
Colombia	270	303	337	305	297	340
Mexico	520	520	599	1,292	1,225	1,783
Peru	105	106	87	94	87	109
Venezuela	78	79	147	145	76	200
Rest of Latin America	321	315	332	272	285	292
North America	25,837	26,120	26,318	29,459	31,182	32,225
Canada	3,009	3,004	2,997	3,325	3,377	3,532
United States[a/]	22,828	23,116	23,321	26,134	27,805	28,693
Asia	19,654	20,811	19,083	18,915	19,777	20,503
Aden	178	130	78	78	86	81
Burma	112	148	125	154	161	127
China (mainland)	11,400	12,900	11,500	10,000	10,500	11,000
China (Taiwan)	430	453	432	595	626	602
India	2,770	3,435	3,461	3,886 b/	4,549 b/	4,647 b/
Indonesia	315	198	445	304	304	305
Iran	80	130	145	179	345	345
Japan	1,166	886	828	879	795	887
Korea (North)	440	324	392	421	554	399
Korea, Rep. of	390	399	122	388	230	386
Pakistan	288	431	389	459	455	522
Philippines	175	95	93	96	70	47
Thailand	459	335	250	150	200	249
Turkey	492	445	268	431	398	322

(Foot-notes on following page)

Table III (continued)

	1959	1960	1961	1962	1963	1964
Asia (continued)						
Viet-Nam, North	.	.	.	144	128	150
Viet-Nam, South	156	144	100	193	128	128
Yemen	100	100	120	150	100	35
Rest of Asia	703	258	335	408	276	271
Europe	29,157	32,405	34,700	36,619	38,043	39,014
Western Europe	17,859	19,667	20,557	21,994	23,063	23,690
EEC countries	10,108	11,401	12,220	13,316	13,902	14,228
France	3,484	3,736	3,846	4,248	3,694	3,695
Germany, Fed. Rep. of	3,649	3,969	4,680	4,906	5,588	5,796
Italy	1,989	2,600	2,580	2,900	3,141	3,141
Netherlands	986	1,096	1,114	1,262	1,479	1,596
EFTA countries	6,302	6,778	6,619	6,923	7,378	7,666
Austria	403	483	433	289	345	392
Portugal	214	214	267	389	347	347
Switzerland	137	149	157	168	191	182
United Kingdom	5,548	5,932	5,762	6,077	6,495	6,745
Greece	98	97	119	115	85	100
Spain	1,351	1,391	1,599	1,640	1,698	1,696
Eastern Europe	11,240	12,682	14,109	14,594	14,973	15,320
Bulgaria	89	87	126	149	105	105
Czechoslovakia	161	168	188	182	187	184
Germany, Eastern	1,686	1,785	1,999	1,996	1,996	1,996
Poland	1,828	1,946	2,051	2,075	2,131	2,242
Romania	840	1,045	1,330	1,477	1,637	1,809
USSR	6,500	7,500	8,200	8,500	8,750	8,800
Yugoslavia	136	151	161	215	167	184
Rest of Europe	58	54	34	31	7	4
Oceania	496	488	508	553	603	614
Australia	475	471	503	544	592	592

Source: United States Bureau of Mines, Preprint from Minerals Yearbook, 1962 and 1964; calculated in metric tons; estimated in part.

a/ Including Puerto Rico.

b/ Including Goa.

/...

Table IV

World production of phosphate rock

(1,000 metric tons)

