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SUMMARY

DEVELOPMENTS IN THE PLASTICS INDUSTRY SINCE 1964 AND THEIR SPECIAL INTEREST FOR DEVELOPING COUNTRIES 1/

by

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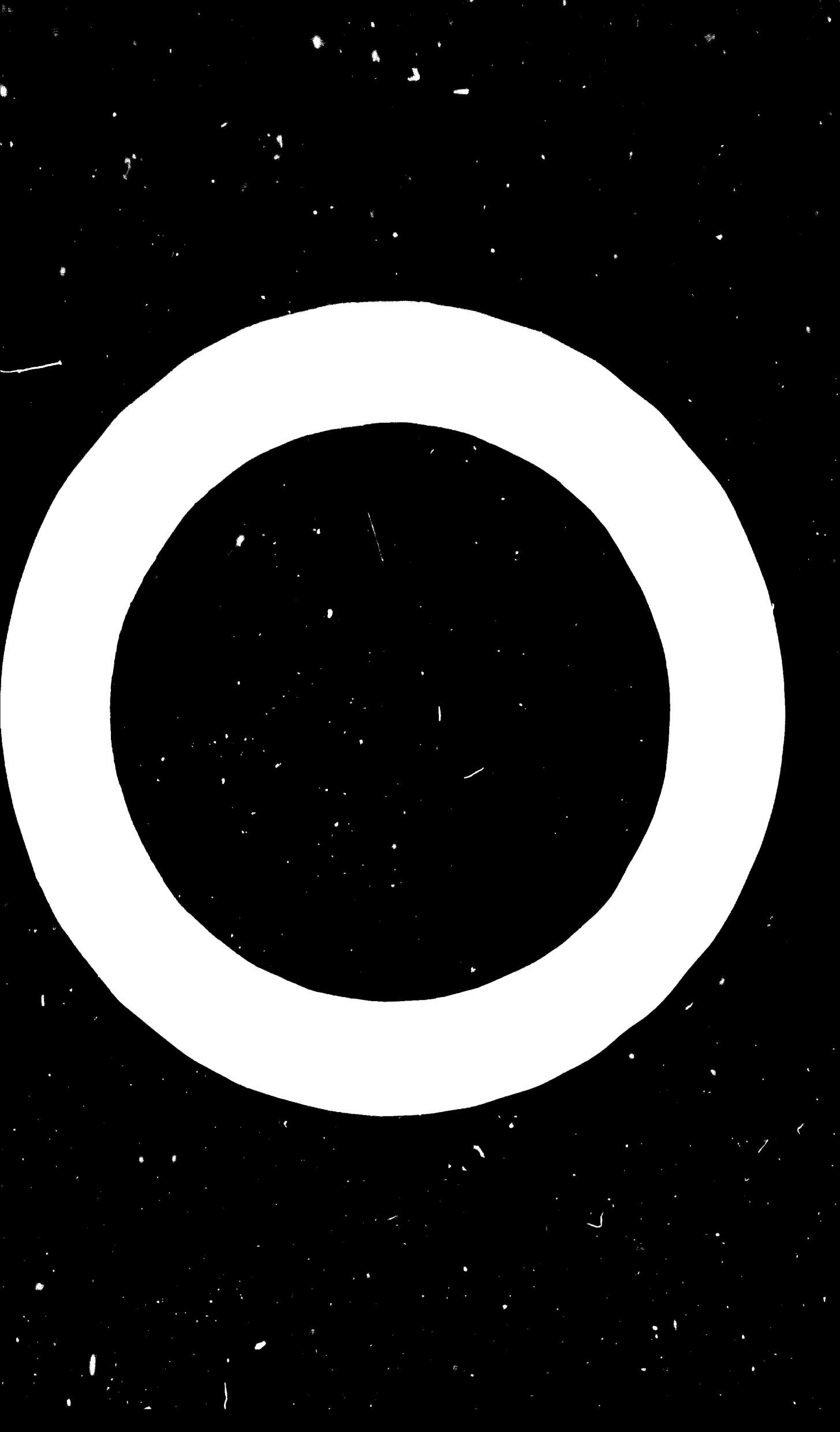

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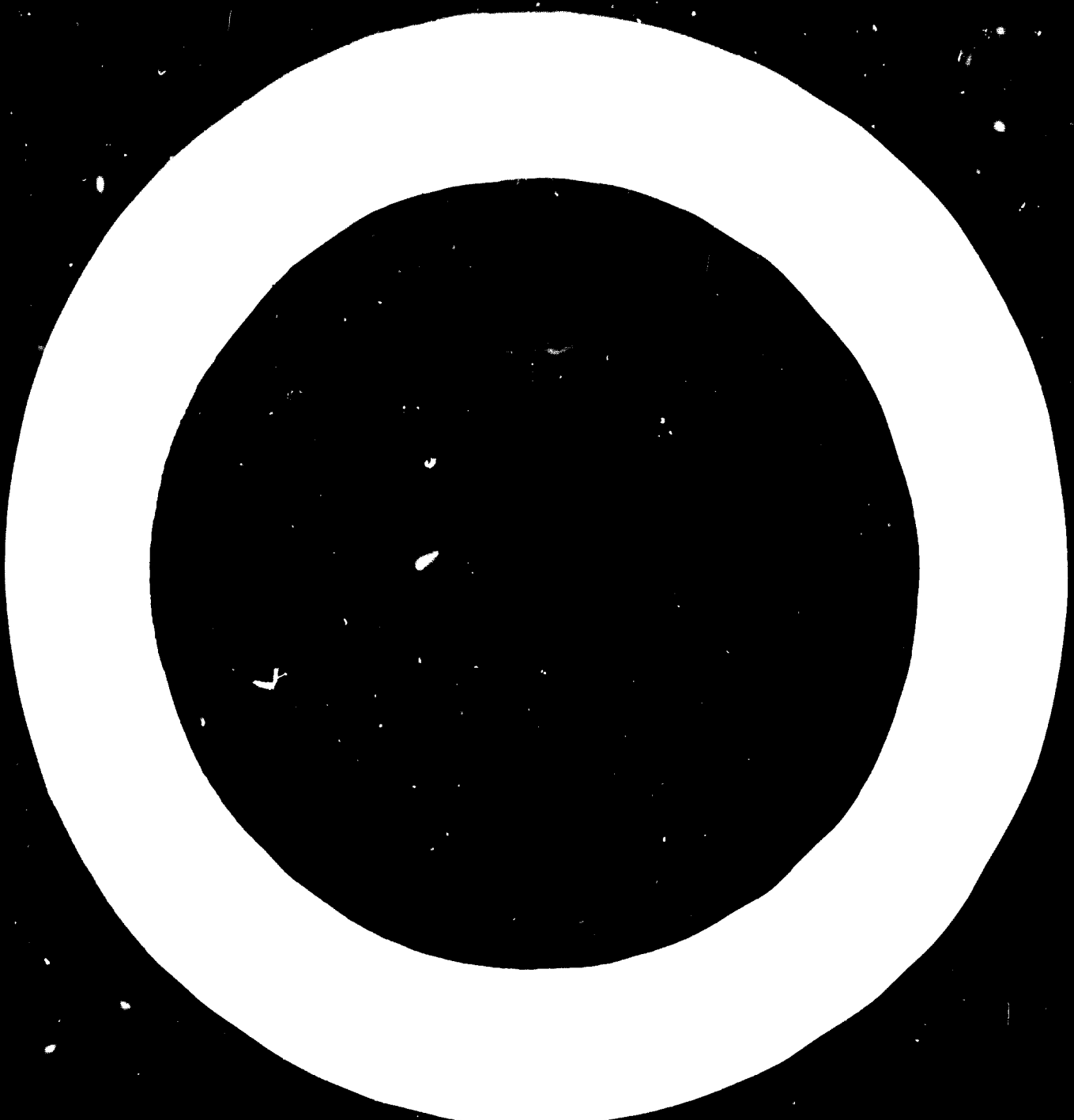

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I. CONSUMPTION OF PLASTICS

I.1. Global consumption of plastics

I.1.1. Volume of world consumption

In 19[illegible] world production of plastics and hence, more or less, consumption [illegible] figure of 22 million tons, consumption by developed countries amounting to 1,400,000 tons or [illegible] of this total, whereas in 19[illegible], with world consumption rather over 11 million tons, the developing countries accounted for 5.8%. The size of these figures places plastics performed in the front rank of the basic materials necessary for the economic development of these countries.

The production of plastics is still far below that of steel, but in close [illegible] that of sulphur whose essential role in the chemical industry is well-known, however, for some years now it has exceeded that of the most important non-ferrous metals - aluminium, copper, zinc and lead - which have been replaced by plastics in some of their applications.

The plastics era really dates from the Second World War, it was during this period that, thanks in particular to thermoplastic resins, their use started to become widespread.

The stages in this growth are summarized in Table 1.

It will be seen that the production of plastics has developed rapidly and also fairly regularly: it has, in fact, just about doubled every five years, corresponding to an average annual increase of about 15 .

A development of this kind, both rapid and steady, characterizes the growth period in the economic history of most industrial products. In the case of plastics this phase does not appear to be closing, because there is general agreement that by 1980 production will be of the order of 80 or 100 million tons (i.e. an average annual increase of 11 - 14%).

