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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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FINAL REPORT

ON

MAN-MADE FIBRE INDUSTRY IN BRAZIL

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17 April 1972 - 17 June 1972

by

E. E. BRAUNSTEINER

"This report contains the findings of the expert and does not necessarily reflect the views of UNIDO and has not been cleared by the UNDP Resident Representative in Brazil".

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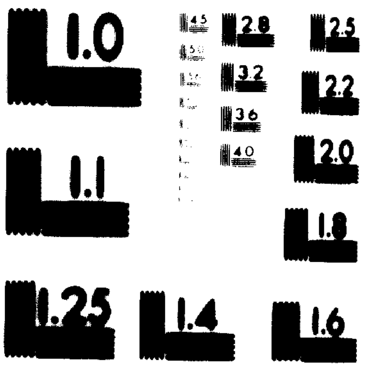

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1. Introduction

For many centuries the textile industry used nothing but natural fibres such as cotton, wool, silk, flax, jute, and others. Around the turn of the century a new class of fibres was added to the list, namely viscose and acetate rayon. In their production one still uses a natural polymer as base material but it is chemically modified and the fibres themselves are "man-made". Thirty years later another important step was made and "man-made" polymers were introduced for the commercial production of fully synthetic or simply "man-made" fibres. Their properties were such that they did not only provide new interesting products for the textile industry in all its sectors - apparel, lingerie, carpets,upholstery and household fabrics - but also for many so called industrial uses such as transport - and seat belts, tire cords, filters and felts.

At present three classes of synthetic polymers dominate the field - polyesters, polyamides and polyacrylics - and a forth class - polyolefins appears to have a chance to become another useful candidate in certain fields.

In developing countries the three established synthetic fibre formers are attracting most interest. Textiles are second in necessity only to food as an item of consumption and their quality and quantity depends largely on local standards of living. Any improvement of income is immediately reflected in an increased demand for textiles.

Man-made fibres are manufactured from plentiful, low-cost basic raw material, such as shown in table 1. The fibres can be "engineered" to exhibit special qualities and characteristics for specific end uses. A yarn or fabric may be made 100% from one type of fibre or may be a blendof fibres, either natural or man-made, to provide a variety of characteristics.

The properties of synthetic fibres are influenced by chemical composition and by treatment in production. The chemical composition alone does not determine the properties of man-made fibres, or of the fabrics made from them.

Table 1

Basic raw materials for man-made fibre production

Material	Origin	Used for which fibre	Average price range in the USA in ¢ per kg.
Ethylene	From oil refining	PE and PAC	5,5 - 7,7
Propylene	" " "	PP, PA and PAC	6 - 8
Benzene	" " "	PA and PE	6 - 11
Para-xylene	" " "	PE	12 - 14
Ammonia	" N_2 and H_2	PA and PAC	5 - 8
Ethyleneglycol	"ethylene and O_2	PE	18 - 19

PA = polyamide, namely 6 and 66 nylon

PE = polyester

PAC = polyacrilic

PP = polyolefin, namely polypropylene

General processing principles

All three important man-made fibres - PE, PA and PAC - together with the now developing PP (polypropylene) are chemically based on oil refining and on the petrochemical products which a refinery supplies (compare table 1)

The primary olefins

ethylene C_2H_4 and

propylene C_3H_7

and the primary aromatics

benzene C_6H_6 and

para xylene C_8H_{10}

are amongst the immediate products of oil cracking and reforming. They have to be modified by reaction with oxygen and ammonia to obtain these intermediates which are to become the individual units of the main backbone of the fibres

ethylene glycol and terephtalic acid	for PE
diamines, dicarboxylic acids and caprolactam	for PA and
acrylonitril	for PAC.

These units are connected with each other by so called polymerisation reactions in the course of which long chain molecules are formed which are equivalent and analogous to cotton, wool, and silk and represent the man-made fibre forming polymers:

PE, PA and PAC (and recently also PP); they are very hard, tough, high melting and solvent resisting materials, which can eventually be obtained in the form of a granulate (chips) or a powder.

For the manufacture of the fibres these polymers are fused or dissolved and the melt or solutionis extruded through a plurality of small holes to form the primary filaments which are then exposed to further processing steps such as stretching, bulking, crimping, setting, cutting, and finishing. In chapter S, there will be given detailed flow sheets and descriptions of the individual processing steps for PE, PA and PAC.

