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D00401



United Nations Industrial Development Organization

Distribution
LIMITED

ID/WG.34/29.Rev.1
17 February 1970

ORIGINAL: ENGLISH

Interregional Petrochemical Symposium on the
Development of the Petrochemical Industries in
Developing Countries

PET. SYMP. C/5

Moscow, USSR, 21 - 31 October 1969

RELATIVE MARKETABILITY OF POLYVINYLCHLORIDE, POLYSTYRENE AND

POLYETHYLENE IN DEVELOPING COUNTRIES^{1/}

by

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The general development in the marketability of plastics is characterized by a 15 year cycle. Between 1935 and 1950 the basic research for the production and processing of plastics was developed in preparation for future expansion. Between 1950 and 1965 this expansion continued, extending in all possible fields of application and processing techniques. For the next 15 years (1965 - 1980), we can expect further important improvements, especially in the rationalisation of the production and processing of plastics, by further automation but also by further progress in the field of copolymerization. This will result in a wide range of new and different types of plastics, applicable for numerous new purposes.

Graph. 1 World trend of plastic production between

1960 and 1970

In 1980, the world plastic production, including synthetic rubber and synthetic fibres production, will attain a production capacity which has never been equaled by any other natural or synthetic material so far. Vinylpolymers, polyolefines, polypropene and its copolymers will play an important role in this increase.

In 1960, the plastic production amounted to only 6.7 million tons/year, about 64 % of which were polyolefines, 32 % polycondensates.

Graph. 2 Distribution of the different types of plastic and resin production in 1960.

In 1970, the plastic production will increase to about 25 million tons, 65 % of which will be covered by polycondensates and 35 % by polyolefines.

Graph. 3 Estimated ratio of the world plastic production for 1970 with regard to the different types of plastics.

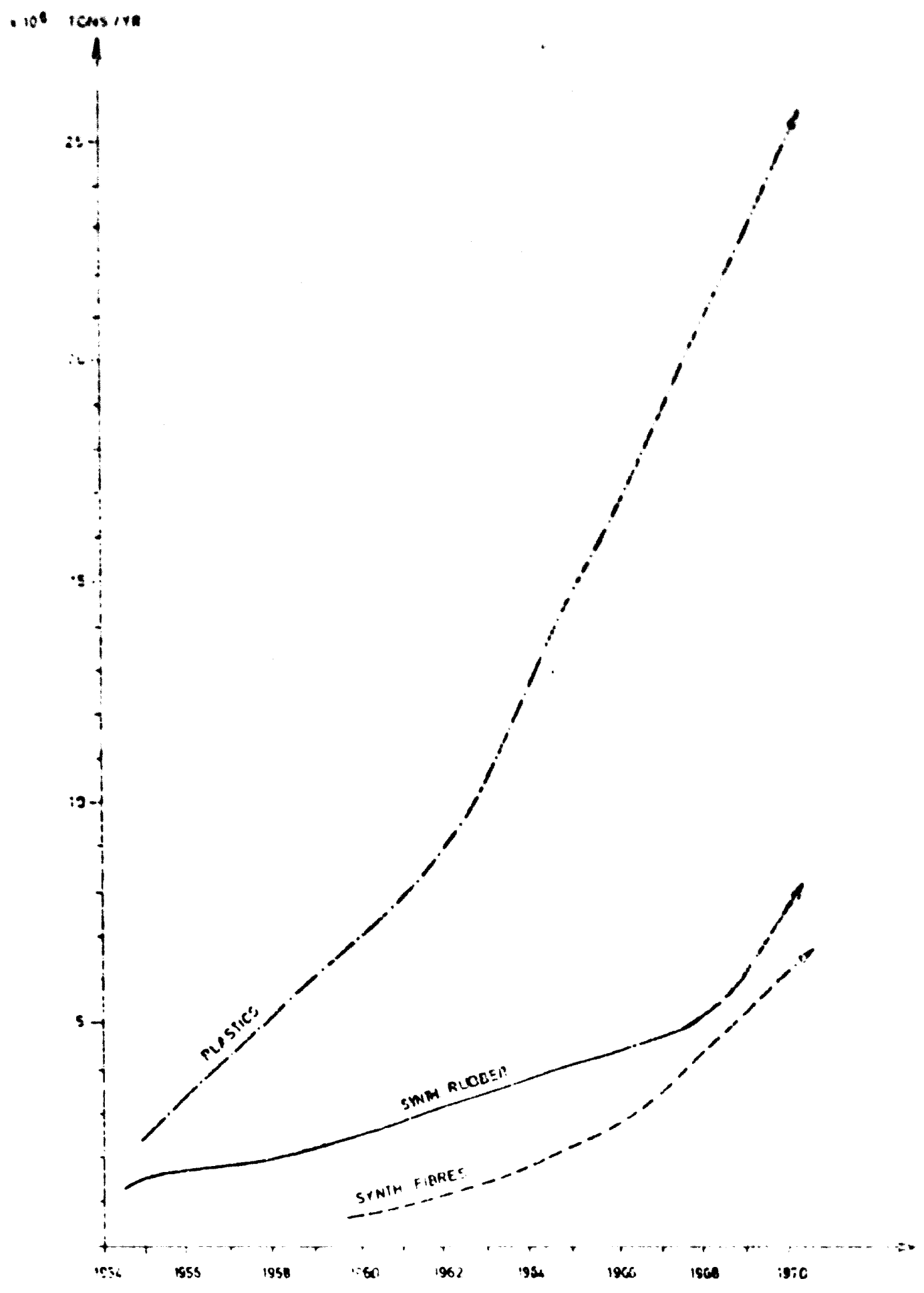
From this vinylpolymerisation will cover about half the total production, i.e. 45 %, and polyolefines and polystyrene and its copolymerisation about 35 %.

In the USA, owing to the raw material situation, the polyolefines are expected to cover 50 % of the demand of plastics. The balance will be divided between polyvinylchloride, polystyrene and others, whereby the major part will be covered by vinylpolymerisation.

Graph. 4 Expected development of the plastic production

in the USA between 1965 and 1980.

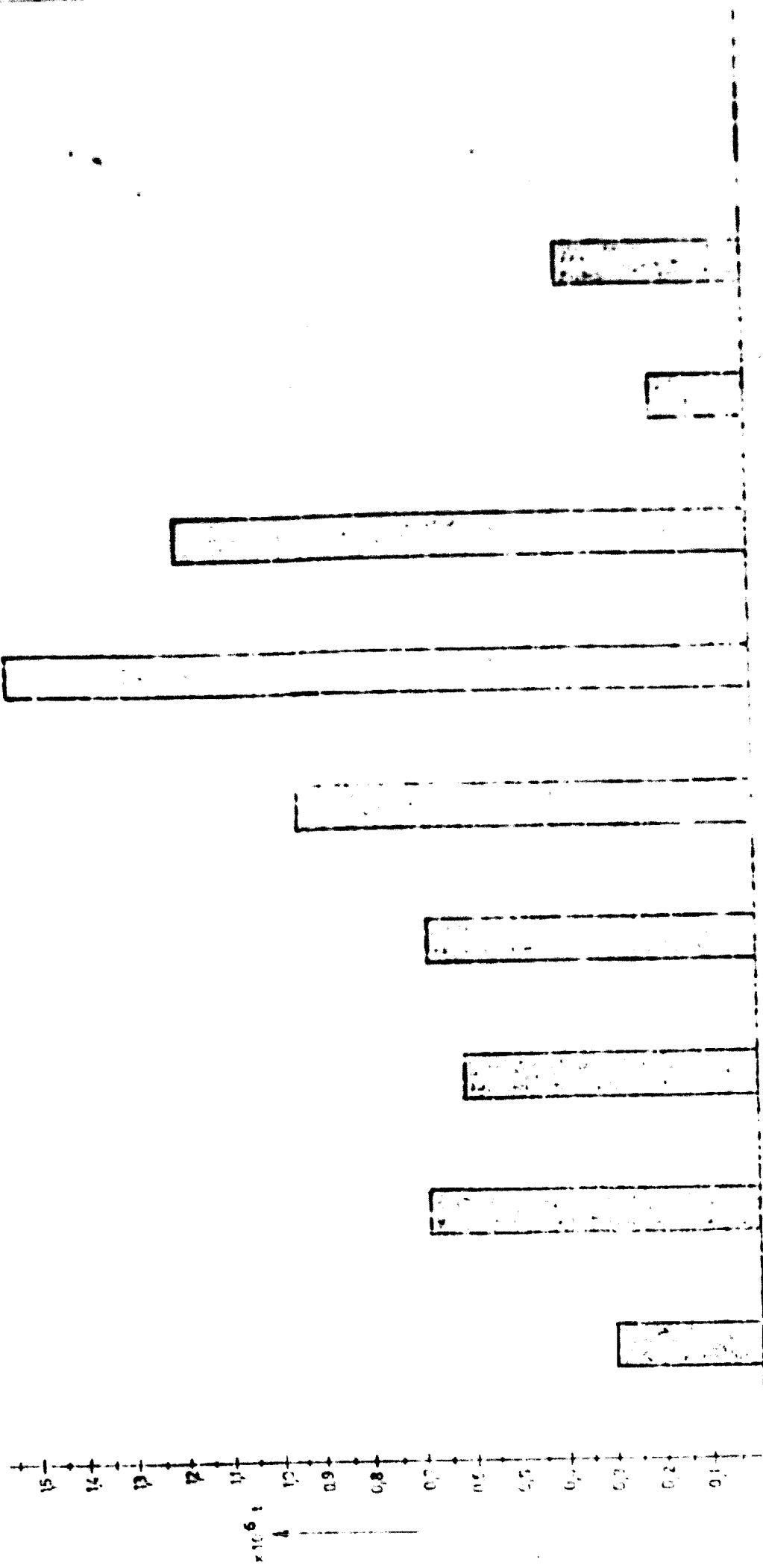
WORLD PRODUCTION 1955-1970 (TONS/YEAR)