Table 1 - [illegible]

Year	Platinum	Silver	Electrolytic	Copper	Lead	Zinc
1955	0.55					
1960	1.50	190				
1965	3.10	255				
1966	6.90	335				
1967	12.90	431	6.2	5.80	3.0	3.85
1968	14	455	6.6	6.14	3.9	3.06
1969	17	455	7.3	6.40	3.3	4.26
1970	19	481	7.9	5.96	3.3	4.30
	27.5	535				

[illegible] on the one hand, have long [illegible] such [illegible] to the value of industrial [illegible]

[illegible] fluctuat[illegible] the [illegible] view [illegible] other [illegible] [illegible]

[illegible] picture [illegible]

[illegible] between [illegible] upswin[illegible] [illegible] short [illegible]

• [illegible] in 1966, [illegible] Europe [illegible] repron[illegible] in the [illegible] years since, according to [illegible] of GDP, three [illegible] become [illegible]

1.1.2. [illegible]

As for production, so for the consumption of plastics there are today [illegible] to the largest, on a footing [illegible] for [illegible] years, and the United [illegible] the [illegible] third great [illegible]

[illegible] which [illegible] give [illegible] of these [illegible] account for over [illegible] world consumption.

[illegible]

[illegible]	[illegible]	[illegible]	Japan	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] total [illegible] expected [illegible]

[illegible] gives a list of western Europe countries (OECD) showing how individual consumption of plastic and per capita income compare for each country.

From this table, we see that consumption is relatively high in Germany (which has a far lower income level than the United States and Sweden) or Italy and U.K. These three countries are remarkable for the dynamism of their plastic industry either for historical reasons or because of strict [illegible] etc.

Table 3 - [illegible] consumption of plastics and gross national [illegible]

	Per capita consumption			Gross national product per capita in U.S. $	Percentage of thermoplastics	
	1960	1965	1967		1964	1967
[illegible]	[illegible]	21.5	31.5	2,[illegible]	[illegible]	60
France	[illegible]	17.3	18.7	2,[illegible]	51	[illegible]
[illegible]	[illegible]	[illegible]	17.3	1,[illegible]	62	65.5
[illegible]	[illegible]	[illegible]	[illegible].9	[illegible]	54.5	54.5
[illegible]	[illegible]	16.2	19.1	1,[illegible]	63	57
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	69.5	71
[illegible]	[illegible]	[illegible].8	[illegible].5	[illegible]	41	60
[illegible]	[illegible]	[illegible].7	[illegible].2	[illegible]	–	–
[illegible]	[illegible]	[illegible]	[illegible]	2,[illegible]	50.5	52
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	–
[illegible]	[illegible]	5.7	9.2	72[illegible]	42	64
Portugal	[illegible]	3.8	[illegible]	[illegible]	68	71
Weighted [illegible] of [illegible] countries	[illegible]	14.7	19.7	-	58.5	6[illegible]
United States	9.[illegible]	20.8	[illegible].0	[illegible],9[illegible]	61	78
Japan	[illegible]	[illegible].6	21.4	1,1[illegible]	63	75

Taking the trend of plastics demand in the industrialised countries in recent years, we see that the rates of growth have everywhere remained high and that consumption appears to continue to rise independently of the level already reached; this indicates that the markets are not yet saturated.

However, and this is true of all the countries under consideration, progress has been slower in the very last few years. Thus in Western Europe the average rate of growth, which stood at 17% per annum from 1958 to 1964, fell to [illegible] and 12% chiefly because of the temporary stabilising of demand in Germany and Britain in 1966 and 1967. It may, therefore, expect that the consumption of plastics in these countries will grow at a slower pace in the coming years. It is also noteworthy that the demand for plastics has remained at a high level only in a few of the industrial countries in matters of income and plastics consumption, namely Japan and Portugal.

Finally, it may be observed that over the past [illegible] years the consumption of plastics per capita in the United States has grown from a few kilos to about 70 kg and in Western Europe from 10 kilos to 30. This still very recent, however, only a fraction of the potential market for plastics which, according to the most optimistic forecasts, will in the near future reach 100 kilos in these countries to a hundred or even several hundred kilos per capita.

1.1.3. [illegible]

Despite international specialisation advances, the consumption of plastics in most developing countries is still only a hundred or a few hundred grams per head. This is due either to the absence of local production (e.g. West Africa: 50 g or USSR: 600 g) or to the enormous size of the population (e.g. India: 120 g or West Pakistan: 135 g).

There are, however, a few countries, important producers and processers and in general less densely populated, where the demand has reached [illegible] level of [illegible] these countries [illegible] of [illegible] Europe [illegible] ten years ago (e.g. [illegible])

[illegible] the [illegible] developing countr[illegible] today in [illegible] that the [illegible]. In most [illegible] exc[illegible] their [illegible] find in [illegible] 30 in pr[illegible]

[illegible]

2/3 [illegible] indu[illegible] [illegible] United [illegible]

---

[1] Results [illegible] countries in economic cl[illegible] II.

These exports thus increased by some 18% annually between 1958 and 1967. This figure, though impressive, is below the estimated increase in local production in the developing countries. Following this trend, imports will pay an ever-decreasing part in the overall supplies of plastics to these countries.

Although these imports represent an important sum (1 million of plastics exported daily to developing countries), they are increasing less in value than in tonnage (11% annually from 1958 to 1967). This is due on the one hand to the price-cuts and still maintained drop in plastics prices and on the other, to the greater proportion of the cheaper grades in the total, those rising being customarily less expensive.

The imports of plastics fall into four major groupings which cover most of the developing countries:

- Latin America
- The Middle East
- Africa - except the Union of South Africa
- Asia - except Japan and China

Each of these represents different characteristics which we shall examine briefly after giving some statistics in Table 1.

Table 4 - Principal imports of plastics by regions

	Total in 1000 t			Index 1967	kg per capita		
	1965	1966	1967		1965	1966	1967
Latin America	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Middle East	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Africa	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Asia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	40.3			

In 1967, imports of plastics amounted to 321,000 tons, rather more than [illegible] in 1966, but [illegible] lower imports in 1965. The largest exporters [illegible] were the United States and Western Europe (principally [illegible] Italy).

The level of imports [illegible] and is consequently nearly [illegible] - since not [illegible] to depend on the [illegible] - but the level of imports varies widely between one [illegible] another.

For example, in 1967 imports of plastics by the two largest producers in Latin America, [illegible] Brazil, worked out at nearly 1 kg per capita for the former covering

one-third of the demand) and only 0.18 kg for the latter (roughly one-tenth of consumption), this quantity having doubled in [illegible].

Colombia, whose production is still on a small scale, imported [illegible] kg per inhabitant in 1966 (roughly three-quarters of the demand).

In 1967, the countries of the Middle East imported for the first time over 100,000 tons of plastics.

As in Latin America, the increase was slower between 1966 and 1967 than between 1965 and 1966, when it rose by one-third.

The principal supplier to the Middle East is still Western Europe (mainly Germany and Italy). The average level of consumption is about the same as for Latin America, i.e. [illegible] kg. Since however, local production is still on a very small scale, the level of consumption remains below that of Latin America.

Africa

The African continent still remains a very small consumer of plastics, the demand in various countries being [illegible] local production being found in South Africa.

The expansion of demand, although sustained (35 per cent in one year), is never [illegible] below the figure for developing countries. Western Europe (France, Germany, Italy) is [illegible], represented on this market. In 1967, the average level of imports was nearly 0.5 kg per inhabitant.

Having regard to the size of demand and the volume of imports of plantics in the South Africa, together with the absence of production in other African countries, this figure is therefore distorted [illegible] African States other than [illegible].

Asia

[illegible] largest [illegible] offers the largest [illegible] market, [illegible] potential market for [illegible] to the [illegible] rapidly expanding market [illegible]. Among [illegible] will now [illegible] (a) [illegible]

The [illegible] of [illegible] the [illegible] African [illegible] to [illegible] of [illegible]

By [illegible] of [illegible]

We [illegible] the [illegible] the [illegible] the [illegible] the [illegible] can [illegible]

[illegible] are [illegible] [illegible] [illegible] and

where consumption per capita is very low, and the Middle East where the level of imports (1 kg per capita) is sufficient to afford a fairly large consumption per capita before the establishment of local production.

I.2. Structure of plastics consumption

I.2.1. Growth of importance of thermoplastics

It is well known that there are two major categories of plastics: thermosetting resins and thermoplastic resins.

In the first group there are three principal types of resins: phenolic resins (used mainly for moulded objects and for plywood), polyester resins (for reinforced plastics) and alkyd resins (for paints and varnishes). Their commercial importance stems from several basic considerations, such as wide diffusion through the world, but their limited applications and their high production costs considerably restrict their markets, to the advantage of other resins.

The second group is by far the most important group of plastics; consists of the two basic plastic resins: polyethylene, PVC and to a lesser extent polystyrene, being the most common plastics. These resins offer a wide field of applications (which we shall examine below) and by advanced processes which enable the mass production of moulded objects, and a low cost of the raw material makes ever more competitive.

To these two categories of plastics - the most important - we should add those of the cellulosic derivatives used chiefly in the form of films and varnishes. Their production is concentrated chiefly in the developed countries (3 per cent of total plastics production in the United States and Japan) and is overtaken by thermosetting.

This rapid growth rate is the first which distinguishes the present structure of the plastics industry, namely the increasing part played by thermoplastics which impose the rapid rate of their development upon the whole field of plastics.

1.2.2. Specific examples of countries

1.2.2.1. Industrialised countries

Table 4 shows how the consumption of thermoplastic resins in the industrialised countries of OECD has recently evolved in relation to the overall consumption of plastics.

It will be seen that this advance has been noteworthy over so short a period as 1964 - 1967. At the same time the proportion of thermoplastic resins in Europe has progressed on average from 58.5% to 66.5% of the total. In this connection, we note a slight lag in Germany, which remains the highest consumer of thermosetting resins (11.1 kg per capita in 1967).

Progress in the United States has been far more marked during the same period, so much so that thermoplastic resins account for nearly 80% of the demand in this country. In Japan, this proportion is 75%, following a rather slower development.