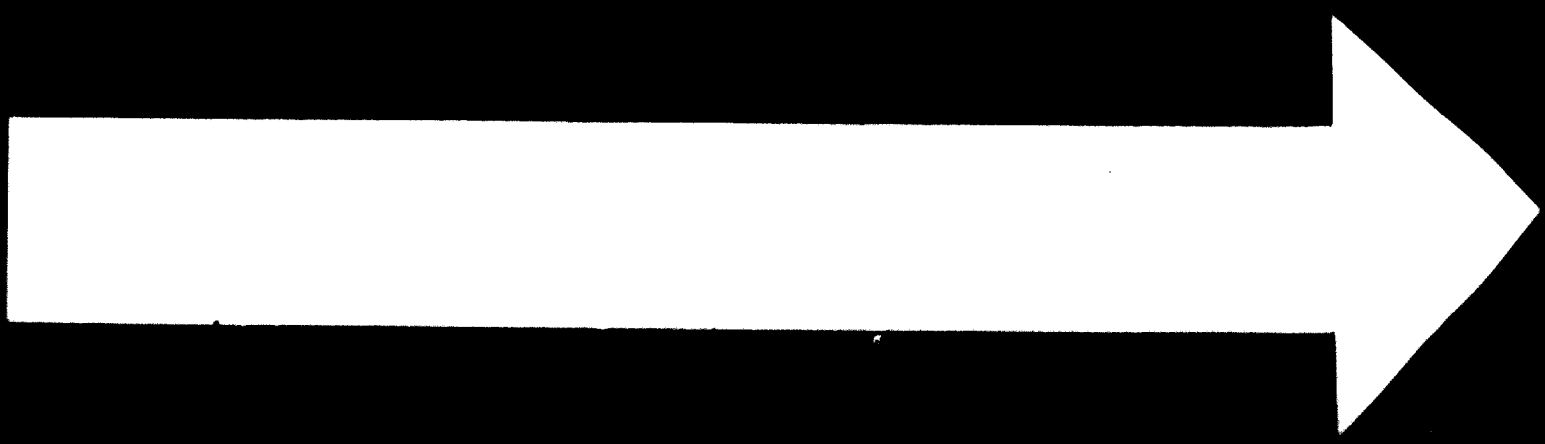
	1960	1961	1962	1963	1964	1965[a/]
World total[b/]	41,700	45,700	47,700	50,800	59,000	65,000
Africa[b/]	11,210	12,100	12,400	13,560	15,700	18,200
Algeria	563	440	390	348	72	100
Morocco	7,492	7,450	8,162	8,549	10,098	12,000
Senegal	212	546	638	596	780	900
South Africa	268	297	307	455	579	700
Togo	-	118	192	518	768	600
Tunisia	2,096	1,982	2,097	2,367	2,750	3,000
United Arab Republic	566	627	602	612	613	600
Asia[b/]	1,680	1,700	2,170	2,380	2,600	2,650
China (mainland)	600	500	600	700	800	900
Israel	224	220	210	300	240	250
Jordan	362	423	681	614	564	300
North Viet-Nam	480	555	667	740	980	1,200
America	18,997	19,857	20,613	20,753	23,909	25,620
Latin America[b/]	1,200	1,000	920	600	580	620
Brazil	880	659	566	279	246	280
Netherlands Antilles	115	152	132	128	120	125
Peru	157	160	206	192	205	200
United States	17,797	18,857	19,693	20,153	23,329	25,000
Australia and Oceania	2,113	2,188	2,132	2,274	2,571	2,600
Pacific Islands	2,111	2,183	2,128	2,269	2,565	2,595
Europe	7,111	8,926	10,144	11,133	13,055	15,100
USSR	7,000	8,800	10,000	11,000	13,000	15,000

Source: Statistical Summary of the Mineral Industry, 1959-1964.

a/ Estimated.

b/ Round figures.

/...



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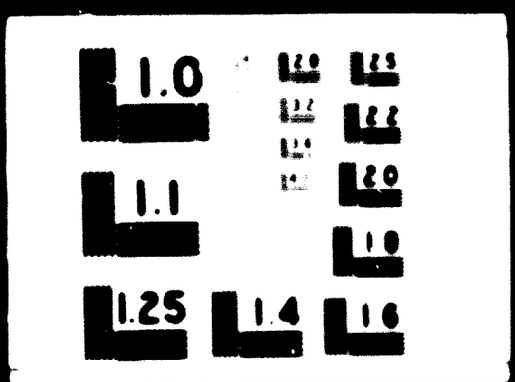