1950

PLANT PRODUCTS

CELLULOSES PHENOLIC UREA, MELAM ALKYL RESIN POLYESTER POLYURETHAN POLYOLFINES POLYOLFINES ACRYLATES OTHERS



PLANT PRODUCTS

x 10⁶ t

The excellent properties of modern types of plastics will help to create a large field of new applications. Up to now, the most remarkable technical progress has been achieved by the results summarized below:

- 1) by exhausting all technical and material opportunities afforded by light weight construction systems;
- 2) by the use of material with maximum stability to abrasion, humidity, soiling and detergents to achieve maximum freedom from maintenance;
- 3) by the selection of materials with great versatility with regard to design, surface, finish and colour.

Graph. 5 Average distribution of plastic products in different fields of application.

Considering the local conditions in developing countries, polyvinyl-chloride, polyethylene and polystyrene, their copolymers etc. with regard to application and end use be divided in the following groups:

- 1.0.0 Plastics for construction and building
- 2.0.0 Plastics for the furniture, including interior decoration
- 3.0.0 Plastics for packing, containers, bottles, cans etc.
- 4.0.0 Plastics for agricultural application
- 5.0.0 Plastics for apparatus construction and electrical industry
- 6.0.0 Plastics for the electrical industry
- 7.0.0 Plastics for transport and vehicle construction
- 8.0.0 Plastics for the production of household goods and articles for every day use
- 9.0.0 Plastics for textile applications

1.0.0 Construction and building industry.

Construction systems with plastic foam insulation, rigid sheets for construction, profiles, corrugated sheets, profiles for windows, shutters, coating sheets, floor covering materials, roof tiles, roofing films, sealing films, gutters, drain pipes etc.

Pipes, tubes, valves, fittings

Insulation materials, coating materials, metallized foils and films.

1.0.0 Furniture, especially plastic furniture.

Rigid and soft profiles for doors and construction, coating materials for wall decorations, table and bench covering materials, uphostry materials, wall coverings.

Acrylic or polyester, laminated, specialty

Decorative foams, fabrics etc.

Light diffusers, machine glass for special machines etc.

1.0.0 Plastics in general

Cellulose, acetate

Thermoplastic and thermosetting plastics, foils, films, oriented films, extruded films, sheets, pipes, plastic bottles, containers, metalized foils, etc.

1.0.0 Plastics for agriculture

Teaching materials for agricultural products, films, bottles, containers, drop films for irrigation, etc.

Tapes, tubes for irrigation, water coverage channel lining, wall covering materials

Insulating and covering sheets, sheets and films for houses, stables, etc.

Construction materials and foils for hydroponic, metallized foils and films.

1.0.0 Plastics in electrical and electronic industry

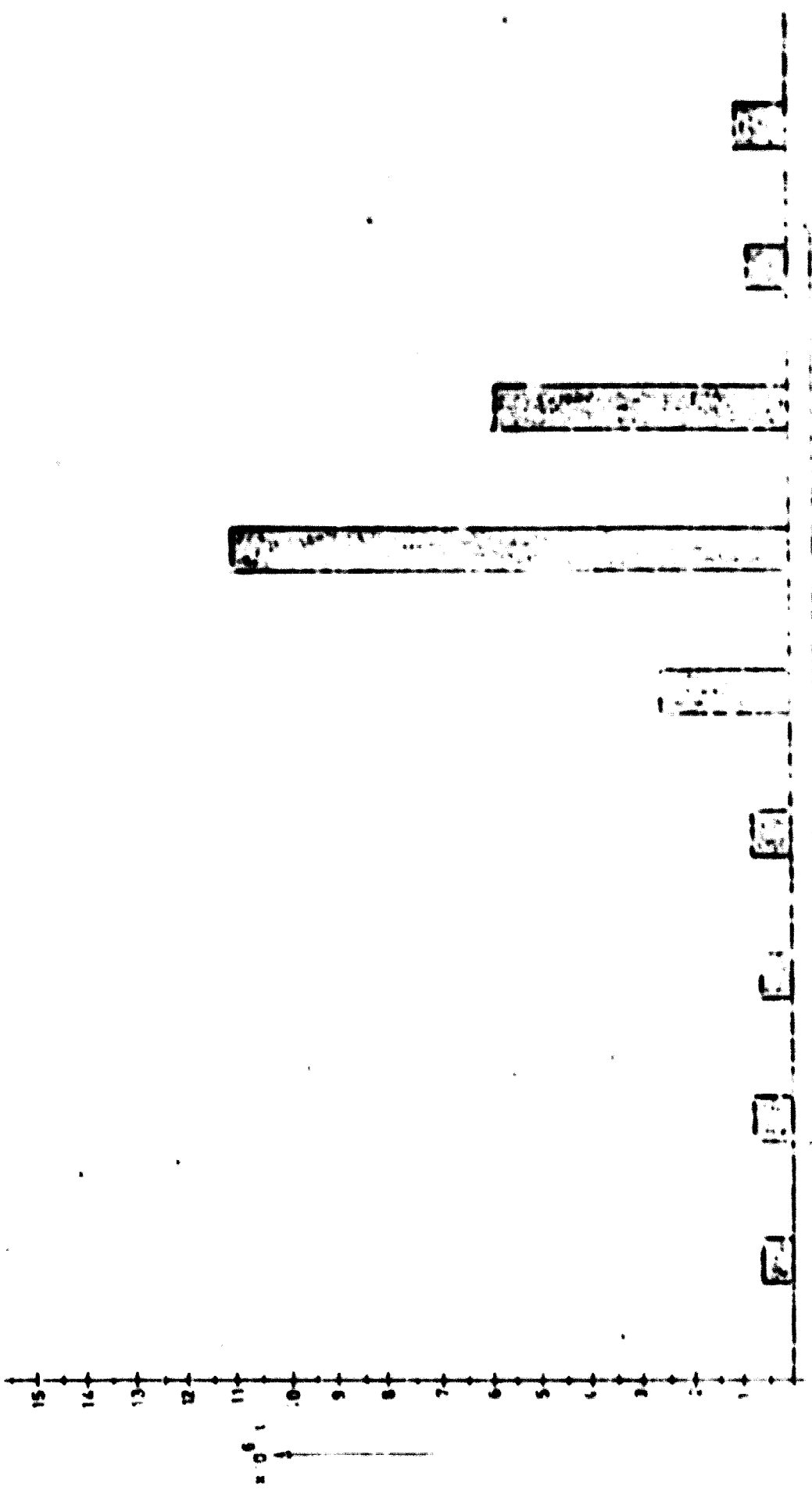
Apparatus for the electrical industry, ventilation techniques, refrigeration, textiles and non-woven fibres industry, air purification, water treatment, paper-pulp industry