It remains to analyse the trend of the demand for the three principal thermoplastic resins, namely polyethylene, PVC and polystyrene, of which we have shown the essential role in the development of the overall for plastics (cf. Table 5).

Table 5 - Apparent consumption of the principal thermoplastics resins in certain industrialized countries, 1957 and 1958

	1957				1958			
	Polyethylene	PVC	Polystyrene	Others	Polyethylene	PVC	Polystyrene	Others
Fed. R. Germany	145	168	138	423	210	256	163	629
France	111	154	78	343	208	214	82	504
Italy	81	133	56	292	202	206	91	499
Netherlands	33	50	13	94	72	85	12	170
B.L.E.U.	24	28	11	63	50	46	17	113
Total OEEC	416	660	176	1,252	649	1,007	397	2,253
United Kingdom	150	198	89	437	241	236	116	593
United States	1,010	715	520	2,245	1,210	920	1,000	3,130
Japan	259	235	148	642	512	353	291	1,156

During the period under review, the demand for the three principal thermoplastics resins increased at an average rate of 15 per annum, both in the United States and in Western Europe. The corresponding rate for other countries (Japan) and for other plastics resins, the production of which is small, was also very high, tending to settle around 15 - 20%.

In the United States, [illegible] grew in parity with [illegible]. The question [illegible] the United States [illegible] in the latter [illegible] in 1958 [illegible].

1/ The total [illegible] 10% [illegible] in the case [illegible].

On the other hand, the demand for the principal categories of thermoplastic resins moved quite noticeably in favour of polyethylene in the Common Market (38.5 % as against 29) and Japan (38 % as against 42 %).

As regards PVC, which in 1964 accounted for more than half of the total in the Common Market countries and Japan, its share is now 41 - 43 %. It remained low in the United States (27 %) and, like polystyrene, more or less steady during the period 1954 - 1964. This stability of consumption indicates the degree of balance attained on the American market.

The relative importance of polystyrene, as of PVC, has generally declined in recent years. This plastic now accounts for less than 20 % of total consumption of the three principal thermoplastic resins. An exception is to be found in the United States, where the percentage is 30 %, and where the demand for polystyrene and styrene resins is even higher than for PVC.

Taken together these observations show the trends which have been emerging for several years and confirm the long-term forecasts made some years ago, namely, the more rapid development and the extent of the demand for polyethylene, followed in order by PVC and polystyrene.

1.2.3.2 Thermoplastics

The demand for plastics in developing countries [illegible] most widely [illegible] of industrialized countries. [illegible] the latter, which [illegible] to explain the [illegible] finished products, [illegible] the installation of [illegible] by [illegible] of polyolefins].

[illegible] of [illegible] the [illegible] structure in [illegible], [illegible] with industrialized [illegible] of the [illegible] of thermoplastics.

[illegible] that thermoplastics [illegible] new [illegible] are of [illegible] which [illegible] and [illegible] certain [illegible] have [illegible] (urea-formaldehyde [illegible], the Philippines, etc.).

In future, [illegible] the industrialized countries, thermoplastics [illegible] will continue [illegible] greater proportion [illegible] chiefly to the expected rise in the consumption of polyethylene and PVC. These two resins, which enjoy an immense market throughout the industrialized

countries, have become quite cheap. Their usefulness in various forms has been well-established and finally, they are strongly represented in three sectors which will be the most important users of plastics in the developing countries, namely building, packaging and agriculture.

These general principles are illustrated by Tables 6 and 7 which show how the consumption of plastics has evolved in India, Eastern Pakistan and Mexico.

Table 6 - Proof of the structure of demand for plastics in India and East Pakistan

Percentage	India		W. Pakistan	
	1963	1967	1963/64	1967/68
Polyethylene	34.7	33.3	16.9	26.1
PVC	16.5	32.4	13.9	25.3
Other thermoplastics of which Polystyrene	19.2 (13.5)	13.6 (12.9)	16.1 ..	25.0 ..
Other resins	29.6	15.2	53.1	24.6
Total	100	100	100	100
Total tonnage	20,000	57,500	6,500	14,600
% of thermoplastics	70.4	84.8	46.9	75.4

Table 1 - Trend in the structure of demand for plastics in Brazil

Percentage	[illegible]	[illegible]
Polyethylene	32.5	29.5
PVC	15.2	16.3
Other thermoplastics	19.0	21.0
Other resins	33.3	33.2
Total	100.0	100.0
Total tonnage	2[illegible],000	135,000
% of thermoplastics	66.7	[illegible]

[illegible] but on the [illegible] in the [illegible] products [illegible] Both [illegible] represent [illegible] in input [illegible]

[illegible] or [illegible] In Brazil, [illegible] the price [illegible] of plastics [illegible] 74% in 2000. [illegible] very high [illegible]

[illegible] Middle East, [illegible] plastic resins to start at a level [illegible] to attain a level comparable with that of the industrialized countries. In Algeria, for example, the

proportion of thermoplastic resins rose from 47.5% in 1963 to 56.7% in 1966. The figures for the Maghreb (Algeria + Morocco + Tunisia) over the same period rose from 43% to 52.4%. These increases are due largely to local sales efforts and the expansion of trade with the industrialized countries.

The industrialized countries indeed, anticipating enormous growth potentialities for thermoplastic resins, have increased their exports of these materials to Africa in their efforts to find new outlets. Exports of only polyethylene from the EEC to Africa, for instance, in the common market, for example, [illegible] the approximate total for thermoplastic resins, can scarcely now account for 8% of total EEC exports. Despite these productions, are expected to maintain this proportion in the years to come.

Table 3 - Importance of thermoplastics in total exports to the Developing Areas

Percentages	1965	1966	1967
Latin America	59.5	66.9	70.5
Middle East	64.5	62.5	69.5
Africa	67	69	70
Asia	77.5	81	82
General average	73.7	78.7	80.9

I.2.1. Factors in the growth of the market - Expected trends

The [illegible] polyethylene and in particular for polyethylene [illegible] market in Africa, the growth of the market [illegible] in developing countries. The factors [illegible] decisive influence and which [illegible] by these statistics are three in number :

- [illegible]
- [illegible]
- [illegible]

The plastics market will continue to be characterized by the [illegible] packaging sectors, notably packaging and building [illegible] polyethylene by the recently polyethylene [illegible] subject of Chapter III.

[illegible] polymers [illegible] for polyethylene [illegible] effectively [illegible] enable the [illegible] market for high-density polyethylene [illegible] polypropylene, which [illegible] by them. It must, however, be [illegible] situation will continue [illegible] programmes of research which will [illegible] and the improvement [illegible].

[illegible] such will clearly come into the [illegible] wealth of knowledge [illegible] will give them a distinct advantage [illegible] structure and will ensure them a predominant role in the installation of new plants.

In contrast to the firm prices of most industrial products, the reduction in the prices of plastics and of certain other products of the petrochemical industry excited lively attention.

For instance, during the period 1955 - 1965, the average price of plastics was approximately halved. In particular, the tendency to a fall in the price of thermoplastics held good for exports to developing countries, as shown in Table 9.

Table 9 - Average price of exports FOB $/lb

Country of origin	1965	1966	1967
Japan	19.5	17.5	16.5
United States	20	21.5	20
EEC countries	20	18.5	17
General average	20.5	19	17.5

(thermoplastics, resins and semi-products)

During the last years or two, this downward movement has slowed considerably and on certain markets there have even been some limited increases in price, especially in the case of polymers produced in large quantities.

The successive reductions in the price of plastics in recent years have greatly contributed to the expansion of their market. It seems likely that still further reductions will occur as a result of increasingly keen competition, but at a diminishing rate as we get closer to cost prices.

This being so, it seems likely that the prices of polymers will tend in the medium or long term towards levels close to those forecast for the United States internal market. While the short prices on the U.S. domestic market are higher than current international prices, they are estimated on average at 10 - 10.5 £/lb for low density polyethylene as well.

Table 10 - [illegible] prices of the principal polymers in the United States

£/lb	Present current prices	Prices after 1975
Low density polyethylene	11.5	8
High density polyethylene	16.5	12
Polypropylene	19.5	15
PVC	10.5 (monomer 5)	9 (4)
Polystyrene	14 (monomer 8)	11 (6)

It will be seen that the greatest reductions in prices to be expected in the next few years will be for polyolefins, whereas they will be less marked in the case of polystyrene and PVC, both of which are now sold at prices not far above cost of production.

II - APPLICATIONS OF PLASTICS

II.1. Sectors of use

II.1.1. Evolution and developments since 1964

The applications of plastics have expanded in all fields in which they were already used before 1964. The properties of plastics have not only been maintained and even improved their original characteristics. This is true, in particular, of the two foremost sectors - packaging and construction.

Table II shows the relative proportions of the most important applications and their development in the USA and Britain. We see that packaging has maintained its predominance and that building applications are making rapid progress.

While other sectors have kept their respective places, one only appears to have a slower rate of growth, namely electrical and electronic applications, where the demand for plastics was already practically satisfied (e.g. for the coating of electric wiring and telephone cables).

Table 11 - Percentage distribution of plastics in the main fields of application (*)

	USA		Britain	
	1963	1969	1967	1968
Packaging	31.9	30.9	30.1	29.1
Construction - building	17.0	19.1	18.4	20.1
Electrical - electronic	12.0	12.7	14.2	13.5
Household articles	9.0	8.0	9.2	9.3
Transportation - transport	6.2	7.15	7.0	7.1
Furniture	5.1	6.05	5.0	5.1
Toys	5.0	5.1	5.3	5.2
Domestic appliances	3.4	3.1	3.05	3.4
Agriculture	1.1	1.05	2.05	2.1

It is interesting to note the evolution which has taken place in various sectors since 1963 and to consider the extent to which the hopes placed in an increase in plastics consumption in the developing countries have been realised. At the Tokyo Petrochemical Conference it was stressed that special attention should be given to fields offering the greatest promise, namely building and agriculture. Apart from these two it is interesting to note that applications in other pre-established sectors such as household articles and domestic appliances.