Table V

World production of sulphuric acid

(1,000 metric tons)

	1960	1961	1962	1963	1964	1965
World total	51,500	53,400	56,700	60,900	66,700	72,300
Africa	1,228	1,219	1,257	1,329	1,493	1,630
Algeria	40	30	23	32	46	55*
Congo, Rep. of	110*	105*	103	94	107	110*
Morocco	33	33	35	36	40	45
South Africa	885	900*	950*	1,000*	1,050*	1,100*
United Arab Rep. (Egypt)	103	96	94	88	170	240*
Zambia	57*	55*	52*	79*	80*	80*
America	18,609	18,637	20,501	21,912	23,921	25,956
Latin America	866	982	1,072	1,194	1,353	1,474
Argentina	135	140	100	109	151	168
Brazil	210	240	275	315	320	325*
Chile	84	117	129	130	150*	221
Colombia	9	23	27	35	39*	40*
Mexico	249	276	339	390	440	450*
Netherlands Antilles	147	154	167	154	165*	170*
Peru	30	29	29	33	37*	40*
Venezuela	2	3	6	28	51	60
North America	17,743	17,655	19,429	20,718	22,568	24,482
Canada	1,520	1,464	1,560	1,725	1,778	1,964
United States	16,223	16,191	17,869	18,993	20,790	22,518
Asia[a/]	5,093	5,434	5,730	6,026	6,572	7,018
China (Taiwan)	84	100	116	163	202	269
India	354	422	468	568	679	884
Israel	123	116	120	150*	163	158
Japan	4,452	4,683	4,910	4,991	5,372	5,652
Korea, Rep. of	8	9	9	13	18	20*
Pakistan	1	2	2	19	22*	20
Philippines	48	79	85	80*	80*	85*
Turkey	23	23	20	42	36*	110*

(Foot-notes on following page)

Table V (continued)

	1960	1961	1962	1963	1964	1965
Europe	23,403	24,527	25,466	27,713	30,342	32,925
Western Europe	15,399	15,713	15,915	17,010	18,468	19,754
EEC countries	9,800	9,933	9,977	10,511	11,311	12,185
Belgium and Luxembourg	1,423	1,350	1,332	1,236	1,348	1,488
France	2,046	2,205	2,271	2,394	2,701	2,840
Germany, Fed. Rep. of	3,170	3,103	3,101	3,316	3,602	3,800
Italy	2,299	2,446	2,551	2,711	2,684	2,966
Netherlands	862	829	822	854	976	1,091
EFTA countries	4,082	4,084	4,166	4,434	4,863	5,154
Austria	140	150	160	200	217	225*
Denmark	198	204	208	217	223	239
Norway	100	100	101	103	108	112*
Portugal	331	341	352	417	460	490*
Sweden	409	421	448	472	510	560*
Switzerland	160	163	122	148	159	170*
United Kingdom	2,744	2,705	2,775	2,927	3,186	3,358
Finland	187	229	238	333	355	380*
Ireland	95	129	100	100*	100*	100*
Greece	105	102	125	120	168	185*
Spain	1,129	1,236	1,319	1,462	1,671	1,750*
Eastern Europe	8,005	8,814	9,551	10,703	11,964	13,171
Bulgaria	123	192	247	269	291	319
Czechoslovakia	553	599	643	725	893	933
Germany, Eastern	731	819	853	919	937	985
Hungary	164	189	212	283	322	378
Poland	685	794	852	888	1,004	1,062
Romania	226	248	326	343	417	541
USSR	5,398	5,718	6,132	6,885	7,647	8,518
Yugoslavia	125	255	286	391	453	435
Oceania	1,429	1,498	1,495	1,680	1,957	2,195
Australia	1,088	1,140	1,154	1,269	1,452	1,689
New Zealand	341	358	341	411	505	506

* Estimated figures.

a/ Excluding China (mainland).