Electro plating industry

Food industry

PLASTIC CONSUMPTION 1970

CELLULOSES PHENOLIC UREA, MELAM, ALKYL BIPHENYL POLYMER, POLYURETHANE, POLYESTER, POLYAMIDES, OTHERS



EUROPEAN COUNTRIES

OTHER COUNTRIES

x 10⁶

USA
 1965-1980

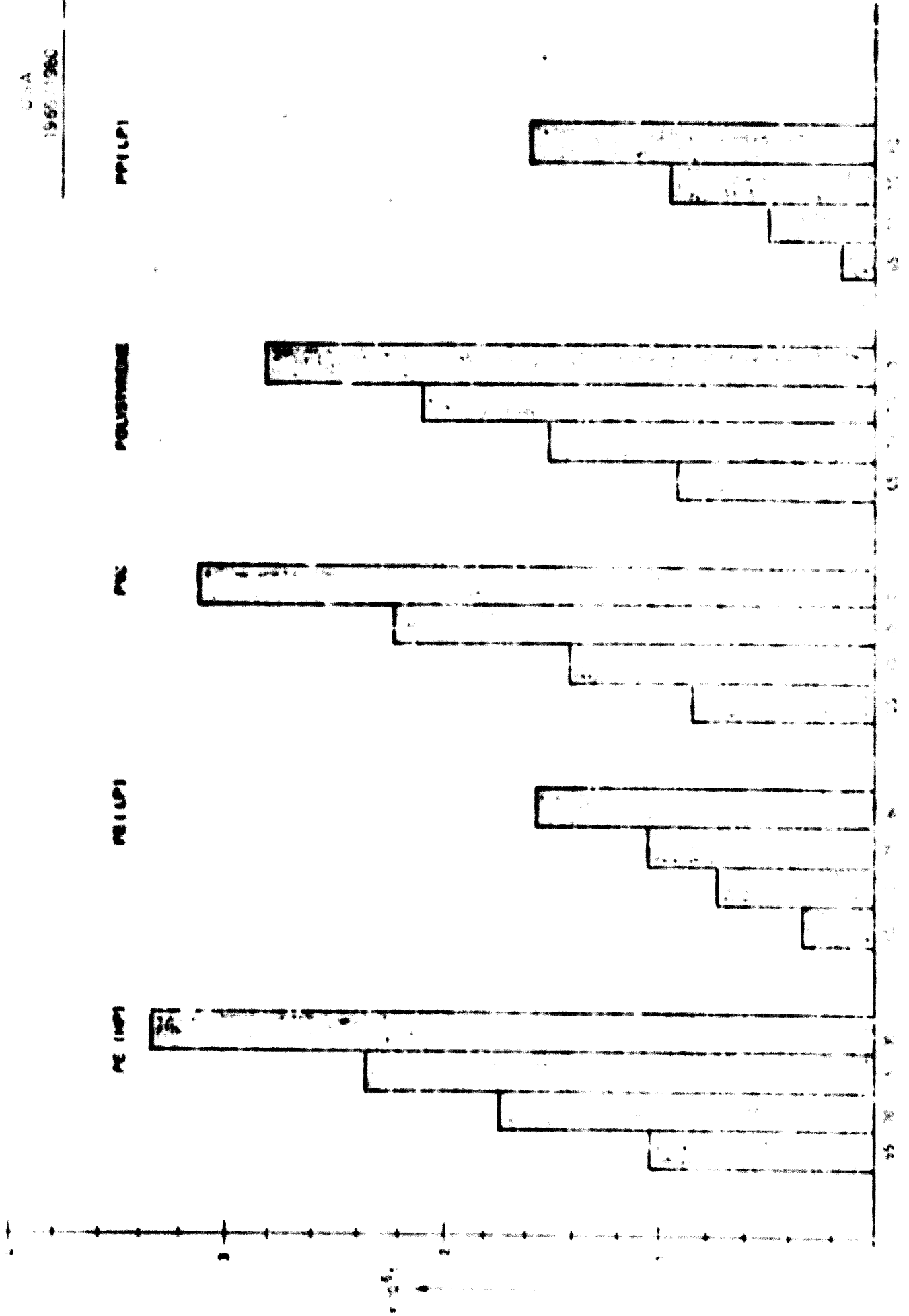
PE (LDPE)

POLYSTYRENE

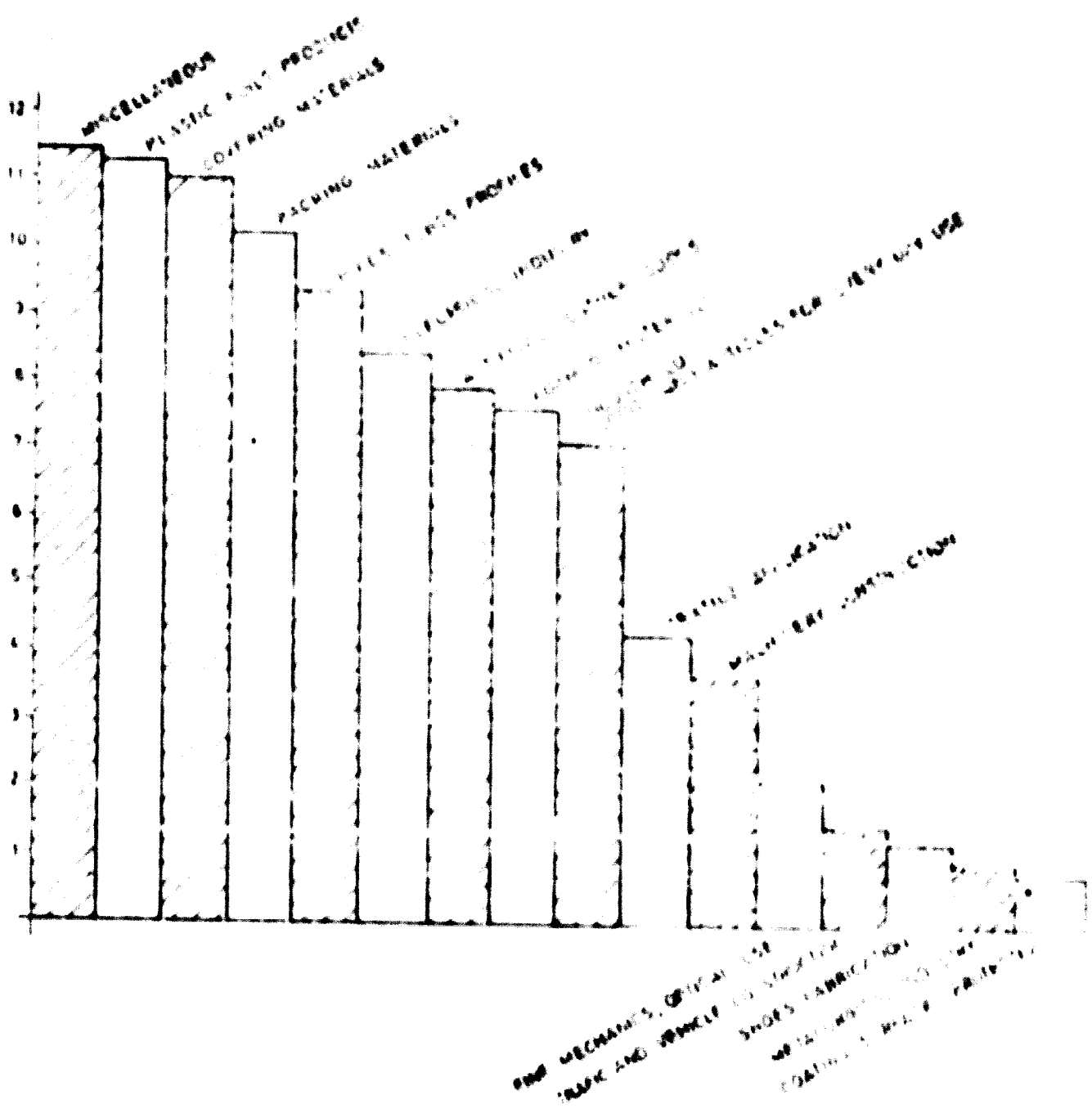
PC

PE (HDPE)

PE (MDPE)



ANNUAL REPORT OF THE COMMISSIONER OF THE GENERAL INVESTIGATING BOARD
 1958



Film and photo industry

Machinery parts, drilled, welded, bonded.