For all applications of plastics we divided the developing countries into two groups, viz.:

- producer countries are those which already produce polymers or at least have a highly developed processing industry (e.g. extrusion, calendering)

- non-producers are the other developing countries.

a) Building

In 1964, attention was concentrated on piping, floor coverings, thermal insulation and the possibility of building all or part of a house (walls, partitions) in plastics.

While in the producer countries an existing tendency towards the consumption of floor covering was strengthened, the use of plastics piping developed very little, often because of legislation or for psychological reasons. In all non-producing countries the first application to catch on seems to have been floor covering.

As regards other uses - thermal insulation, panels, pavilion - the market is to all intents and purposes non-existent. The developing countries have preferred to await technological studies and more soundly established purchasing habits in the industrialized countries instead of seizing the opportunity of replacing classic and sometimes expensive materials as soon as possible.

b) Agriculture

In this sector hopes have on the whole been disappointed except in certain countries where plastic irrigation piping are beginning to be used. All other

agricultural applicants as have remained too sophisticated for countries whose level of technology is not in the least [illegible] level than in the industrialized countries [illegible] in the United States and in certain countries, because of its inability [illegible] to another example of the lack of interest in the new applications that [illegible].

c) Packaging

In developing countries, as in the more industrialized, these applications are tied to problems because their market [illegible] very large part of the population, even with limited incomes, consume quite sizable [illegible] of products, especially in food packaging (film, sheathing, [illegible]). On the other hand, certain more recent applications such as the packaging of bread, milk, or edible oils [illegible] but have to expand.

d) Packaging [illegible]

The [illegible] on the one hand, molded objects (household articles, [illegible] which need to cover their market, [illegible] very large [illegible] and, on the other hand, packaging [illegible] more reasonable [illegible] than in the industrialized countries.

In order [illegible] applications which exist [illegible] to the developing areas, owing to their special needs [illegible]. The last few years have not fundamentally modified [illegible] despite the potential [illegible] and growth and the [illegible] of fresh applications in packaging.

II.1.3. Trends to be expected

Under the influence of changes in legislation and in the habits of consumers, those sectors which appear to offer the greatest employ - packaging and building - will be affected [illegible] very substantial markets for plastics [illegible] in which it would be true to say that a substantial [illegible] such as already known [illegible] of building.

[illegible] have been slow to be restructured or [illegible] to make their [illegible] of plastics. They will be the last [illegible] and the furniture industry in particular is [illegible]. The transformation [illegible] will [illegible] for packaging for [illegible] under way in the coming years. [illegible] will [illegible] the relative regression will be [illegible].

As regards the [illegible] it is interesting to observe the trends which can be applied in the next few years in the [illegible] operations.

a) Existing [illegible]

[illegible] are being [illegible] with domestic or household [illegible] and with [illegible] objects produced in recent years [illegible] household articles, toys, components of domestic appliances.

These applications will form the starting-point of the plastics processing industry in countries where it has not yet really found a footing. In producer countries, as in the industrialised countries some groups of these applications will expand more slowly than the others.

Among material objects, plastic footwear could make rapid progress owing to its low cost by comparison with footwear in leather or rubber.

Another promising field is that of synthetic leather and textile coatings, which could, for footwear and "leather goods" as well as other uses, find a constant growth in the developing countries.

A [illegible] which is already well developed is that of the coating of wire[illegible] or telephone cables. To the extent to which [illegible] already use PVC for this purpose, this market is relatively saturated and can expand only in keeping with the increase in cable installations. In the non-producer countries this application will be largely under the influence of legislation or of decisions taken by the principal cable manufacturers.

b) [illegible]

It is in this sector that we may look for the greatest progress and the most diversified applications.

The [illegible] will be found in all [illegible] wrappings for foodstuffs and [illegible] packaging. Another important [illegible] which appears particularly competitive is that of heavy-duty bags, which may ultimately replace jute bags and partially [illegible] bags for the transport of fertilizers or chemical products, either in the form of plastic-lined jute bags, or of all-plastic bags.

We may also expect to see a beginning of packaging in the form of bottles or seals (for milk, oil, and other beverages) and various containers for non-foodstuffs such as shampoo, detergents, lubricating oils, etc.

c) Building

Although still limited, this sector offers the greatest potential applications for plastics in the developing countries. New legislation and decisions taken at national level should result in very large quantities of plastics being consumed, at least for uses already familiar in the industrialized countries - piping for water supply and drainage, gutters, window-frames and floor covering.

The other applications which were expected even in 1964, namely thermal insulation and whole panels in plastic (walls, partitions and roofs) will take time to establish themselves because they require a highly heavy manufacturing industry and have to overcome psychological barriers. In terms of savings they represent the largest potential for plastics in countries where their prices are competitive with traditional material - steel, wood, cement - which are often expensive.

d) Agriculture

This sector, in which plastics have made little headway in the industrialized countries, should occupy a larger proportion of the market in developing countries. In particular, applications connected with irrigation should develop a first priority - irrigation piping first of all and then reservoirs and the lining of channels. Other applications for films and wrappings, such as tarpaulins and packaging of the fruit and vegetables produced will gradually develop.

Other and more sophisticated applications, to be found in only a few countries (such as Holland, Austria, Scandinavia, greenhouses and shelter-trunks), despite their [illegible], will not yet establish themselves at the present time, where the chief aspect is a better agriculture, farms are much more exten[illegible], mainly intensive and fertilized.

II.2. Principal applications of plastics

The use of plastics is known to be varied in building, packaging and agriculture. It is clear that, thanks to their wide range of applications as well as their low price, only polyolefins and PVC will [illegible] in all countries, for values [illegible] per plastics. By virtue of the space to which they are destined or will be put in building, materials, whose plastics will attention, mainly polyolefins, polystyrene and [illegible].

II.2.1. Applications of PVC [illegible]

a) In rigid [illegible]

For some years rigid PVC has had the [illegible] developing [illegible] to [illegible] than flexible plasticized PVC. [illegible] PVC in terms of [illegible] the outlook [illegible], brings out these facts:

- The very notable increase in rigid applications - rigid extrusion and sheets : rigid pipes, sheets for engineering or building, profiles.

- The relatively lower increase in the tonnage and applications of flexible PVC, especially in floor coverings, flexible extrusions and cable coating.

- The fairly large increase in moulding, due chiefly to the appearance of PVC bottles for the food industries.

These three trends will be maintained in the years to come, together with a steady increase in covering materials (leather cloth, applications in automotive industry).

Table 12 - Uses of PVC (in %) in the industrialized countries

	U.S.A.	Britain	France	Japan*
1964				
Films and rigid sheets	20.3	28.4	27	23.45
Flexible extrusion	9.8	7.4		24
Rigid extrusion	11.1	14.0	16.9	20.9
Cross linked cables	12.55	13.75	11.3	9.7
Floor coverings	10.5	13.85	12.2	4.2
Moulding	9.75	11.9	11.55	7.25
Coating	7.1	7.9	7.45	9.6
Others	7.9	7.1	7.9	0.7
1967				
Films and rigid sheets	24.5	19.6	23.65	19.45
Flexible extrusion	6.3	5.2		13.55
Rigid extrusion	13.75	19.0	22.55	26.05
Wire and cable	11.15	12.5	11.2	9.45
Floor coverings	14.45	11.2	10.75	3.25
Moulding	11.15	14.25	11.5	8.65
Coating	9.45	7.8	8.5	7.1
Others	5.25	6.7	5.25	0.9
Rate of annual increase of total consumption for these applications	14.1	11.1	14.4	14.4

* Figures for 1964 - 1967

b) Industrial production

The quantities of flexible PVC were [illegible] by computer (cf. Table 11). This trend is, however, likely to be reversed, especially in countries [illegible] production [illegible]

- The [illegible] for plant, especially [illegible] supply [illegible] should [illegible] begin [illegible] will begin [illegible] extend [illegible] widely [illegible]

- [illegible] tions [illegible] their production [illegible]

  - [illegible]
  - [illegible]
  - [illegible]
  - [illegible]

- [illegible] telephone [illegible] increase [illegible]

[illegible] for packaging [illegible] quantities [illegible]

II.2.2. Applications of polyethylene - Trends

Both because its applications are more important and above all because only its production seems to be envisaged in the developing countries, we shall here consider only the applications and trends of the market for low density polyethylene.

Both in the industrialized countries and in the developing countries, the applications of high density polyethylene are objects moulded either by injection or by blowing (housewares, articles and appliances in the first case, bottles and containers in the second). A new application, that of fibres, strings and films, will be mentioned together with the corresponding applications of polypropylene.

a) Low density polyethylene in the industrialized countries

The application initially most widespread, namely films and sheets for the packaging of foodstuffs or non-foodstuffs, "general purpose" films and heavy-duty bags have increased their proportion to account for more than half the total amount. This trend will be accentuated in the United States and Europe until it reaches the present level in Japan where films and sheets account for nearly 60% (cf. Table 15).

This increase will be made at the expense of moulded applications where other plastics such as high density polyethylene, polypropylene and other thermoplastics are more suitable by reason of their specific properties than low density polyethylene.

While polyethylene pipes are gradually yielding ground to PVC pipes, the same is not true of the field of cables, where polyethylene will take the lead due to reasons of the expansion of the market for telephone cables and coaxial cables.