3) General forms of man-made fibres and textiles manufactured therefrom:

Man-made fibres are produced as

Monofilament - A single filament of continuous length

Filament yarn - Two or more continuous monofilaments assembled or held together by twist or otherwise.

Tow - Large bundles of continuous monofilaments assembled without twist.

Staple fibres or short length (2-10 cm) which have been cut or broken from a large bundle (tow) of continuous monofilaments.

Spun yarns - the short fibres, or staples, may be twisted or spun, just as short lengths of cotton and wool. Staples of different lengths are designed for use in various systems of spinning, such as the cotton system, the wool system, and the worsted system. Some staple is used without spinning - as filling in pillows, mattresses, sleeping bags and comforters.

Yarns spun from staple are more irregular than those made of filament; the ends of the short fibres, projecting from the yarn surface produce a fuzzy effect. Spun yarns are also more bulkythan filament yarns of the same weight. They contain more air and are therefore used for porous, warm fabrics.

Slit Film - A recent method to produce fibre forming polymers without the use of spinnerets is the slit-split film process. In it a wide (1-2m) and thin (20-50 microns) film is extruded and slit into narrow continuous strips of 2-4mm width. These strips are stretched (10-15 fold) and split into finer threads either by additional slicing or by twisting. There result continuous filaments in the denier range from 6 - 20, which have yarn-like appearance and properties. The preferred material for the slit split process is polypropylene.

Textured filament yarns

Some types of textured yarns are manufactured by man-made fibre producers. In addition, the yarn throwing (twisting) industry processes filaments to impart to their yarns bulk or stretch properties. The function of a throwster, in addition to other textile functions which he performs, is to twist or manipulate filament yarns. After a certain crimping and bulking steps, the filament yarns are known as textured yarns. The added physical properties are achieved through the use of special processing machinery, and advantage is taken of the capacity of man-made fibres to "remember" twists and turns imparted to the filaments particularly of those twists and turns which have been "locked in" by heat setting. Filaments take on new characteristics by such processes as twisting and untwisting, false twisting, crimping, knitting and deknitting. The bulk or stretch properties which are built into filament yarns add an important new dimension to textile technology. In addition, texturing of filament yarns imparts a soft hand to fabrics made therefrom.

Blends and combinations

Frequently, the characteristics of two or more types of staple fibre, either man-made or natural, may be combined by blending the fibres together before they are spun into yarn. Fabrics manufactured from such mixtures of spun yarns are called "blends". In addition, various types of monofilaments or filament yarns may be combined and twisted together to form a "combination" filament yarn.

4) Most important fields of applications

Polyesters, polyamides and polyacrylics have different chemical composition and therefore differ in their physical and thermal properties; hence they have their preferred fields of application.

4 A) Polyesters are strong, tough, very resistant to stretching and shrinking, wrinkle resistant, abrasion resistant, crisp and resiliant when wet or dry, and able to retain heat - set pleats and creases. Therefore they find principal uses in:
Durable press (permanent press) merchandise, suits, shirts, slacks, underwear, dresses, blouses, lingerie, curtains, draperies, carpeting, sails, fire hose, rope, tire cord, fish nets, and power belting. Texturised polyester fibres are used in woven and knit fabrics.

4 B) Polyamides. Due to their strength, abrasion resistance and extensibility their main textile uses are:
Hosiery, upholstery, underwear, shirts, blouses, stockings, stretch fabrics, bedspreads, carpeting, and other-industrial uses - are air hoses, racket strings, sails, tire cord, sleeping bags, ropes, nets, parachute canopies and harnesses.

4 C) Polyacrylics are made in many modifications to give special properties best suited for different types of fabric constructions, to blend harmoniously with other fibres, or to meet particular requirements in an end use. Their most important properties are warmth, leightweight, shape retention, resilience and resistance to sunlight. Many fabrics made from acrylic fibres are of soft, light and fluffy constructions. Some principal uses are:
sweaters, skirts, carpets, dresses, blankets, draperies, slacks, upholstery and fleece fabrics.

4 D) Polyolefin fibres. Recent newcomers are the olefin fibres (polypropylene and polyethylene) which are also direct products of the petroleum industry, derived from propylene and ethylene gas. Both fibres are characterised by their resistance to moisture and their chemical inertness. Of the two, polypropylene has the higher melting point and is therefore more favoured for textile applications; its uses have become rather numerous since its introduction around 1960.