6.0.0 Electrical industry:

Insulating tapes, insulators

Pressure vessels, etc.

Control panels, separating walls

Cable she

Circuits, etc.

Radio and TV sets, enclosures, telephone

Refrigerator parts

Insulating materials.

7.0.0 Transportation and public construction.

Wagon and chassis parts

Flexible parts, etc. weather covers

Rear windows, etc.

Traffic signs, etc.

Upholstery, etc.

Covering materials

Hall, door, etc. covering

Safety glass

Protective covering walls.

8.0.0 Manufacture of articles for every day use.

Bottles, etc., etc.

Material for articles, etc.

Blankets, etc., etc.

Floor covering, etc.

Table covering, etc.

9.0.0 Textile applications.

Synthetic fibers, etc.

Non-woven fibers, etc.

Covering materials, upholstery materials

Fabrics for industrial use.

In highly industrialized countries possessing a wide range of raw materials, intermediate and final products, the expansion of the market is supported by publicity and advertising, pointing to scientific new properties of a product, to lower prices in comparison with traditional goods, to simpler methods of processing or lower maintenance charges. All these points are need to promote the marketability of a product. In many cases trends of fashion and demand in order to attract a market to a place with a comparatively high cost of income, these trends are of open market for the most diverse products.

As to the marketability of plastic products in developing countries, however, the situation is quite different. In such countries the following points must be considered.

- 1) The most important condition for the production of saleable products is the maximum use of locally available raw materials.
- 2) The main items of demand will probably differ widely from those of industrialized countries. Plastic products should be of low order products which can be adapted to local conditions and be easy to be supported.
- 3) Combining plastics with local raw materials which cannot be successfully processed in their own countries to produce new types of material, i.e. for construction and other purposes.
- 4) The final products selected for manufacturing should cover the demand for construction as far as possible and prevent the frustration of other materials.
- 5) When planning a plastic processing industry, the region should be target of the raw materials likely to become available from indigenous production.

The fields of application of plastic products in developing countries are manifold, especially where certain local available raw materials which cannot be processed successfully.

The possibility of producing plastics with exceptional and individual properties should induce new construction ideas promoting the application of PVC, PE and Polystyrene in developing countries, replacing

raw materials not available locally and using locally available auxiliary products. This can result in a completely new style of design and new ways of using plastic materials for construction, furniture and interior decoration, as well as for the production of different plastic products for technical and every day use.

Table 6 Main fields of application and end uses of plastic products in developing countries

In regard to the natural situation, developing countries can be divided into four main groups:

- 1) Countries with rich resources of minerals, wood and crude oil
- 2) Countries with limited resources of minerals, but rich resources of wood and crude oil
- 3) Countries with limited resources of minerals and wood, but large crude oil resources
- 4) Countries with limited resources of minerals and crude oil, relatively small resources of wood, but rich resources of natural gas.

The market potential of the countries is given in the above summary. It depends on the maximum use of all opportunities. In countries with rich natural resources, the demand for furniture, packing materials, agricultural and textile products will be higher and there will be also greater opportunities in the electrical and machinery industry.

Developing countries which have only crude oil resources combined with sufficiently large existing refineries connected with a petrochemical industry, should have the possibility of producing cheap construction materials as well as different types of plastics for various purposes and these could substitute materials which must be imported.

Graph. 7 Production possibilities of plastics based on light naphtha

Developing countries which possess only resources of natural gas can also produce a wide range of plastic materials for the furniture-, packing- and building industries, for agricultural application, machinery construction and the electrical industry. They will select a production program manufacturing vinylpolymers, acrylic polymers and resins which can be produced from natural gas.

Table 6 Main fields of application and end uses of plastic products especially polyethylene, polyvinylchloride, polystyrene and its copolymerized in developing countries

<u>Products</u>	<u>Polyethylene</u>	<u>Polyvinylchloride</u>	<u>Polystyrene</u>
Field of application	Low density medium density high density	rigid, flexible copolymer cases	general purpose medium impact high impact expandable
construction and building industry	profiles, pipes, tubes, etc.	profiles, sheets, corrugated sheets, shutters, windows, doors, flooring and covering materials, pipes, tubes, valves	insulation materials
furniture industry, interior decoration		coating and covering materials, curtains, upholstery materials, decoration foils, metalized foils	light diffusers, decoration foils, metalized foils
packaging industry	films and foils, heavy duty bags, PE-coated bags, containers	films and foils, bags, bottles, containers, PVC-coated bags, food containers	cups, bottles, container lids, food containers
agriculture application	irrigation pipes, floods, packing, channel lining, water storage	irrigation and drainage pipes, green houses construction, channel lining, water storage	vegetables and food packing materials
apparatus and machinery industry	apparatus lining, machinery parts	apparatus lining, machinery parts	machinery parts
electrical industry	wire and cable coating	insulative material, separation walls, wire and cable coating	telephone-radio-television casings, instrument parts, battery cases, lighters, panels etc.

Table 6 (cont'd)

<u>Products</u>	<u>Polyethylene</u>	<u>Polyvinylchloride</u>	<u>Polystyrene</u>
traffic and vehicle con- struction	-	profiles, sheets, covering and up- holstery materials, flexible panels, traffic signs, plates	lighters, diffusers
articles for every day use, consu- mer goods	bottles, con- tainers etc., cheap consumer goods	bottles, containers, plates, cups etc., covering materials, cheap consumer goods	refrigerators, air conditioner parts, bottles, plates, cups etc.
textile and other appli- cation	-	footwear, synthetic leather, shoes ma- nufacture, PVC- staple fibers, PVC fabrics, fabrics for technical use, non-woven fabrics	

Graph. 8 Production possibilities of plastics based on natural gas

It can be expected that by 1980, the largest field of application for plastics will be the building and furniture industries. About 25 - 30 % of the plastics produced will be used for these purposes, especially in the developing countries. The larger use of plastics in the building industry and for furniture will make it possible to build up homes at low prices and in a short time. About 30 % of the plastic production in 1980, will be processed for the packing industry, e.g. for the production of film, bottles and containers. Some increase can also be expected in the use of plastics in transport and vehicle construction as well as in the engineering industry. Especially in developing countries, the agricultural application of plastics will increase considerably to meet the demand of cheap irrigation and drainage equipment. But biggest increase can be expected in the manufacture of textiles, household goods and articles for every day use in accordance with the demands of the countries with increasing standard of living.

Polyvinylchloride, polyethylene and polystyrene are the three most important plastic raw materials to meet the constantly growing demand of plastic materials for construction, packing and other purposes.