Table 1 ... by ... polyethylene (in %) in the ... countries

	USA	Taiwan	France	Japan
[illegible]				
[illegible] and sheath	44.5	42.8	37.1	64.0
[illegible] moulding	20.4	21.9	47.0	9.0
[illegible] moulding	2.9	11.0	4.8	3.0
[illegible] cable	11.5	9.4	2.9	5.3
[illegible] coating	13.8	9.1	[illegible]	14.3
[illegible]	3.45	4.[illegible]	5.3	0.8
[illegible]	2.75	3.3	2.9	3.6
[illegible]				
[illegible] and sheath	47.3	53.3	53.6	59.0
[illegible] moulding	15.35	16.95	27.45	8.9
[illegible] moulding	1.5	10.1	1.85	3.6
[illegible] cable	[illegible]	[illegible]	3.[illegible]	7.7
[illegible] coating	12.[illegible]	5.[illegible]	1.3	12.95
[illegible]	2.65	2.5[illegible]	4.[illegible]	0.9
[illegible]	[illegible]	[illegible]	2.[illegible]	5.95
[illegible] annual [illegible] total consumption	21.1	12.1	19.3	24.5

b) Low density polyethylene in developing countries

The market for low density polyethylene in these countries is characterised by the existence of only two branches - films and sheets, and mouldings (often by injection and sometimes by blowing). There is practically no market for pipes or the coating of cables (cf. Table 14).

In these two basic branches we find, at least in the processing countries, the same market trends as in the industrialized countries, namely the predominance of films and sheets (60-70% of the market) and relatively important markets for injection-moulded articles.

This structure will probably be maintained in the future if we consider the enormous potential for polyethylene films and sheets represented by packaging, agriculture and building.

Owing to the fact that sophisticated plastics will not yet make their appearance in the field of moulded objects, low density polyethylene may be expected to maintain a far from negligible proportion - but decreasing in the processing countries - beside high density polyethylene and polypropylene.

To the extent that these countries can meet their requirements for piping or cable coating with PVC, it seems likely that low density polyethylene will appear only marginally in these fields.

The coating of textiles should continue or at least make its appearance for heavy-duty bags for fertilizers.

Table 14 - Applications of PVC and low density polyethylene in 1967-68 in developing countries (%)

	India	Mexico	Pakistan
PVC			
Films and sheets	14	25	22
Rigid extrusions - pipes	20	7	
Moulding	17	28	18
Wires and cables	18	10	45
Floor covering	10	7	-
Coating	15	-	14
Other	6	3	-
Low density polyethylene			
Films and sheets	60	70	65.5
Injection moulding	15	30	29.5
Blow moulding	8		
Pipes	7		-
Wires and cables	6		5
Other	4		

II.2.3. Applications of other plastics in the developing countries

As in the industrialized countries, the market for thermosetting resins shows a tendency to decrease in relative or even in absolute value - except perhaps for resins used as adhesives for plywood in certain countries (urea formaldehyde and phenolic resins); however, certain thermoplastic resins offer appreciable applications.

a) Polypropylene

Owing to its recent production or imports place it on a competitive footing with the more classic plastics (high density polyethylene, high impact polystyrene), polypropylene should have its place on the market in two main sectors:

- injection-moulded objects, for packaging (crates for bottles, for example) or for household articles and domestic appliances;
- applications in the form of tapes or films, where the polypropylene potential is very great, namely in agriculture and fishing (woven bags, strings, ropes, nets) or in the packaging of foodstuffs. The only obstacle to part of this consumption appears to be the technology and the expensive investments required of the processing industry.

b) Polystyrene and styrene resins

As in the industrialized countries, polystyrene, despite its brilliant past and its dominant place it occupies in moulded objects (household articles, appliances, toys), will account for a relatively decreasing,

though still appreciable, some of the market which high impact polystyrene and expanded polystyrene will move to other products.

Moves in the industrialized countries, away from styrene resins such as ABS [illegible] have a great future in such applications as the car safety industry, building or manufacturing [illegible] high temperature, corrosion body [illegible] conditioning [illegible] steel, [illegible] countries will also [illegible].

The use of [illegible] applications of plastics in building, [illegible] are [illegible] reinforced [illegible] will [illegible] by protectionism in the industrialized countries.

III. TRENDS IN PRODUCTION TECHNIQUES

III.1. Production of [illegible]

III.1.1. [illegible] the steam-cracking process

[illegible] development in the last five years has been the [illegible] replacement of acetylene by ethylene in the production of numerous. Since 1964, apart from the production of polyolefins which was necessarily based on ethylene or propylene, the other widely consumed thermoplastics such as PVC, [illegible] acrylonitrile, [illegible] and polystyrene, [illegible] exclusively acetylene as raw material. This hydrocarbon was itself usually derived from calcium carbide and, more rarely, synthesized by pyrolysis of methane. While the production of these monomers from acetylene is relatively easy, because of acetylene's high reduction costs to levels which limited the expansion of these polymers.

[illegible] processes were initially based on the hope of obtaining cheaper acetylene, among them the high temperature pyrolysis [illegible] (production of synthesis), but these hopes did not [illegible] to have been realized and the number of plants using these processes remains very small.

[illegible] competitively with [illegible] in acetylene production, other routes were discovered whereby monomers could be produced from ethylene. In fact, these routes were already known in 1940, but at that time the industry was not entirely convinced that they offered economic advantages over the traditional processes based on acetylene. Since then, they have been overwhelmingly implemented, for all plants built from 1955 to 1965 for the production of PVC, acrylonitrile and vinyl acetate are based solely on ethylene.

This change-over from acetylene to ethylene as the basic material was only possible because acetylene could be obtained sufficiently cheaply and technically no restriction on capacity, thanks to the use of steam crackers using various feeds ranging from natural gas to petroleum products such as naphtha.

In addition to ethylene, steam-crackers give a number of easily recoverable by-products of great value for the production of other polymers. It is for this reason that this route to multiple monomers [illegible] can be [illegible] economically [illegible] petrochemicals).

The ethylene, propylene, butadiene homologs, toluene and the xylenes have been [illegible] easily obtainable materials, the size factor [illegible] further.

This has led to the development of new processes for producing monomers, which are [illegible] ethylene chain.

III.1.2. Vinyl [illegible]

Vinyl chloride is [illegible] exclusively by the chlorination [illegible] of ethylene and the cracking of the dichloroethane formed.

Chlorination [illegible] by the [illegible] technology and by the catalyst [illegible] the reaction of chlorine in the gaseous or in the liquid phase in the presence of a catalyst (metallic chlorides). In the liquid phase [illegible], making it possible to [illegible] the HCl [illegible] from the chlorination reaction as a [illegible] of over 99% and this is increased to 99.9% after purification. The yield is also very high, 98% for both ethylene and [illegible]. The principal by-products are trichloroethane and tetrachloroethane.

Conversion of the dichloroethane into vinyl chloride is currently carried out by thermal cracking in tubes at 4 bars and 500°C. Conversion is of the order of 50% and selectivity 95%. After purification very high purity of vinyl chloride is obtained, easily meeting the U.S.P. specifications.

The various processes differ little in their consumption of raw materials. The large amount of chlorine required should be noted : 1270 kgs for 1 ton of vinyl chloride.

In the ethylene oxychlorination processes the hydrochloric acid is used [illegible] as follows:

$$CH_2 = CH_2 + 2\ Cl + 1/2\ O_2 \longrightarrow ClCH_2 - CH_2Cl + H_2O$$

This route has been studied by numerous firms in recent years and many of the plants recently built or under construction employ this process. The principal processes based on oxychlorination of ethylene are those of Goodrich, Stauffer, Frontier and Distillers.

To avoid the production of hydrochloric acid inherent in processes operating with ethylene alone (600 kgs per ton of vinyl chloride in the chlorination process), one solution is to use a stoichiometric mixture of ethylene and acetylene which is subjected to the action of the hydrochloric acid resulting from the cracking of the dichloroethane formed during the later stage of ethylene chlorination.

Processes have been devised (SBI and Kureha) for producing directly a suitable ethylene-acetylene mixture and carrying out the sequence of operations without separating the constituents of this mixture. This method, using a dilute effluent, avoids the concentration and expensive separation of ethylene and acetylene, replacing them by that of vinyl chloride and dichloroethane.

Apart from one or two plants built since 19[illegible], in Japan for instance, these processes are no longer employed, having been replaced by more modern techniques.

In conclusion, the most recent figures from the cost point of view are obtained in plants combining chlorination of ethylene. The quantities of raw materials and utilities required for one ton of vinyl chloride are as follows:

Ethylene	503 kgs	Cooling water	200 m^3
Chlorine	750 kgs	Electricity	250 KWH
Steam	2 tons	Fuel	1.10^6 Kcal

III.1.2. Vinyl acetate

One of the recent developments is the elaboration by various companies (Wacker, Celanese, BCL) of processes for producing vinyl acetate from ethylene. The reactions involved are similar to those of the Wacker process for synthesizing acetaldehyde in the presence of palladium chloride, working in a sodium acetate bath, vinyl acetate is rapidly formed, the yield being of the ethylene.

As in the Wacker process the palladium is recycled by means of a Redox system, usually Cu^{++} and Cu^{+}.

Two by-products are formed : acetaldehyde and ethylene diacetate. The process is carried out at pressures of 1 - 5 bars and temperatures of 50 - 150°C.

It has also been reported that the synthesis of vinyl acetate from ethylene can be achieved in the vapour phase. B.P.C.I. has built a pilot plant using this technique. The catalysts employed are said to contain zinc, copper or cobalt. The yield would be 9% for ethylene and 93% for acetic acid.