Table VI

Cost characteristics of a 1,200-ton per day sulphuric acid plant

	Based on elementary sulphur	Based on pyrite	Based on gypsum
Investment costs (in thousand dollars)	3,619	7,459	18,232
Service of capital (thousand dollars per year)	615	1,343	3,284
Machinery costs (thousand dollars per day)	20.4	12.0	13.7[a/]
Personnel expenses (dollars per day)	199	796	1,856
Operating costs, total (dollars per day)	16,471	9,467	2,340
Production costs (dollars per day)	18,228	13,500	12,202
Production costs (dollars per metric ton H_2SO_4)	15.20	11.26	10.17

Source: Chemiebau, Dr. A. Ziehren, GmbH, Köln/Rh.

a/ Excluding costs for gypsum.

Table VII

World production of chlorine

(1,000 metric tons)

	1960	1961	1962	1963	1964	1965
World total	8,600	9,500	10,700	11,800	13,200	14,300
Africa	17	23	31	43	54	62
Algeria	2	2	1	2	2*	2*
South Africa	15	20*	25*	31	37*	45*
United Arab Republic	--	1	5*	10*	15*	15*
America	4,559	4,614	5,175	5,528	6,016	6,560
Latin America	60	119	171	190	185	203
Argentina	--	40	37	40*	40*	45*
Brazil	39	40	36	40*	40*	40*
Chile	--	--	5	6*	6*	6*
Colombia	20	26	27	28	29	32
Mexico	--	--	52*	61*	55*	65*
Peru	1	3*	4*	5*	5*	5*
Venezuela	--	10*	10*	10*	10*	10*
North America	4,499	4,495	5,004	5,338	5,831	6,357
Canada	292	321	338	381	438	516
United States	4,207	4,174	4,666	4,957	5,393	5,841
Asia	674	766	818	933	1,208	1,349
Ceylon	--	--	1	1*	1*	1*
China (Taiwan)	36	32	34	40	51	61
India	32	34	37	44	134	201
Indonesia	--	--	1*	1*	1*	1*
Iran	--	3*	3*	3*	3*	3*
Israel	--	5	7	7	8	9
Japan	600	686	730	831	1,002	1,055
Pakistan	3*	3*	2*	3*	3*	4*
Philippines	3*	3*	3*	3*	3*	3*
Turkey	--	--	--	--	--	9
Viet-Nam, Rep. of	--	--	--	--	2*	2*

(Foot-note on following page)

Table VII (continued)

	1960	1961	1962	1963	1964	1965
Europe	3,300	3,981	4,510	5,088	5,634	5,999
Western Europe	2,308	2,559	2,746	3,088	3,532	3,727
EEC countries	1,431	1,596	1,759	1,980	2,288	2,448
Belgium and Luxembourg	44*	43*	45*	58*	74*	90*
France	332	356	406	462	548	587
Germany, Fed. Rep. of	658	725	801	920	1,017	1,081
Italy	294	367	392	415	494	520
Netherlands	103*	105*	115*	125*	155*	170*
EFTA countries	808	857	865	965	1,090	1,111
Austria	18*	20*	21	26	27	30*
Denmark	4	4	5	4	4	4
Norway	37	40	41	51	60	60
Portugal	1	2	2	3	4	5*
Sweden	151	167	172	189	209	222
Switzerland	30*	30*	30*	30*	30*	30*
United Kingdom	567	594	594	662	756	760
Finland	48	64	75	82	95	98
Greece	--	2	2	2	2	2
Spain	21	40	45	59	57	68
Eastern Europe	992	1,422	1,764	2,000	2,102	2,272
Czechoslovakia	115	133	142	144	147	155*
Germany, Eastern	263*	297*	350*	350*	350	370*
Hungary	15*	15*	15*	15*	15*	15*
Poland	55	67	74	79	90	97
Romania	34*	50*	68*	85*	8*	100*
USSR	500*	850*	1,100*	1,300*	1,400*	1,500*
Yugoslavia	10	10	15	27	30	35*
Australia	28	27	33	40	48	45*

* Estimated figures.