Graph. 9 Comparison of the specification of polyethylene, polyvinylchloride and polystyrene

Graph. 10 Summary of different fields of application for polyethylene, polyvinylchloride and polystyrene

Table 11 Proposal for the processing of polyvinylchloride to final products considering the local conditions of developing countries. (Basis 60,000 t/yr)

(per capita consumption 1 - 2 kg)

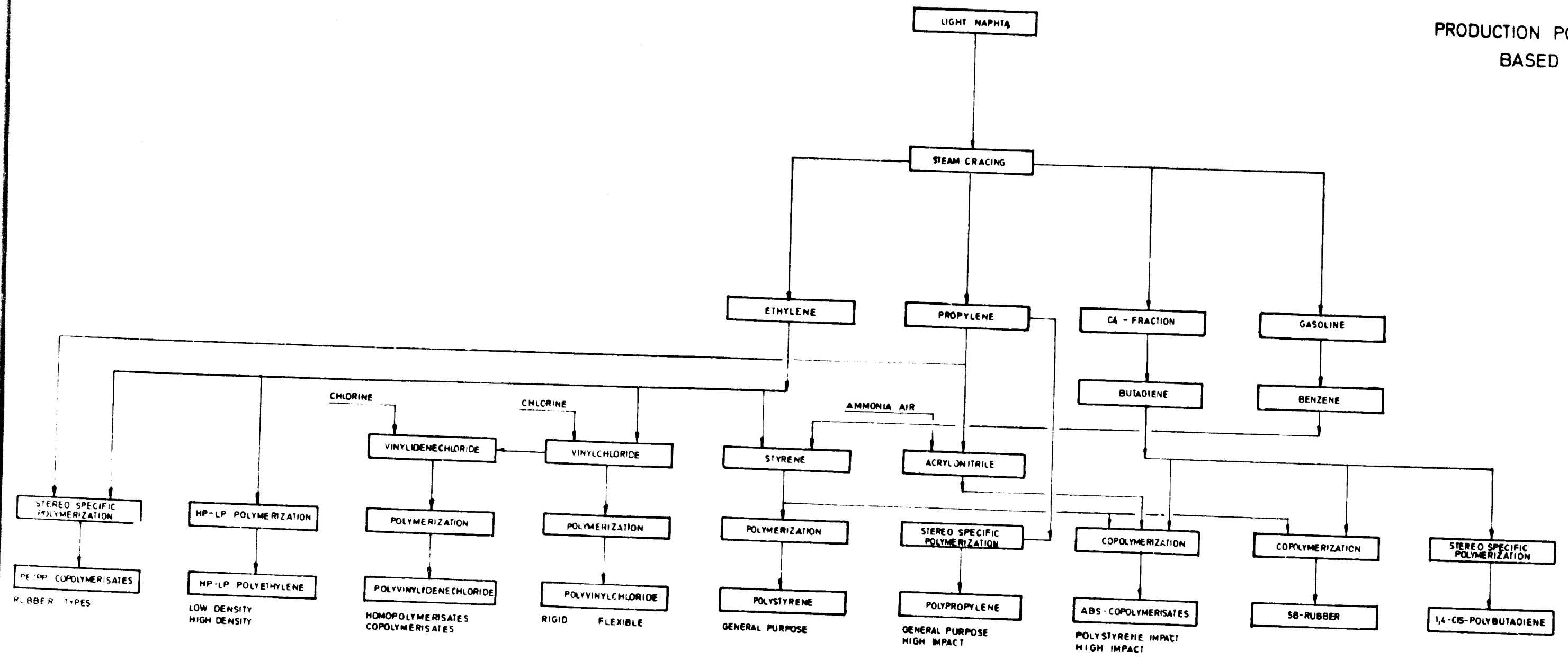
Construction materials

Rigid PVC profiles, sheets, flooring

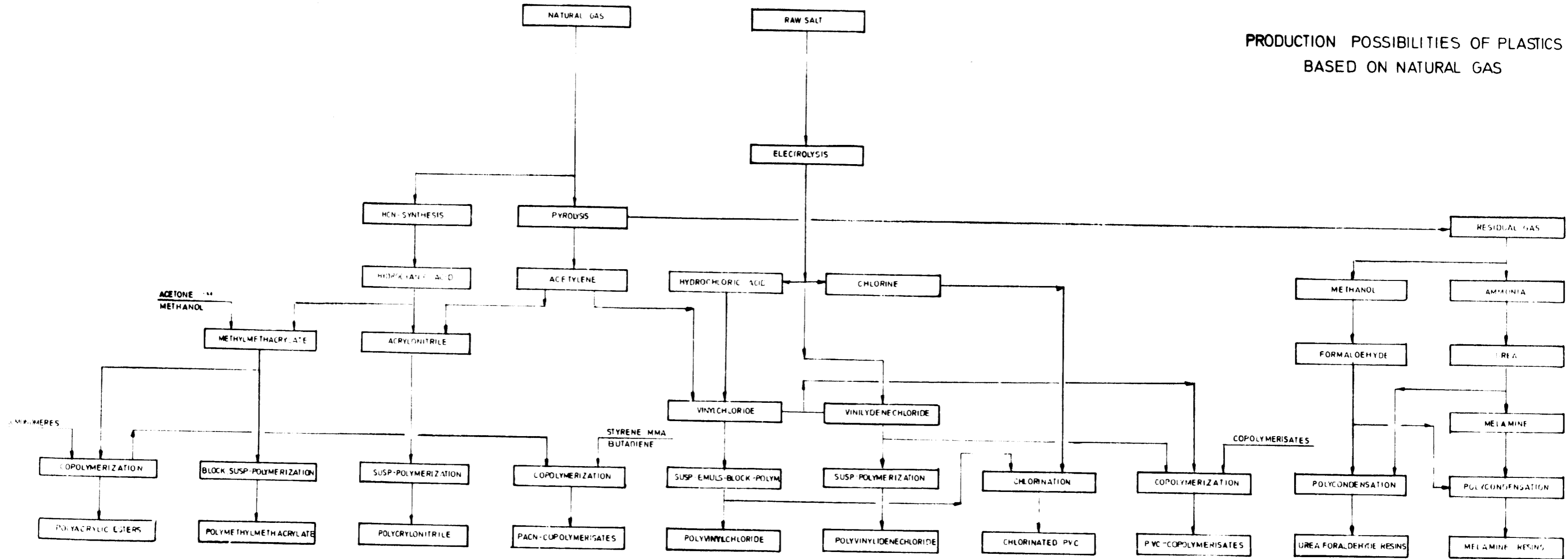
covering materials, pipes, tubes, valves etc.