III.2. Production of polymers

III.2.1. Polyethylene

High pressure polyethylene

Certain [illegible] modifications which were already announced in 1964 have been brought into effect during the last five years, with undoubted economic advantage.

Most of the research now in hand is concerned with tubular reactors giving products of higher quality than the old processes using [illegible].

Tubular reactors with multiple injections of ethylene have been developed and a number of firms have built plants of this type, differing slightly according to the process (CNPA, BASF, Du Pont); this system also presents advantages in the manufacture of ethylene copolymers.

All tubular reactors have been modified by injecting the catalyst at several points and by creating two separate zones of polymerization. This takes place in the first zone between 150 and 190°C and in the second between 190 and 240°C. The quality of the films obtained with these polyethylenes is much improved. The internal volume of these reactors has been doubled, to 500 litres, and it is not impossible that even larger volumes may be reached.

At the same time, in all types of reactor, higher pressures are being used. Pressures of over 2,000 kg/cm^2 are common, giving polyethylenes of intermediate density, but the present limit imposed by the [illegible] is 2,500 kg/cm^2.

Certain minor improvements are also to be noted, such as:

- the addition of carbon black and stabilizer directly into the polymerization reactor, which reduces the cost of production and ensures greater regularity in the quality of the product,

- the direct production of emulsions in the reactor in the presence of water and a surfactant.

New [illegible] have appeared on the market, especially ethylene copolymers:

- vinyl [illegible] (Dow Chemical)
- methyl [illegible] (Du Pont)
- vinyl [illegible] (Solvay)
- methacrylic [illegible] (Du Pont Canada)

[illegible] are starting commercial [illegible] with:

- vinyl [illegible] (Du Pont)
- [illegible] (U.C.C.)
- vinyl [illegible] (Du Pont Canada)

Low pressure polyethylene

The two processes [illegible], Ziegler and Phillips, have maintained their respective positions from the economical standpoint and a number of improvements have been carried out on the various processes. It should be mentioned that [illegible] of antioxidants has been studied. It seems, however, that it has given rise to any industrial applications.

The Phillips process has been improved mainly from the economic standpoint (lower energy consumption), while the Ziegler method has progressed chiefly in its catalytic system (titanium tetrachloride associated with organic aluminum compounds is still the most frequently used) and in the elimination of the catalytic residues.

Polymerization

From the technological standpoint, we find the same improvements as for the Ziegler process for the polymerization of ethylene, with a few additional modifications [illegible].

- the catalyst is essentially based on titanium trichloride and an organic aluminium compound
- polymerisation takes place in cylindrical reactors, the process being continuous, sometimes assisted by the propylene flow.

The use of [illegible]-screw reactors has been recommended for polymerisation in the absence of solvent; certain polymerisation processes work with liquid propylene.

- Substantial progress has been made in quality: homopolymers [illegible] have given way to copolymers, which have much better mechanical properties, resistance to cold in particular being much improved. Propylene is copolymerised with:

ethylene
ethylene/propylene copolymer
butene
higher olefins

All these products have slightly different characteristics which find their application in highly specialized fields.

Other polymers

Since 1965 the following have appeared on the world market:

Polybutene - 1, marketed by Phillips and by Huls
Polymethyl - 3 - pentene, marketed by ICI

Some companies are proposing to manufacture polymethyl-3-butene, to be used for a very special purpose, namely for tyre cords.

Size of plants

At the present time it is scarcely feasible to set up in the industrialized countries a high pressure polyethylene plant of less than 50,000 tons per annum, with reactors of 25,000 tons per annum unit capacity, or a low pressure polyethylene plant of less than 20,000 tons per annum for the Ziegler process or 40,000 tons per

anhan for the Phillips process. For propylene, the lowest existing unit capacities are 11,000 tons per annum. It is however not absurd to envisage the construction of high pressure polyethylene plants with a single unit of 40, or even 60 thousand tons, and a polypropylene plant of 10, or even 20 thousand tons.

III.2.2. Polyvinyl chloride

Polyvinyl chloride can be produced by several processes according to the form in which it is introduced. In bulk polymerization process has been used with the help of two stages (suspension, suspension), but to avoid the difficulties of heat evacuation, has been achieved successfully in a vertical tube bundle.

Polymerization in bulk

In bulk polymerization it proves possible to obtain a very pure polymer of a high degree of polymerization by suppressing the aqueous phase and operating in the really divine conditions the process has been achieved only by Montedison and Solvay, which has produced increases in capacity and cuts throughout the world. The key point of this process is the control of the temperature because the polymerization is highly exothermic and the heat formed must be rapidly eliminated. A very high degree of the polymer this is obtained by operating with a stirrer. In a first reactor a conversion of the monomer polymer is obtained, then this is transferred into the turbulence. The monomer is then removed under the stirring. The degree of polymerization is controlled depending on the temperature. Polyvinyl chloride thus obtained is characterized by great purity and lack of porosity, which makes it possible to manufacture transparent articles of very high quality.

- This little progress has been in the dispersion process, we may mention the modification introduced by Air Reduction,

namely the copolymerisation of vinyl chloride with 3 to 8% propylene. This gives products which can be extruded at lower temperatures than ordinary PVC, the end product being a transparent material particularly suitable for food packaging and easily stabilised by non-toxic anti-oxidants.

- Technically, it seems that suspension polymerisation of vinyl chloride could be improved, especially from the economic aspect. By using a novel system it is hoped to increase the speed of polymerisation from 8 hours per batch to 4 hours per batch, whereas if the same reactors are used independently, the speed is only 12 hours per batch.

- In practice the temperature required for suspension polymerisation is normally higher than for bulk polymerisation. However, the latter leads to a very acceptable product, ready to use for milling and extrusion.

- The emulsion polymerisation process continues to give the best PVC for many coatings. It has scarcely changed since 1935.

Superchlorinated PVC

An important development in recent years has been the superchlorination of PVC, which makes it possible to obtain a material with similar properties to those of PVC, but stable at higher temperatures. The properties are particularly improved if the dry powder is dissolved, rather than in paste in plasticiser, suspension, bulk or emulsion polymerised PVC, and they seem to have been significantly improved by 3 years. The chlorine content of commercial superchlorinated PVC is between 63 and 70%; its principal application is in hot water transportation, such as central heating pipes or other pipework in buildings, and in

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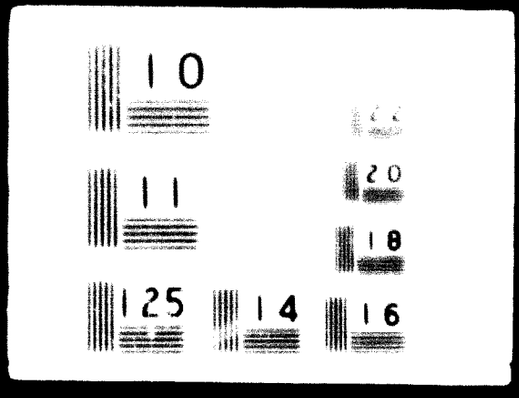


... ...ses their use makes it possible to dispense with the insulation ... ...ssary with metal piping. The material can also be worked by calender-... thermoforming, injection moulding and extension.

... of plant

The plants established in the industrialized countries have continually increased in size: a PVC plant has an annual output of at least 5,000 tons, although one might reasonably envisage (particularly for bulk uses) plants of 15,000 tons per annum. On the other hand, vinyl chloride producers planned now in construction, especially those using the more complex oxychlorination process, become economically profitable only above 60,000 tons per annum and often have a capacity of 100,000 tons per annum or more.

III.3. Plastics manufacturing techniques

Apart from new manufacturing processes existing in 1964, but mainly developed since then (extrusion-blow moulding, thermoforming, extrusion of strip), the main developments have been the general improvement of the old methods in performance, reliability and investment cost.

III.3.1. Improvement of old manufacturing methods

... ... - has developed little except in the size and performance employed (articles of several kilos and pressures of several tons), while techniques such as extrusion or extrusion-blowing or blow-moulding have considerably improved in performance.

... ... is the extrusion of rigid PVC for pipes: in 1964 for large extruders (screw diameter 150 mm) hourly outputs of 600 tons per machine were obtained, while the only 200 kg obtained - still with single-screw extruders - were about 900 kg per machine for an investment of the same order of magnitude (+50,000). This period has also seen the widespread use of dry mixed powders usable directly, with which higher rates and better qualities can be obtained in the finished

product, provided that the formulae are properly mastered and the labour force trained accordingly. These powders and the use of double screw extruder make it possible to obtain average annual rates of 1,200 t on [illegible] diameter of 120 mm at the cost of a barely higher investment.

Extrusion blowing, blow-moulding and calendering have also seen progress in [illegible] and performance increase for scarcely higher investment [illegible] blowing on blow - extruders of 150 mm diameter, containers with a capacity of several hundred litres, production speed [illegible] and aspect of extended objects. In all manufacturing [illegible] the integration of various stages [illegible] control has been [illegible] development, especially [illegible] pipe extrusion, extrusion - blowing, extrusion for wire [illegible] and other extrusions.

III.3.2 [illegible]

Certain manufacturing techniques which had already appeared by 1939 were developed after that date, as for instance the following ones, based on [illegible] thermoforming, extrusion-blowing, blowing, extrusion of strip for straps, fibres and woven bags, [illegible] moulding.

Thermoforming

This [illegible] process has been known for a long time. It consists [illegible] sheet of thermoplastic polymer to softening point and forcing the plastic into a hollow mould by means of a mechanical [illegible] such as a punch, or by compressed air blast, or again, by vacuum suction; after cooling, the part retains the form of the mould.

As a result of the progress made with thermoforming machinery, this processing method is increasingly used in the working of plastics and would seem to have the highest expansion rate compared with the other methods.