The main characteristics are:

Very light in weight (olefin fibres have the lowest specific gravity of all fibres), able to give good bulk and cover, strong, tough and abrasion resistant.

Some principal uses are in carpeting (largest single application), non woven felts, carpet backing, bags, dye nets, ropes and cordage, sandbags, upholstery, filter fabrics, and pile fabrics.

[illegible]) General forecast of man-made fibre demand in Brazil

After the foregoing general introduction into the field of man-made fibres and before embarking on a more detailed description of the most important materials it might be useful to take a "birds eye view" on the evolution of man-made textile goods in Brasil from 1972 to 1975 and attempt to establish the probable demand at the end of this period. Let us first take a look at the consumption of the most important man-made textile fibres in the USA in 1970. (These figures do not include industrial fibres for such uses as tires, belts, hoses, ropes, nets etc.)

The consumption of PE was about 1 400 million lbs or 640 000 tons. Using 200 millions for the population of the USA at that time, we arrive at a per capita consumption of 3,2 kg PE in the textile field. The corresponding figures of polyamides are 740 000 tons or 3.7 kg per capita, and for PAC we find 260 000 tons and a per capita consumption of 1.3 kg.

Taking these figures as a <u>base line</u> we arrive at the conclusion that the population of an industrially developed country such as the USA in 1970 is capable to consume per capita

3.2 kg of PE
3.7 kg of PA and
1.3 kg of PAC.

Let us now ask the question: If the Government of Brasil wants its people by 1975 to have available a corresponding supply of man-made textile goods what production capacities will be needed to do that at that time?

The answer is simple. I understand that the population of Brazil is forecast to be 110 million by 1975. Then, if the <u>same standard</u> should prevail for Brazil in 1975 as it did for the USA in 1970, the consumption of

PE will be 3.2 kg times 110 million = 352 000 tons; of
PA " " 3.7 " " " " = 407 000 " and of
PAC " " 1.3 " " " " = 143 000 "

Now, of course, the Government may not expect to have in Brazil in 1975 the same consumptive capacity in the textile market as the USA had in 1970 but a <u>lower one</u>. Then table 2 shows the capacities of PE, PA and PAC production which are necessary to satisfy a demand of 25, 50 and 75% of the USA standard in 1970.

Table 2

Production capacities for PE, PA and PVC, necessary to satisfy various percentages of the 1970 consumption in the USA

Man-made fibre	yearly production in tons to satisfy the USA standard consumption in 1970 to			
	100%	75%	50%	25%
PE	352 000	264 000	176 000	88 000
PA	407 000	306 000	203 500	102 000
PVC	143 000	107 000	71 500	35 800
Total	902 000	677 000	451 000	225 800

In order to advise and regulate the man-made fibre industry the Government will have to set a target for the probable domestic consumption by 1975. Once this target is set one can readly calculate from table 2 what production capacity has to be organised by 1975 in order to meet this expected demand. If this capacity is below the figure taken from table 2, the Governments demand will not be satisfied: there will be underproduction and imports might be necessary. If the actual capacity in 1975 will be above the figures in table 2, there will be overproduction and some mechanism of export will have to be looked for.

During my conversation with numerous representatives of the man-made fibre industry in Brazil and during my plant visits I have collected certain data, which appear to give the following figures for the 1975 man-made fibre production:

PE (staple and filament, without industrial fibres)	121100	tons
PA (staple and filament, " " ")	55000	"
PAC (staple and tow)	20500	"
PE, PA and PAC	196500	"

Comparing those figures for the 1975 intended capacity with those of table 2, we arrive at the conclusion that in 1975 the available:

PE will	correspond to	33.4%	of the	1970	US	per	capita	standard
PA "	" "	13.5%	"	"	"	"	"	"
PAC "	" "	14.0%	"	"	"	"	"	"

Let us take all man-made fibres in Brazil together, than we arrive at a grand total production of 196 500 tons in 1975. This is 21.7% of the 1970 US standard if one takes all man-made fibres together.

If the Government of Brazil feels that in 1975 the consumptive capacity of its people in the man-made textile field will be about 20% or one fifth of what it was in 1970 in the USA, then the presently intended expansions are adequate.