Table VIII

Structure of soda ash, caustic soda, chlorine, and hydrochloric acid consumption (percent)

	Soda ash		Caustic soda		Chlorine		Hydrochloric acid
	Japan[a/]	United States [b/]	Japan[a/]	United States	Japan[a/]	United States	Japan[a/]
Glass	51.5	45.8	--	--	--	--	--
Chemical industry	30.9	27.1	44.4	45.3	35.7	73.5	45.6
Man-made fibres	--	--	25.1	9.5	0.5	--	0.4
Fibre printing	1.9	--	4.6	6.3	0.7	--	0.6
Paper and pulp	2.7	9.4	9.9	10.5	47.0	17.0	2.2
Iron and steel	3.2	--	0.6	--	0.5	--	6.3
Soaps and detergents	--	5.2	--	5.3	--	--	--
Petroleum refining	--	--	1.5	5.3	0.5	--	1.0
Food industry	6.4	--	3.2	--	0.1	--	27.4
Aluminium	--	4.2	4.7	5.3	0.3	--	0.2
Others	3.4	8.3	6.0	12.5	14.7	9.5	16.3

Sources: a/ Ministry for International Trade and Industry of Japan.
b/ Oil, Paint and Drug Reporter.

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Table IX

World production of calcium carbide

(1,000 metric tons)

	1960	1961	1962	1963	1964	1965
World total	7,750	8,150	7,950	8,550	9,100	9,100
Africa	59	65	61	56	65	74
South Africa	59	65	61	56	65	72
United Arab Republic	--	--	--	--	--	2
America	1,440	1,390	1,367	1,249	1,246	1,218
Latin America	103	109	103	130	99	102
Argentina	27	31	31	36	42	45
Brazil	60	63	55	75	32	35
Chile	5	4	4	4	7	4
Mexico	10	10	11	13	15	15
Peru	1	1	2	2	3	3
North America	1,337	1,281	1,264	1,119	1,147	1,116
Canada	345	336	281	113	120	120
United States	992	945	983	1,006	1,027	996
Asia a/	1,401	1,708	1,526	1,799	2,027	1,881
China (Taiwan)	18	21	23	45	45	50
India	10	19	26	27	42	35
Israel	10	9	5	6	5	5
Japan	1,210	1,518	1,323	1,553	1,766	1,622
Korea, North	135	125	125	150	150	150
Korea, Rep. of	4	4	10	4	5	5
Philippines	7	5	7	7	7	7
Turkey	7	7	7	7	7	7
Europe	4,596	4,741	4,709	5,164	5,472	5,603
Western Europe	2,583	2,642	2,530	2,861	3,080	3,063
EEC countries	2,000	1,984	1,927	2,148	2,243	2,263
Belgium and Luxembourg	106	127	137	194	216	220
France	447	432	426	515	586	604
Germany, Fed. Rep. of	1,101	1,089	994	1,067	1,051	1,039
Italy	292	287	321	323	339	350
Netherlands	54	49	49	49	51	50

(Foot-note on following page)

Table IX (continued)

	1960	1961	1962	1963	1964	1965
Europe (cont'd)						
Western Europe (cont'd)						
EFTA countries	499	566	508	592	633	630
Austria	38	50	30	41	45	45
Norway	58	60	52	81	100	120
Portugal	5	6	11	17	16	20
Sweden	90	106	91	100	100	100
Switzerland	92	85	73	73	76	35
United Kingdom	216	259	251	280	296	310
Finland	8	8	8	5	7	7
Spain	76	84	87	116	137	163
Eastern Europe	2,013	2,099	2,179	2,303	2,452	2,540
Bulgaria	22	27	25	30	30	30
Czechoslovakia	104	107	119	130	136	140
Germany, Eastern	923	951	1,013	1,068	1,160	1,188
Hungary	13	13	13	13	15	17
Poland	321	360	360	380	430	460
Romania	97	60	65	75	90	100
USSR	500	500	500	500	500	500
Yugoslavia	73	81	84	107	91	105
Australia	13	13	14	13	14	15

a/ Excluding China (mainland).