The great advantage of this method is that [illegible] can be produced with it, ranging from the very large [illegible] to the very small [illegible] [illegible] [illegible] [illegible] [illegible] plications.

<u>Extrusion [illegible]</u>

[illegible] used for this [illegible], and [illegible] applied [illegible] ing [illegible] the bottle [illegible] and polishing [illegible] integrate [illegible] a tube bl[illegible] moulds and [illegible] very high [illegible] pre PVC ([illegible] [illegible] This [illegible] with integration and [illegible] powder [illegible]

<u>Extrusion [illegible] strip</u>

This [illegible] very popular [illegible] to become [illegible] industr[illegible] it is only concerned [illegible] high [illegible] The extruded strip [illegible] string for [illegible] strip may be [illegible] This process[illegible] calls for [illegible] for a more [illegible] competent [illegible] the line [illegible] an extrusion, drawing and cutting section and [illegible]

<u>Rotation moulding</u>

This method is used for low or high density polyethylene and is not yet very widespread; it is employed for the manufacture of

[illegible] IN THE DEVELOPED COUNTRIES

[illegible] since 1964

[illegible] of production capacity of polymers in developed countries (North America, Western Europe, Japan, South Africa and the Middle East countries) by [illegible].

[illegible] increases in production in 1964 have largely [illegible] of the three principal thermoplastic resins (PVC, low density polyethylene and polystyrene).

[illegible] although fairly [illegible] of the [illegible] of the establishment of [illegible]. On the one hand, the [illegible] producers (Japan, Canada, Italy, Germany and the United Kingdom) have [illegible] capacity to meet their own needs and [illegible] and [illegible] in addition to [illegible] exports.

- [illegible]
- [illegible]

[illegible] relative saturation in the number and the products of new producing countries [illegible] by 1972. Then we may expect [illegible] in the three zones, [illegible] and Africa. [illegible] only production on [illegible] level [illegible] the fact that [illegible] of the [illegible] plants [illegible] small [illegible] 5,000 and 15,000 tons per year and [illegible] economic [illegible] later on [illegible]. The output from Argentina, Brazil and India is explained by the large number of firms and producing centres in these countries.

In all these countries the only expansions to be expected are in the realm of thermoplastic resins, chiefly PVC and low density polyethylene, more rarely polypropylene and polystyrene. Whereas

Latin America, following the example of U.S.A., tends to orient its production primarily towards polyethylene, the other zones appear to maintain a balance between these two principal resins with PVC slightly in the lead.

Having taken note of the small production capacity newly installed in the developing countries, it is interesting to compare their rates of growth with those recorded for the industrialized countries.

Since 1972-73, the output of thermoplastic resins in Argentina, Brazil, Mexico, and India has multiplied two or three times. Over the same period (from 1973 to 1977) Western Europe increased its production of these resins by 1.25, U.S. by 1.9 and Japan by 2.85. The rate of growth is therefore already comparable for all countries who have not yet made the great leap forward which would make up their minds in this field. Nevertheless, the older producing countries and others which will soon join them (Chile, Venezuela, [illegible]) should, if they maintain their previous rate of growth, encounter great difficulties and satisfy a large proportion of the local demand for plastics.

This conclusion rests on the ratio between local production and consumption has already occurred as regards the important thermoplastics resins (polyethylene, polyvinyl chloride) in countries already possessing [illegible]. For example, Mexico's previously imports accounted for roughly [illegible] of consumption in Argentina, Brazil, Mexico and India over the years 1972-1976. It is not impossible that newly developing countries (e.g. Algeria and Chile, may begin to export plastics to their neighbors.

While no comparison can be made in absolute terms, the evolution of developments has been quite different in Europe, for example, where local production has served to fill an increasing proportion of local demand.

As Europe turned increasingly towards local production, the United States began to reduce their exports. Today their policy

Table 15 - Production capacities of plastics plants (1000t)

Country	Polyethylene			PVC			Polystyrene		
	1963-64	Present	1970	1963-64	Present	1970	1963-64	Present	1970
...tina	33	41	110	7	17	82			
...l	29	50	90	12	30	65	7		10
...a			30			30			
...bia		15	15		5	5			
...o	13	25	50	5	14	40		2	4
...uela			60			45		20	50
						25			
Latin America	66	131	357	24	96	352	12	33	96
...ria						40			
...Arabia			40			60			
...i						(20)			
...ece				4	4	24			
						(10)			
...ey		6	20		7	33		6	8
		12	24		24	24			16
Africa & the Middle East		18	84	1	35	226		6	24
...th Korea									
...a					15	15			
	16	51	90	6	6	24			
...istan		5	20		10	10		20	40
...ippines					5	5			
...an		30	35		20	20		5	8
Asia									

These last should join the ranks of the producing countries and supply substantial contribution to meet local needs for:

- pipes for [illegible] and water-piping
- films and packaging for the packaging of foodstuffs and clothing
- [illegible] by calendering
- [illegible] household [illegible]

A considerable [illegible] goods will [illegible] and their processing [illegible] result of [illegible] at [illegible] of product [illegible] and [illegible] to the extent that [illegible] their production may still [illegible] in the direction of [illegible].

IV.2. Capacity [illegible] in developing countries

IV.2.1. [illegible]

Resin [illegible]

[illegible] number of polymerization units have reached a [illegible] (see Chap. III - 2), since today it is not desirable to [illegible] per annum, either for [illegible] from PVC. The production of [illegible] some cases [illegible] of ethylene, since a steam-cracker unit of [illegible] production of 100,000 tons of ethylene, a vinyl chloride unit using the new oxychlorination process can produce 60,000 tons annually [illegible] worth while. There [illegible] below the capacities now being installed in the industrialized countries, which in order to secure a price of 2.5 - 3 ¢/lb for ethylene or 6 ¢/lb or less for vinyl chloride, steam-cracking units are being built to produce at

least 300,000 tons of ethylene per annum while making use of all the by-products.

The development in economic size has been matched by a development in plant strength. There has been little reduction in the volume of investment required, apart from the effects of the size factor. Investments in the production of plastics are relatively [illegible] and are at the highest in the petrochemical sector. This is due principally to the extremely high royalties demanded for the licences of polycondensation processes. For example, a polyethylene installation producing 100,000 tons of ethylene and 70,000 tons of propylene per annum costs in Europe, without royalties (approximately engineering + royalties) about $ 10,000,000. In the USA countries, a low-density polyethylene plant to produce 15,000 tons a year costs about $ 6,000,000.

Although the principal patents held by the companies which developed the processes have begun to come into the public domain, especially for low-density polyethylene, royalties are still very high, for these have also risen to their amount to 30% of the [illegible] investment. In the case of high-density polyethylene and polypropylene, where patents are still effective (cf. Chapter I.2.4.), royalties often account for over [illegible] of the cost of an installation in foreign exchange. Generally speaking, owing to the complexity and scale of the equipment employed, the plastics industry is very much under the thumb of the patent holders who tend increasingly to control the production of the monomers and polycondensates and above all their applications and the development of products. Their quasi-monopolistic situation and the high royalties which they extort are undoubtedly a hindrance to the installation of production plant in the developing countries. It must, however, be admitted that the patent-holders do make available their technology and know-how which are often very valuable, both at the stage of polymer chemistry and at that of the utilisation and formulation of products, and they give new producers the benefit

of their research and development by means of licences and technical assistance.

General economic conditions

To the extent that the two following fundamental imperatives are observed, a developing country stands a good chance of being able to install a self-sufficient industry able to make a profit and to finance its own expansion.

1) The elimination of the initial deficit in foreign currency, and if possible, an entry in foreign currency after some years of production. In the case of engines manufactured, the cost in foreign currency of the compound royalties, engineering and technical assistance should be kept, over several years, under the cost of the engines to be imported to cover the same local requirements. This is generally easily achieved, on the one hand, in installing basic capacities, for which the investments and more particularly the royalties, when spread over several years produced are comparatively low amounts, and on the other hand to arrange that the maximum proportion of expenditure shall be in the local currency - if possible for the equipment and chiefly for the civil and the off-sites.

2) Sales prices in the country by the current world prices or at least two times normal ex-gin margin; from 30 - 50 %, according to the country concerned. When production gains, this imperative can be lightened by means of tariffs or permitting imports (by taxes or monopolies), but it should be observed that the poor is running normally. It is only to the extent that the prices of finished products are attractive and competitive with classic products and also with imported goods, that the new industry will be able to expand and gradually to meet all local requirements.

When a country is dependent on imports of finished goods, it is not unreasonable to envisage an integrated production (always of economic capacity) starting with the assembly and going through to

the finished product. The cost of the polymer, which weighs heavily on the cost of the polymer, is much less onerous in the finished product. (cf. T 2 to 5).

[illegible] to achieve prices of more equality, [illegible] the prices of [illegible] products (pipes, [illegible] for instance), prices will [illegible] with those of [illegible] or of plastic materials, [illegible] only that this [illegible] could be accepted.

Table [illegible] of polymer [illegible] products

[illegible] in the cost [illegible]	[illegible]	[illegible]
[illegible] in the cost [illegible]	[illegible] PVC	PVC
		[illegible]
[illegible]	[illegible]	Pipes in [illegible] PVC
		[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible] environment. The installation of [illegible] industry is only conceivable if there is the certainty that [illegible] corresponding to an [illegible] by natural [illegible] of transport costs, which [illegible] the use of [illegible]. Investments; [illegible] consumption of the [illegible] in the region of [illegible] markets [illegible].

capita (cf. Chapter I), have so far been reluctant to install a single producing plant to meet all local needs. In most instances these countries have preferred to install several centres of production, of less [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] with a large [illegible] [illegible] [illegible] [illegible] size [illegible] [illegible] [illegible] [illegible] [illegible] able to [illegible] [illegible] [illegible] ([illegible] , Brazil, [illegible] [illegible] [illegible] consideration or [illegible] [illegible] criteria, rise in the ranks of those producing [illegible] [illegible] capacity [illegible] profitable [illegible] [illegible] [illegible], Pakistan, Iran...).