The setting of such a goal is evidently depending on several factors such as climate conditions, distribution of the population in cities and in the country, average yearly income, dressing habits and many others. As a UN textile expert I have no capability to weigh these factors adequately and to predict their integrated influence, but once the target is set the figures of table 2 indicate the necessary production capacities by 1975 to reach the desired goal.

After this general survey we shall now focus our attention on those factors which should be kept in mind as one starts planning the desired expansion until 1975 for each of the three important fibres.

SITUATION IN BRAZIL

3) Comments on minimum plant size for polyester, polyamides and polyacrylics

There exist, at present, about 25 years of experience for commercial operation of many man-made fibre plants in Europe, USA and Japan, and as a result, it is possible to define what is commonly called a "minimum economic plant size". This size, expressed in tons of yearly production, indicates approximately the lower production limit which is still compatible with the industrial and economic conditions in these countries. Any smaller plant would, in the long run, not be able to remain competitive, unless the Government would be ready to subsidise it in an efficient manner. In chapter 7 I shall enumerate the ways and means by which such subsistance can be granted.

3 A) Polyester

During the last few years the larger part of PE-fibre producers in Brazil has step abandoned the use of imported intermediate products and either has already advanced to the basic raw materials - terephtalic acid and ethylene glycol or even to paraxylene and ethylene - or is planning to do this within the next two or three years.

Let us therefore consider a polyester fibre and filament production which starts with terephtalic acid and ethylene glycol and uses the best existing technology for polymerisation, spinning, drawing and finishing both for staple fibre and for continuous filament yarn. Experience collected in above named countries indicates, that a yearly production of approximately 5 000 tons of staple fibre or 3 500 tons of continuous filament should be considered as the minimum plant size. These two figures vary somewhat from country to country but can be taken as a warning that smaller units could - in the long run - not remain commercially successful.

Table 3 contains figures on the PE fibre production capacity in Brazil for 1972 and projected figures for 1973, 1974, and 1975; I have collected them in part during my factory visits and partly in conferences which I had with representatives of the various fibre producers.

This table shows that in 1972 only Rhodia has a staple fibre and filament capacity which are both comfortably above the minimum size. All other staple fibre producers are below the critical size and only two filament producers ([illegible] and Safron-Teijin) are slightly above the critical limit. In 1973 Rhodia is moving further away from the critical limit and Soutex is planning to produce 10,000 tons of staple and 7 000 tons of filament both of which are considerably above the minimun size. Celanese is planning to move with 6 000 tons of staple above the limit but remains with 3 000 tons of filament somewhat below the economically feasible size.

Table 3

POLYESTER

Production capacity at the end of year in tons/year

	1972		1973		1974		1975	
	staple	filam	staple	filam	staple	filam	staple	filam
Rhodia (Rhone-Poulenc) DMT imported until 1974 TPA selfmade upfrom 1974	19,800	7,800	24,300	9,100	28,600	10,600	33,000	12,000
Soutex DMT Chemtex	-	-	10,000	7,000	10,000	7,000	10,000	7,000
Sudantex DMT	2,400	-	2,400	-	2,400	-	2,400	-
Matarazzo (Toray) TPA	3,300	1,700	3,300	1,700	3,300	1,700	3,300	1,700
CBS Companhia Brasileira de Sinteticos (Hoechst) DMT	-	3,600	-	3,600	3,500	3,500	3,500	3,500
Polychimica (AKZO) polyester chips until 1974 DMT 1974 onwards	-	2,100	-	3,600	-	3,600	-	5,500
Cifitex (Toray) DMT	-	-	-	-	-	2,100	-	2,100

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- table 3 continued -

POLYESTER

Production capacity at the end of year in tons/year

	1972		1973		1974		1975	
	staple	filam	staple	filam	staple	filam	staple	filam
Celanese (Celanese) HT	-	-	6,000	3,000 * HT 500	10,000	4,500 * HT 1,000	15,000	6,000 * HT 2,200
Polynor TPA Vickers-Zimmer (SUDENE)	3,100	1,800	3,100	1,800	3,100	1,800	3,100	1,800
Safron-Teijin (Teijin) HT (SUDENE)	2,000	3,600	2,000	3,600	4,000	7,200	4,000	7,200
Total Production	30,600	20,600	51,100	33,900	64,900	43,000	74,300	49,000
Total Production staple fibre & filament	48,100		85,00		107,900		123,300	

* HT = high tenacity = industrial yarn

In 1974 Rhodia expects still to lead and gets rather far away from the limits. Soutex plans to maintain its 1973 position, Celanese moves with 10 000 tons of staple and 5 500 tons of filament above both limits and Safron-Teijin has reached a safe production size for filaments.