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Table X

World capacities of ethylene (1965) and development to 1970

(1,000 metric tons)

	Naphtha	Refinery gas	1965 LPG	Coke oven gas	Natural gas	Total	1970/72
World	3,559	2,090	468	50	2,143	8,506	18,000 a/
America	477	1,988	295	--	2,043	4,381	9,234
Latin America	16	20	--	--	52	102	689 b/
Argentina	16	11	--	--	--	27	132
Brazil	--	9	--	--	--	23 c/	195
Mexico	--	--	--	--	52	52	162
North America	461	1,968	--	--	1,991	4,729	8,545
Canada	170 d/	34	--	--	25	229	545
United States	291 e/	1,934	295 f/	--	1,966	4,500 g/	8,000*
Asia	924	27	--	--	5	965	2,625 h/
India	--	--	--	--	--	9 i/	240
Israel	--	27	--	--	--	27	50
Japan	924	--	--	--	5	929	2,200
Europe	2,158	50	91	50	95	2,603	5,774
Western Europe	2,158	50	91	50	95	2,444	5,174 j/
EEC countries	1,464	50	91	50	95	1,754	3,532
Belgium and Luxembourg	32	--	--	--	--	32	240
France	132	--	--	50	79	261	985
Germany, Fed. Rep. of	716	--	91	n.a.	--	807	1,377
Italy	533	50	--	--	16	599	700
Netherlands	55	--	--	--	n.a.	55	230
EFTA countries	690	--	--	--	--	690	1,467
Denmark	36	--	--	--	--	36	36
Sweden	50	--	--	--	--	50	110
United Kingdom	604	--	--	--	--	604	1,321
Eastern Europe	--	--	--	--	--	159 k/	600*
Bulgaria	--	--	--	--	--	59	n.a.
GDR	--	--	--	--	--	59	n.a.
Germany, Eastern	--	--	--	--	--	41	n.a.
Australia	--	85	82	--	--	107	140

* Estimated figures.

a/ Including 10,000 tons United Arab Republic, 40,000 tons South Africa, and a margin of about 177,000 tons.

b/ Thereof Chile 30,000 tons, Colombia 20,000 tons, Venezuela 150,000 tons.

c/ Thereof 14,000 tons from feedstock ethanol.

d/ 90,000 tons petroleum fractions.

e/ Including straight run distillates.

f/ Condensates.

g/ Including 14,000 tons other feedstock.

h/ Thereof Iran 9,000 tons, Iraq 32,000 tons, Pakistan 80,000 tons, Turkey 14,000 tons.

i/ Ethanol feedstock.

j/ Thereof Spain 175,000 tons.

k/ Excluding USSR, Poland and Hungary.

/...

Table XI

Production and production groups of the most important thermoplastics

(1,000 tons/percentage)

	1960	1961	1962	1963	1964	1965
Polystyrene						
Industrial countries	587	645	876	969	1,168	1,347
Share in percent	97.8	97.6	98.0	98.0	98.3	97.8
Developing countries	13	16	18	20	20	31
Share in percent	2.2	2.3	2.0	2.0	1.7	2.2
Polyvinyl chloride						
Industrial countries	1,377	1,595	1,885	2,231	2,750	3,006
Share in percent	98.9	98.2	97.9	97.4	97.1	97.1
Developing countries	15	29	40	60	81	91
Share in percent	1.1	1.8	2.1	2.6	2.9	2.9
Polyolefines						
Industrial countries	993	1,207	1,751	2,136	2,680	3,220
Share in percent	99.3	99.1	98.9	98.9	98.9	98.1
Developing countries	7	11	19	24	30	61
Share in percent	0.7	0.9	1.1	1.1	1.1	1.9