20,000 t/yr

PRODUCTION POSSIBILITIES OF PLASTICS BASED ON LIGHT NAPHTHA

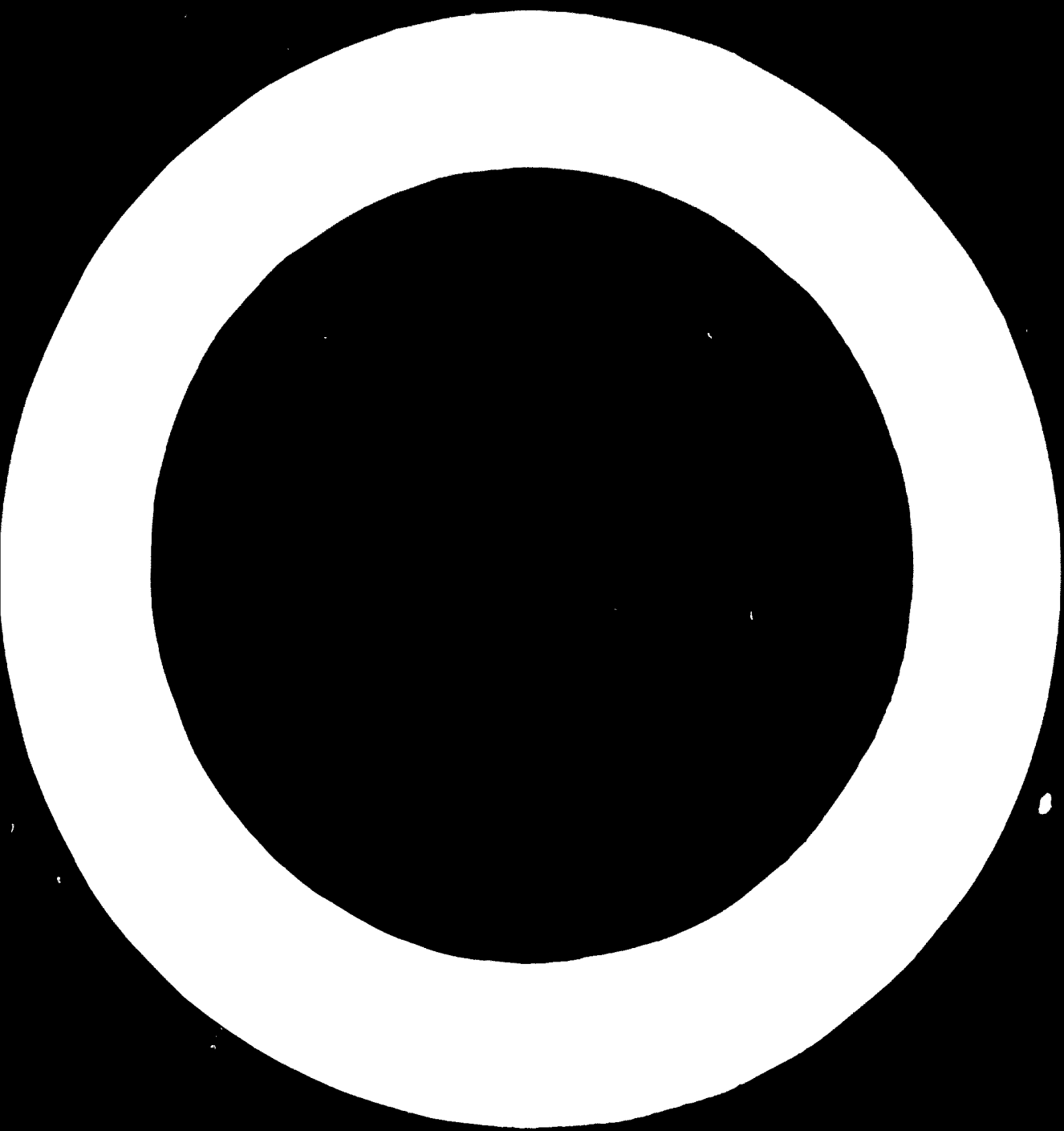


PRODUCTION POSSIBILITIES OF PLASTICS BASED ON NATURAL GAS



COMPARISON OF SPECIFICATIONS OF
PE , PP , PVC , POLYSTYRENE

	POLYETHYLENE HIGH PRESSURE	POLYETHYLENE LOW PRESSURE	POLYPROPYLENE	PVC RIGID	PVC FLEXIBLE	POLYVINYLIDENE CHLORIDE	POLYSTYRENE GENERAL PURPOSE	POLYSTYRENE IMPACT	POLYSTYRENE HIGH IMPACT
SPECIFIC GRAVITY (20°C) g/cm ³ DIN 1306	0,915 - 0,930	0,950 - 0,970	0,905 - 0,910	1,35 - 1,38	1,20 - 1,35	1,80 - 1,80	1,05 - 1,07	1,05 - 1,07	1,06 - 1,07
MELT INDEX 200°C 5 kp ASTM D 1238	2,5 - 3	0,6 - 1,6	2 - 16	—	—	—	1 - 2,5	2 - 10	3 - 6
K VALUE		—	—	50 - 70	50 - 70	50 - 60	80	65	60 - 70
MODULUS OF ELASTICITY kp/cm ² DIN 53457	1400 - 2500	6000 - 10 000	16000 - 27 000	25000 - 30 000	—	20 000 - 40 000	30 000 - 40 000	20000 - 25 000	20 000 - 30 000
TENSILE STRENGTH kp/cm ² DIN 53371	4 - 100	270	250 - 300	500 - 600	—	550	600	450	750
SHORE HARDNESS (20°C) kp/cm ² DIN 51505	4 - 60	50 - 70	60 - 90	70 - 90	—	60 - 70	70	60	40
SPECIFIC HEAT kcal/kg°C	0,45	0,45	0,46	0,23	0,3	0,3	0,3	0,3 - 0,35	0,3 - 0,35
HEAT TRANSFER COEFFICIENT kcal/mh°C	0,15	0,29	0,3	0,14	0,2	0,15	0,14	0,14	0,13
COEFFICIENT OF THERMAL EXPANSION 10 ⁻⁵ /°C	8 - 9	12	12 - 15	7	7	8	7	9	7
DIELECTRIC STRENGTH KV/mm DIN 53481	100	80	50	40	10 - 25	30 - 40	40	40	—
COLOR	TRANSLUCENT TO OPAQUE	TRANSLUCENT TO OPAQUE	TRANSLUCENT TO OPAQUE	CLEAR TO OPAQUE	CLEAR TO OPAQUE	OPAQUE	TRANSLUCENT	OPAQUE	OPAQUE
WATER ADSORPTION 24h DIN 53472	0,15	0,1	0,01	0,4	0,4 - 0,7	0,3	0,1 - 0,2	0,6 - 0,7	0,6 - 0,7
SOFTENING TEMPERATURE °C VICAT ASTM D 1525	85	115	125	85	80	115	105	100	95



SUMMARY OF PROPERTIES OF POLYETHYLENE, POLYPROPYLENE,
 POLYVINYLCHLORIDE, POLYSTYRENE AND COPOLYMERIZATES
 PE, PP, PVC, PVP, PVP/PP AND PVP/PS

1
2
3
4
5
6
7
8
9

CONSTRUCTION BUILDINGS
 TRANSPORTATION
 AGRICULTURE
 CHEMICALS
 ELECTRICAL
 PACKAGING
 MEDICAL
 AEROSPACE
 MARINE
 SPECIALTY USE
 APPLICATION

POLYETHYLENE LOW PRESSURE									
POLYETHYLENE HIGH PRESSURE									
POLYPROPYLENE GENERAL PURPOSE									
POLYPROPYLENE HIGH IMPACT									
POLYVINYLCHLORIDE RIGID									
POLYVINYLCHLORIDE FLEXIBLE									
POLYVINYLCHLORIDE CHLORINATED									
POLYVINYLCHLORIDE CHLORIDE									
POLYSTYRENE GENERAL PURPOSE									
POLYSTYRENE MEDIUM IMPACT									
POLYSTYRENE HIGH IMPACT									
POLYSTYRENE EXPANDABLE									

Table 11 (cont'd)

Agriculture application

Plastic, heavy duty, b-wirenetal films, containers, bottles
15,000 t/yr

Industrial purposes

Films, heavy duty b-wirenetal films, containers, bottles, T-2-film for lining, T-2-fabrics
10,000 t/yr

Apparatus for primary production

Tables, wires, electrical materials, parts and apparatus and machinery
5,000 t/yr

Consumer goods, articles for every day use

Containers, bottles, bags, films, films, house-
hold goods, in every department, leather goods,
furniture, textiles, motor vehicle fabrics covering,
textile materials
10,000 t/yr

When installing plants for the production of polyvinylchloride, polyethylene and polystyrene, the capacity is one of the most important items in determining cost. Another important factor is the value of catalysts and auxiliary chemicals that have to be imported.

Polyethylene plants should not be erected with capacities less than 10,000 t/yr. The same applies to polystyrene plants provided benzene and ethylene are available at competitive prices.

40,000 t/yr is the appropriate minimum for polyvinyl chloride plant.

Graph. 12 shows the estimated costs for polyethylene, polyvinylchloride and polystyrene increases as plant capacity increases (min. 50,000 t/yr)

The viability of plants with the above capacity will be improved if the plastic raw materials can be provided in the same complex to intermediates or finished products with a higher sales value.

In spite of ever widening outlets for plastic products the price of the plastic raw material has fallen continuously, largely due to increases in plant size and in the reduction in price of the petrochemicals needed as prime raw materials.

Graph. 13: shows the change of prices of plastics raw materials in Europe between 1950 and 1968, prospects to 1970 for polyethylene, polyvinylchloride and polystyrene.

Graph. 14: shows a comparison between the change in price for plastics and other constructual materials from 1955 to the present time.

In recent years the sales prices for polyethylene, polyvinylchloride and polystyrene have gone down because of an excessive production. At present the rapid increase in the consumption of plastic products for different new purposes led to an increase of the market prices for polystyrene and polyvinylchloride. For these products an increase in the market prices of 12 - 16 % is expected up to 1970.