Finally in 1975 Rhodia has expanded its lead; Soutex does not intend to change; Polychimica plans to exceed the filament limit by a 5 500 tons production; Celanese definitely moves into a safe range both with fibre and filament and Safron-Teijin maintains its 1974 position.

All other producers are now and will still be in 1975 below the minimum economic capacity. It has already been mentioned, that Government subsidy may assist undersized producers for a while to remain competitive but such assistance becomes very difficult as soon as domestic demands are saturated and export becomes an additional important factor.

6 B) Polyamides.

6 B1) 6-nylon:

If one starts with caprolactam and polymerizes, spins and draws continuously, the lower limit for staple fibre production in the range from 2 - 5 denier per filament is about 2 000 tons a year, whereas the corresponding limit for continuous yarn production can be put at about 1 500 tons a year. Table 4 gives a survey of the 1972 6-nylon activities in Brasil plus the intended expansions until 1975. It shows that in 1972 Matarazzo, Nailonsix, Soutex, CBS and Banilsa are above the critical limit in continuous filaments (no staple is produced at all). Only Fibra and Massaferro are below a yearly production of 1 500 tons.

From 1973 to 1975 CBS contemplates no expansion at all, Matarazzo a small one - 3 240 tons instead of 3 000? Nailonsix goes from 1 800 in 1972 to 4 200 in 1973 with no more change until 1975. Soutex spands considerably from 1972 (4 000) to 1973 (10 000) and remains constant. Fibra moves into the safe range in 1973 (2 800) and then expands to 4 500 in 1974 and 1975. Suzuki intends to enter the field in 1973 but remains slightly under the critical limit (1 300 instead of 1 500). Mazzaferro remains below the economic limit although they are producing industrial yarn and not textile filaments. The critical limit for industrial yarn is difficult to establish without knowing exactly the contemplated uses. Equipesca plans to produce from 1973 on industrial yarn at a rate of 7 200 tons a year which is clearly well in the economic range. Finally Banilsa increases its 1972 production of 1 500 tons to 3 300 tons a year from 1973 to 1975 and will be above the minimum capacity.

Table 4

P o l y a m i d e s (nylon 6 nylon 66)

Production capacity at the end of year in tons/year

		1972		1973		1974		1975	
		staple	filam	staple	filam	staple	filam	staple	filam
Rhodia	(Rhone-Poulence) produce adipic acid & hexamethylenediamine	2,400	9,000	3,800	11,000	4,500	12,500	5,000	14,000
		* HT	8,400	* HT	10,800	* HT	12,000	* HT	13,000
Matarazzo	(Textilquimica) caprolactam Vickers-Zimmer	-	3,000	-	3,240	-	3,240	-	3,240
Nailonsix	(Rohm & Haas) caprolactam Vickers-Zimmer	-	1,800	-	4,200	-	4,200	-	4,200
Sontex	caprolactam Karl Fischer	-	4,000	-	10,000	-	10,000	-	10,000
CBS	Companhia Brasileira de Sintéticos (Hoechst) caprolactam Vickers-Zimmer	-	2,880	-	2,880	-	2,880	-	2,830
Fibra	(Snia-Viscosa) chips 1972, caprolactam 1973	-	1,000	-	2,800	-	4,500	-	4,500
Celanese (66)	(Celanese) AH-Salt	-	4,400	-	4,400	-	4,800	-	6,000
[illegible]	caprolactam Vickers-Zimmer	-	-	-	1,300	-	1,300	-	1,300

continue on next page

Table 4 continued

Polyamides (nylon 6, nylon 66)

Production capacity at the end of year in tons/year

		1972		1973		1974		1975	
		staple	filam	staple	filam	staple	filam	staple	filam
Mazzaferro	caprolactam	-	*HT 700	-	*HT 700	-	*HT 1,000	-	*HT 1,000
Equipesca do Sul	chips Reifenhaeuser Maschinenf.	-	-	-	*HT 7,200	-	*HT 7,200	-	*HT 7,200
Emilsa	caprolactam Vickers-Zimmer (SUDENE)	-	1,500	-	3,800	-	3,800	-	3,800
Total Production		2,400	38,200	3,800	62,320	4,500	67,420	5,000	71,120
Total Production staple fibre and filament		40,600		66,120		71,920		76,120	

* HT = hight tenacity = industrial yarn

6 B2) 66-nylon:

If one starts with adipic acid and HMD, prepares or buys the salt and polymerises, spins, draws and finishes continuously it was calculated that the minimum economic size would be around 3 000 t/year for staple and 2 500 t/year for filament.