Table XII

Elastomers, their synthesis and applications

Type	Synthesis	Applications
Chlorinated rubber	Chlorination of natural rubber	Protective coatings, adhesives
Rubber hydrochloride	Hydrochlorination of natural rubber	Packaging films, lacquers
Cyclo-rubber	Cyclisation of natural rubber with sulphuric acid, sulphuric acids a.o.	Hard rubber, lacquers
Styrene-butadiene rubber (SBR)	Copolymerisation of butadiene (75-54%) and styrene (25-46%)	Most important tire rubber, hoses, cables and other rubber articles
SBR oil extended	(Addition of oils and plasticisers)	Tire covers, technical articles
SBR high styrene	(More than 50% styrene)	Floor coverings, soles
Nitril-butadiene rubber (NBR)	Copolymerisation of butadiene (72-60%) and acrylonitrile (28-40%)	Technical articles resistant to oils and hydrocarbons
Chloroprene rubber	Polymerisation of 2-chloro-butadiene	Adhesives, cable sheathing, technical articles resistant to oils, fats and weathering coatings and linings, protective clothing
Butyl rubber	Polymerisation of isobutylene with small amounts of isoprene	Tire tubes, air tubes and hoses, cables, rubberized fabrics
Cis-1,4-polyisoprene	Polymerisation of isoprene with Ziegler catalysts	Tires, technical articles
Cis-1,4-polybutadiene	Polymerisation of butadiene with Ziegler catalysts	Automobile tires
Ethylene-propylene-terpolymers	Copolymerisation of ethylene, propylene and small amounts of dienes	Technical articles
Ethylene-vinyl acetate copolymers	Copolymerisation of ethylene and vinyl acetate	Technical articles
Thio rubbers	Condensation of polysulfides with aliphatic dihalides	Full hoses and tubes, coatings, printing cylinders, sealings, container linings
Silicone rubber	Hydrolysis of alkyl dichloro-silanes and further polymerization by heating	Insulating materials, many special applications
Polymethane rubbers	Polyaddition reactions of poly-esters with isocyanates	Sealings, buffers, bearings, soles a.m.o.