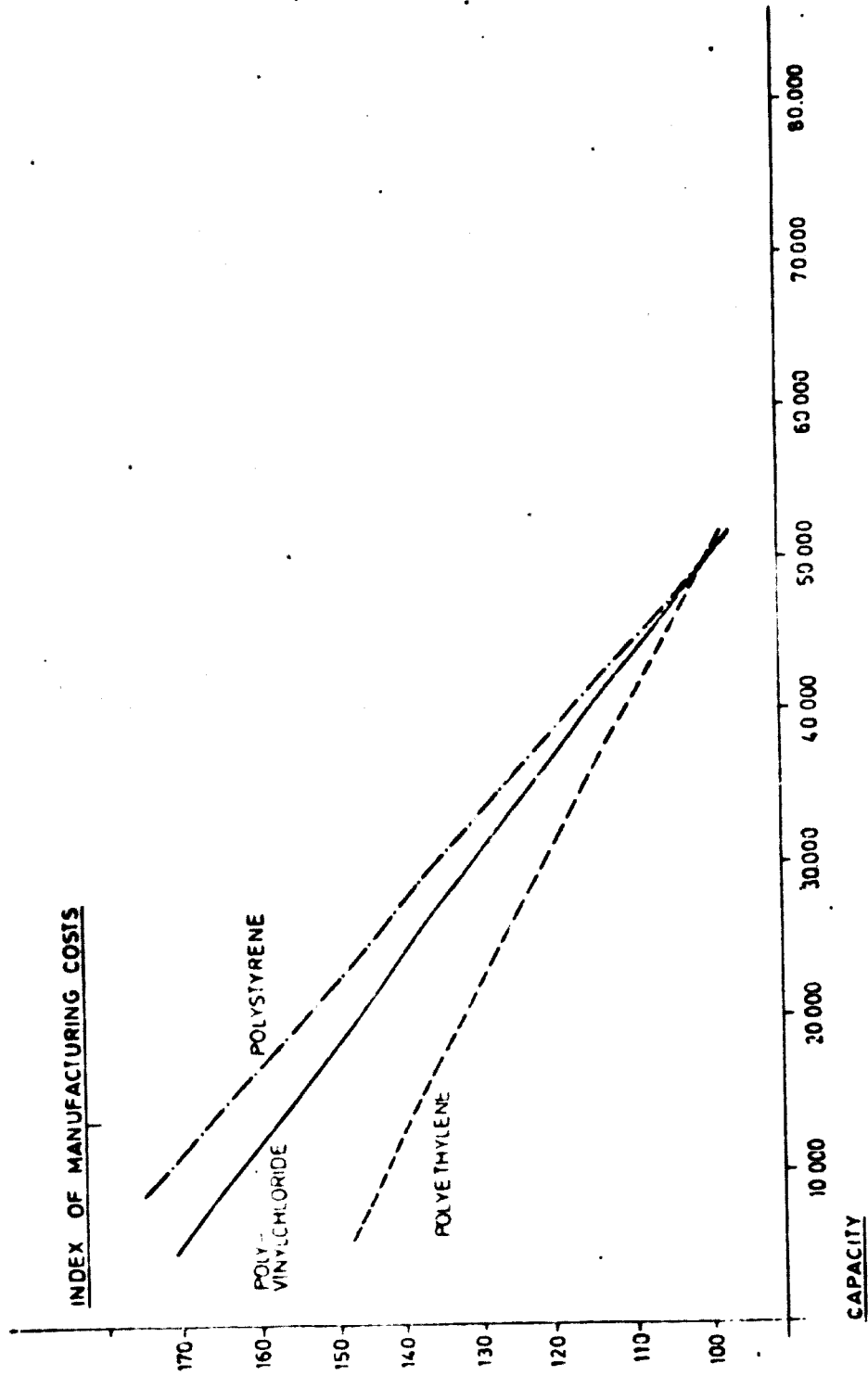
Graph. 15 Increase of plastic production in the Western World between 1958 and 1970 Increase rate 12 - 18 % /yr.

Up to now, the application of plastics has been marked by a gradual replacement of traditional materials by plastic materials: PVC bricks replaced the usual pentiles, plastic chairs, wooden chairs, etc. This development and the possibility of producing plastics with completely new and individual properties, with shape and functions of their own should induce new construction ideas promoting the application of plastics. Especially in developing countries this can result in a completely new style of design and new ways of using plastic materials for construction purposes, for furniture and interior decoration, as well as for the manufacture of different plastic products for technical and every day use.

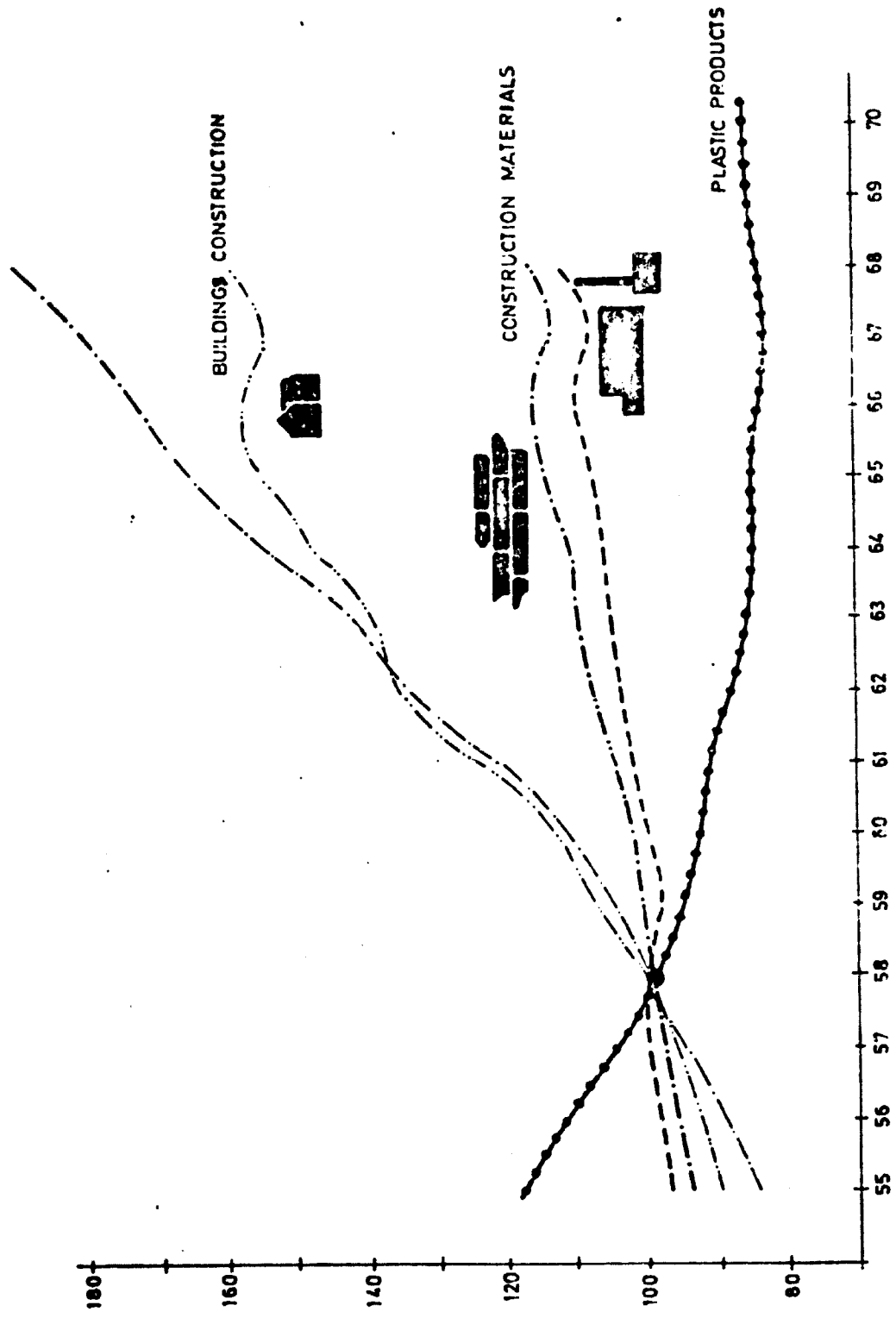
Such a development is the key for an improvement in the marketability of plastic products in developing countries, which finally certainly will help to increase the living standard, providing inexpensive articles for every day use, accomodation facilities, packing materials, textile products and materials for agricultural purposes.