There are [illegible], local [illegible] [illegible] which, though less [illegible] [illegible] [illegible] occur, [illegible] habits of the consumer [illegible] [illegible] [illegible] development of [illegible] [illegible] [illegible] objects or for the [illegible] [illegible] agri-cult[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] necessary [illegible] a special effort [illegible] applications [illegible] of the marketing of finished products.

If the [illegible] is too small to warrant the installation of a production [illegible] [illegible], this difficulty can sometimes be [illegible] [illegible] [illegible] [illegible] countries belonging to the same [illegible] region and having common interests. Taking the production of [illegible], which calls for the largest capacity, one might, for example install a [illegible] [illegible] of adequate size associated with [illegible] vinyl [illegible] (50,000 - 100,000 tons [illegible] [illegible] [illegible] region. This would supply at least [illegible] [illegible] of profitable size producing PVC in the other countries of the region. This example may be easily envisaged,

the more so as the transport of vinyl chloride is tending to develop (at present towards countries which started with the production of PVC and no that of monomer).

On the other hand, lacking a convenient proximity (300 kms by pipeline) to costly investments for transport by water and the corresponding savings, the difficulties of transporting ethylene do not seem to occur that a use solution for polyethylene.

[illegible]

[illegible] have reached a high level and it is possible [illegible] a surplus in foreign exchange balance if a plastics-[illegible] complex is installed in a country or a region a large [illegible] of the output may be earmarked for export to other [illegible] countries and even to the industrialized countries. The obvious price [illegible] between the prices obtained on these markets [illegible] with the CIF prices already current and the [illegible] oil prices. Since these prices are already fairly low (11 ¢/lb for high-density polyethylene and PVC) and will probably [illegible] further in the next few years, (cf. Chapter I.2.), large reductions should in general, be observed for these export prices.

1) Proximity of markets, since transport costs rapidly affect competitive prices and may increase the price of polymers by 2 - 5 %;
2) The assurance of contracts, if possible long-term, either through preferential trade agreements or through barter;
3) The possibility of inducing the local market to pay higher prices than would have been charged with a smaller producing plant not export-oriented.

These plants will have to compete against the output of well-established plants in the industrialized countries, with capacities three or four times larger than those planned for the developing countries. Advantages in the cost of raw materials,

though they play a part in launching a petrochemical industry and especially a plastics industry (e.g. Iran and Mexico, where the refining industry played the part of promoter) [illegible] the installation of [illegible] complex. In the case of naphtha steam cracking [illegible] the lack of scale economies [illegible] low natural gas [illegible] polyethylene. The [illegible] cost [illegible] the industrialized [illegible])

If all these conditions are fulfilled, it is not unreasonable for countries [illegible] naphtha cracker, to tackle the problem of [illegible] (Algeria, Nigeria).

IV.2.2. [illegible]

When [illegible] country or region favourable conditions [illegible] are not present, then [illegible] in the case of the [illegible] Except [illegible] ments and the [illegible] than in the chemical sector [illegible]

The dependence [illegible] in the field [illegible] highest [illegible] monomers [illegible] developing [illegible] ments for [illegible]

The most favourable [illegible] plastics processing industry [illegible] undertaken [illegible] hold goods, toys,...) by means of injection presses.

[illegible] industrialized countries, [illegible] markets both by their [illegible] and by prices generally competitive with classic materials (steel, castings, [illegible]) [illegible] appear to have [illegible] promising [illegible] fields, which [illegible] highly qualified [illegible]

[illegible] (water supply, irrigation, [illegible] cables) [illegible] profiles and [illegible];

[illegible];

[illegible] leather.

[illegible] have also [illegible] the first half [illegible] stuffs in [illegible]

[illegible] resins – [illegible] the compounds [illegible] first-stage [illegible] cover only [illegible], the investment [illegible] required for compounding [illegible] firm and [illegible] make it possible [illegible] an assured profit. It will also be found [illegible] compounds are competitive [illegible] normal increase, [illegible] margins, [illegible] the price of [illegible]

In the [illegible] countries which produce polymers the processing industry [illegible] part to play. Processing firms familiar with the various processing techniques and with the numerous formulae of compounds are [illegible] element in the development and in the

direction taken by the plastics industry generally. The essential pre-condition for success and for opening up a market of satisfactory size is an intensive effort to build up sales and to promote finished products with strong private or public support. This can only be achieved by close collaboration between the technologist and the possibilities of the [illegible].

One might propose an ideal sequence for a developing country wishing to enter the plastics field and to encourage plastics in the growth of [illegible]:

1. A wide range of [illegible] the finished products using [illegible] and to demonstrate the advantages of plastics both in terms of their quality and of their [illegible] competitive with local traditional materials. Using the authorities and [illegible] an important role in [illegible]:

   - pipes, bags, films, [illegible] of footwear and [illegible]

2. [illegible]

   (extrusion, [illegible]) by [illegible] the above [illegible] force and the [illegible] the [illegible] formation of [illegible] and [illegible].

These two [illegible] upon become [illegible] labour [illegible]

3. [illegible] at least [illegible] sufficient [illegible] [illegible] [illegible] ethylene, [illegible] those with the [illegible].

before deciding to install these expensive industries, dependent upon engineering and processes held by the industrialized countries, [illegible] conditions must be fulfilled:

- Stabilization of the foreign exchange balance [illegible] the [illegible] earning a [illegible] for several years by the [illegible] imports.

- [illegible]

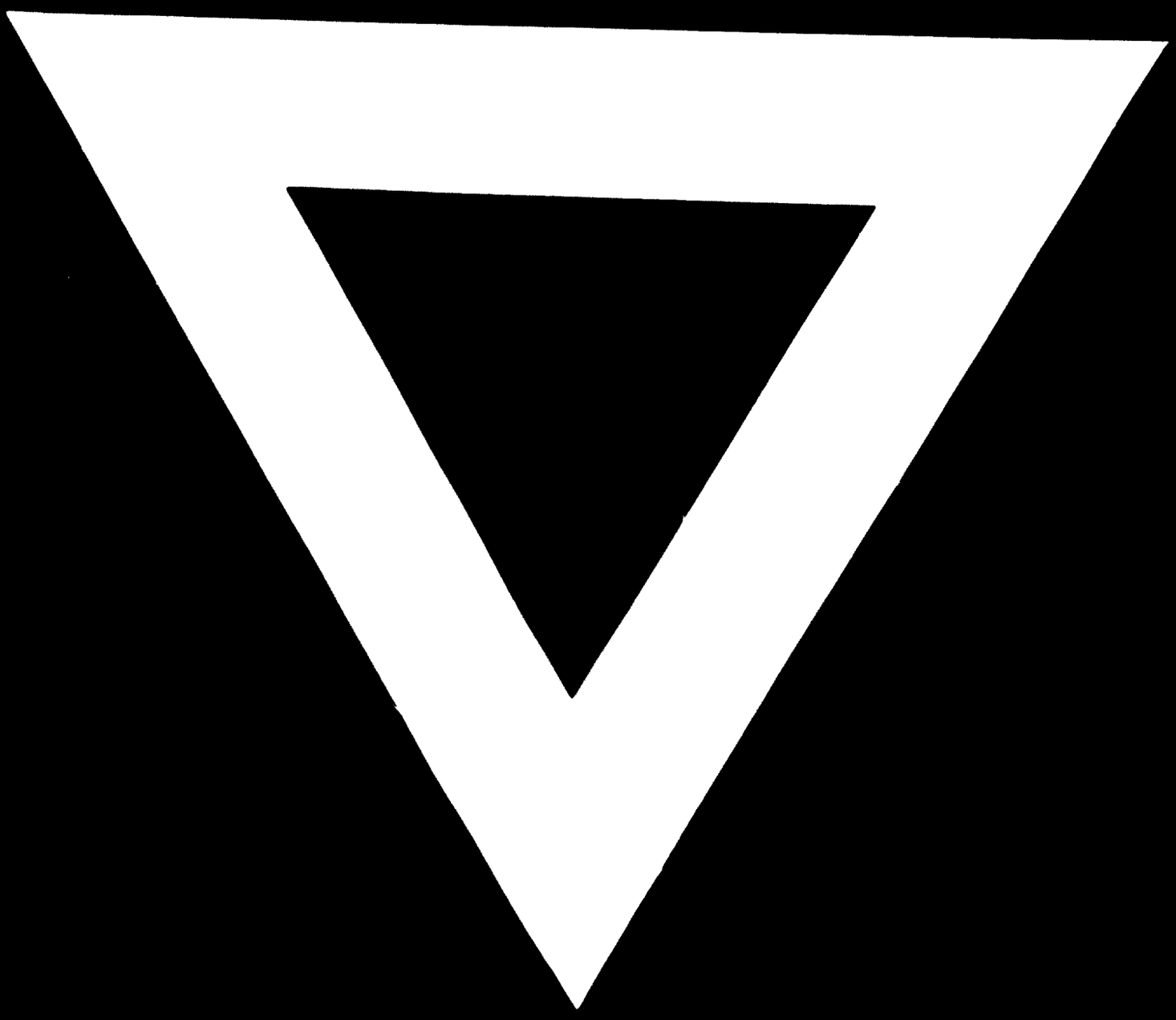
- [illegible]

[illegible] and the [illegible]

- [illegible]

- [illegible] satisfactory [illegible]

- [illegible]



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