Table XIII

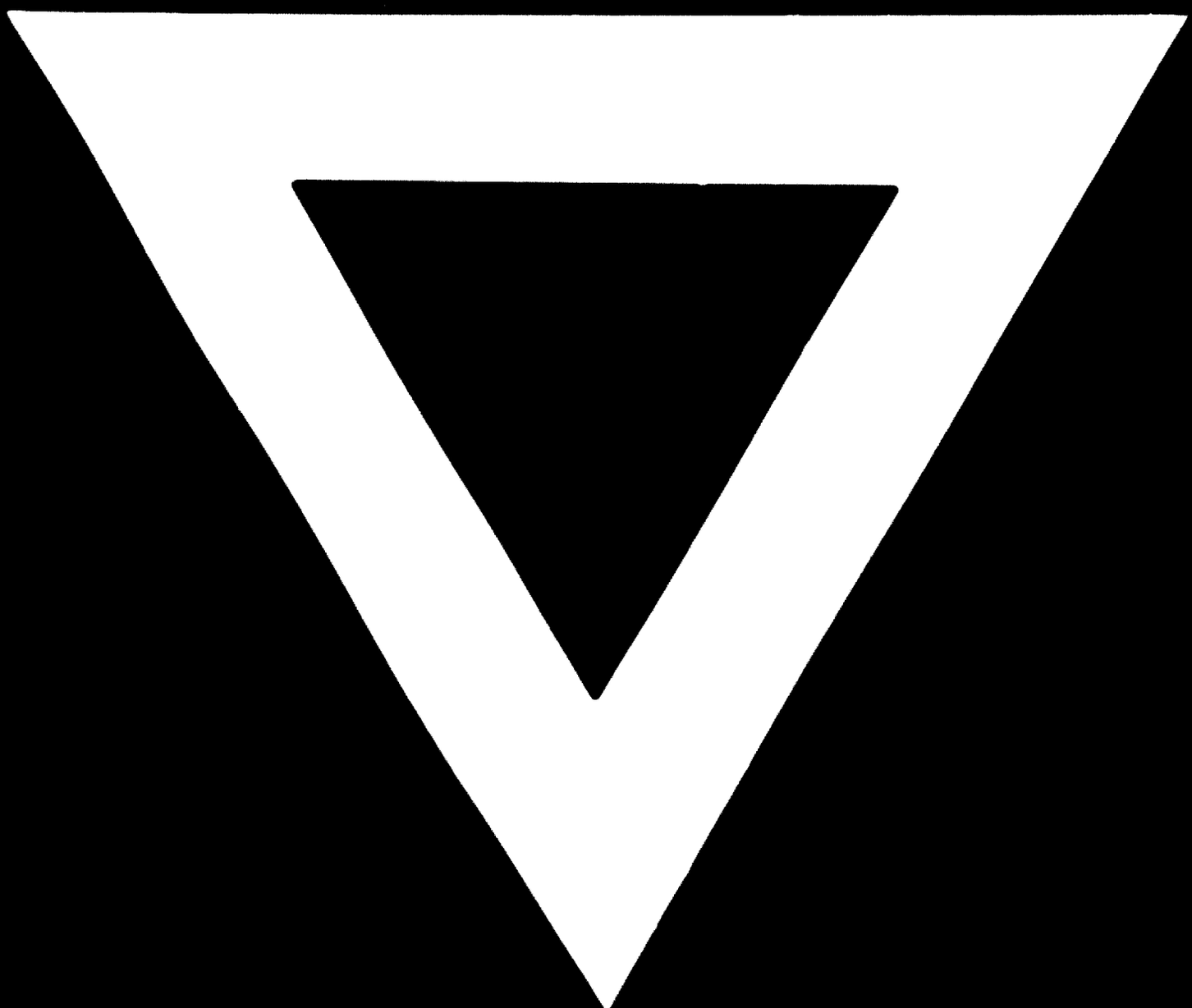
Production of man-made fibres in the developing regions

(1,000 tons/percentage)

	1960	1961	1962	1963	1964	1965
Africa[a/]						
Total 1,000 t.	11.3	11.3	12.1	12.6	13.3	12.2
Share of grand total %	6.9	6.4	6.3	6.1	5.5	4.7
Cellulosic fibres 1,000 t.	11.1	11.1	11.8	12.2	12.8	11.6
Share %	98.2	98.2	97.5	96.8	96.2	95.1
Synthetic fibres 1,000 t.	0.2	0.2	0.3	0.4	0.5	0.6
Share %	1.8	1.8	2.5	3.2	3.8	4.9
Asia[b/]						
Total 1,000 t.	47.3	55.1	67.4	76.2	89.7	97.6
Share of grand total %	28.7	31.2	35.0	36.9	36.8	37.3
Cellulosic fibres 1,000 t.	46.9	54.3	66.0	73.8	85.0	88.5
Share %	99.2	98.5	97.9	96.9	94.8	90.7
Synthetic fibres 1,000 t.	0.4	0.8	1.4	2.4	4.7	9.1
Share %	0.8	1.5	2.1	3.1	5.2	9.3
Latin America						
Total 1,000 t.	106.0	110.0	113.1	117.9	140.7	152.2
Share of grand total %	64.4	62.4	58.7	57.0	57.7	58.1
Cellulosic fibres 1,000 t.	98.7	99.5	96.7	96.4	108.5	109.5
Share %	93.1	90.5	85.5	81.8	77.1	71.9
Synthetic fibres 1,000 t.	7.3	10.5	16.4	21.5	32.2	42.7
Share %	6.9	9.5	14.5	18.2	22.9	28.1
Grand total of the three regions 1,000 t.	164.6	176.4	192.6	206.7	243.7	262.0

a/ United Arab Republic only.

b/ Excluding China (mainland).



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