MANUFACTURING COSTS FOR PE HP PVC AND
POLYSTYRENE BY DECREASING PLANT CAPACITIES

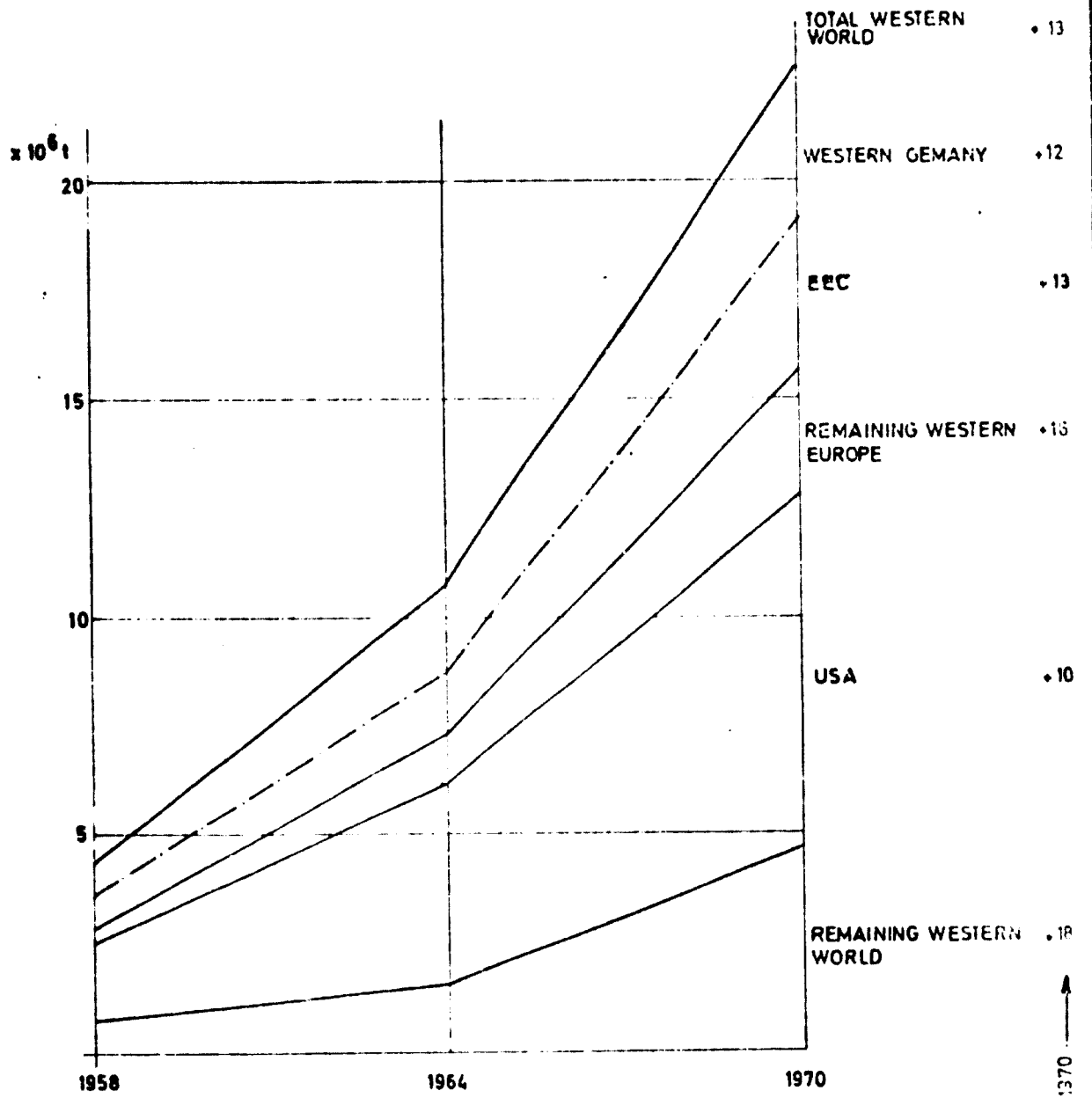
(BASIS: 50 000 TO/YR)



DEVELOPMENT OF CORRESPONDING PRICE INDEX



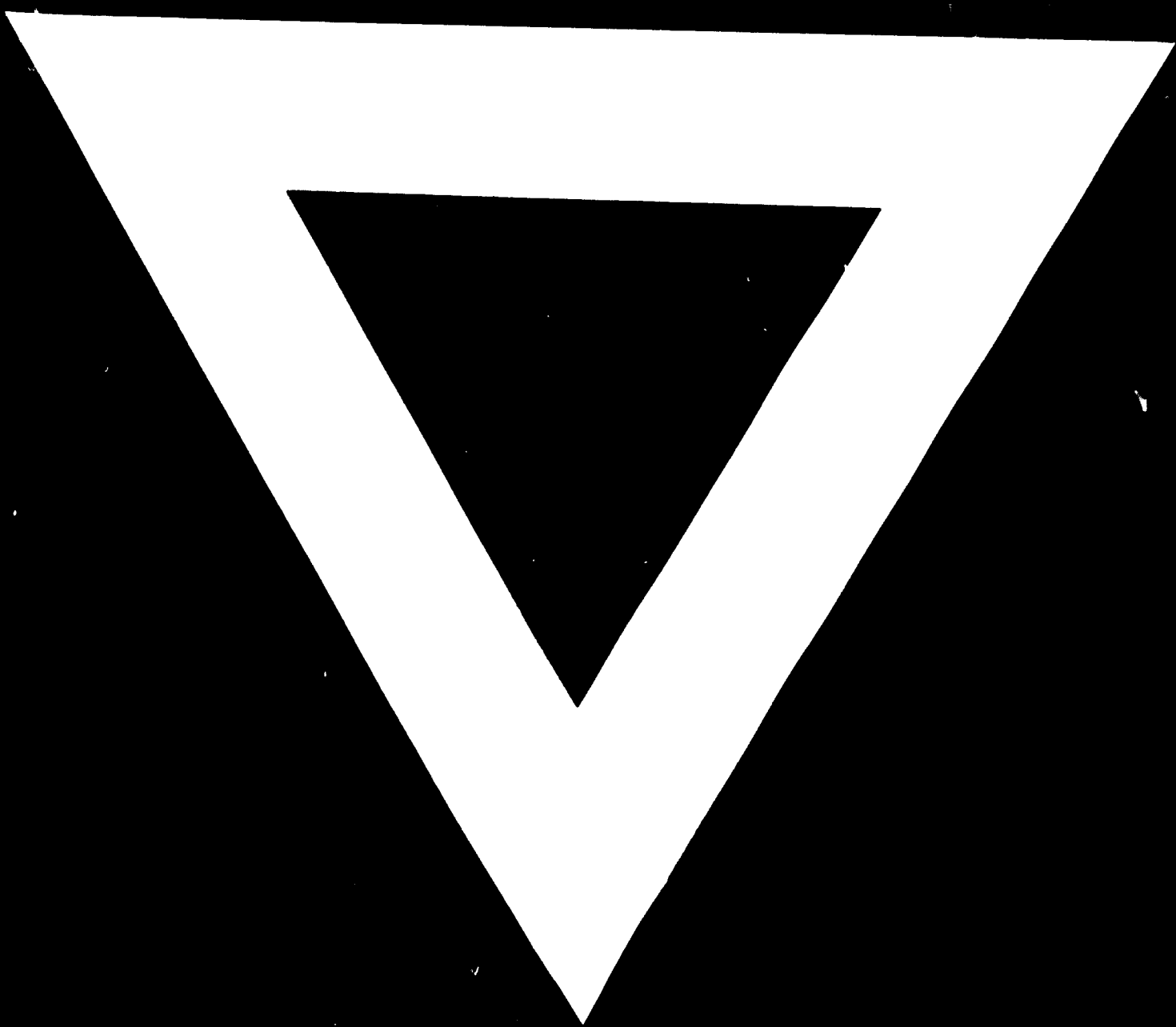
PLASTIC PRODUCTION 1958-1970



INCREASE P.A. 1954 - 1970

UNIDO and its organizations should consider these problems and carefully investigate into the local conditions of developing countries. Actual trends in the development of petrochemical products will certainly help to improve the living conditions by providing inexpensive articles for every day use, accomodation facilities and finally help to increase the agricultural productivity in developing countries.





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