Hence table 4 indicates that Rhodia is very well in the safe range in 1972 for filaments and continues to move into better and better economic conditions for staple and filament from 1973 to 1975. It also operates a large industrial fibre production which is bound to make its total fibre output even more profitable. Celanese in 1972 produces only filament above the critical size and continues to do so until 1975 when it reaches a 6 000 tons per year level.

Summarizing it can be stated that the polyamid production in Brasil has been organized in such a manner that only very few plants were undersized* and that by 1975 all will be above the minimum economic capacity.

6 C) Polyacrylics:

If one starts with acrylonitrile monomer, carries out the polymerisation in a continuous suspension reactor, dissolves the polymer in an appropriate solvent (at 25-28% in dimethylformamide or dimethylacetamide), spins the solution either dry or wet, draws the resulting filaments and works it into staple fibre by crimping, setting, cutting and finishing, the minimum economic plant size is about 3 500 tons per year.

Table 5 shows that already in 1972 both present producers Rhodia and Fisiba - have established production above this level and that in 1974 and 1975 both will be in the fully economic range. Neracryl intends to join them in 1974 and 1975 with 3 500 tons a year. There will be, at no time, any undersized polyacrylic plant.

6 D) Finally table 6 contains the present PP staple fibre production of Spumar for 1972, 1973 and 1974 which is 600 tons per year. It appears that the polymer is purchased and that a melt spinning operation is carried out by Spumar. This report does not contain data on the quantity and quality of polypropylene slit-split threads since they are not yet used in the mainstream of textile goods.

Table 5

Polyacrylonitrile-Fibres

Production capacity at the end of year in tons/year

		1972	1973	1974	1975
		staple & tow	staple & tow	staple & tow	staple & tow
Rhodia	(Rhone-Poulenc) wet process	5,700	6,800	7,900	9,000
Fisiba	(Sabrin) monomer production planned dry process (Mitsubishi)	4,000	4,000	8,000	8,000
Mon.cryl	(Asaki) Katarazzo (SUDEME) wet process	-	-	3,500	3,500
Total Production		9,700	10,000	19,400	20,500

Table 6

Polypropylene - Fibres

Production capacity at the end of year in tons/year

	1972	1973	1974
	staple	staple	staple
Spumar	600	600	600

6 [illegible]) Estimated minimum economic plant sizes:

Table 7 summarises the presently available estimates for minimum economic plant sizes for PE, PA and PAC.

Table 7

		staple	filament
Monomer	to PE	5 000	3 500
Caprolactam	to 6-nylon	2 000	1 500
Monomer	to 66-nylon	3 000	2 500
Monomer	to PAC	3 500	-

7) Ways and means of Government subsidy:

Several supporting measures have been especially established for the man-made fibre industry, and it has together with other selected industries received some degree of government encouragement and economic growth.

Apparently the man-made fibre industry has been selected amongst other industries, as one worthy of encouragement and development as it permits:

Utilisation of indigenous raw materials
Development of exports
Import substitution
Conservation of foreign exchange
Development of new skills and technology.

Against these criteria government policies and measures to assist the man made fibre industry are many, and vary from country to country in their extent and emphasis. There follows a short description of measures adopted generally within producing countries, under the following headings:

Financial assistance
Tariffs and import control
Taxation relief
Export development
Other measures.

7 a) Financial assistance

In certain of the developing countries financial assistance by government institutions, as well as private institutions, is provided in the initial stages of industry establishment. Such assistance includes short, medium and long-term loans at favourable interest rates. Government measures also include the encouragement of overseas finance and investment and in some instances approval and guarantee of long-term deferred repayment loans from overseas [illegible].

7 B) Tariffs and import control

In many developing countries tariff protection is granted to the domestic industry in some measure. The rates of duty vary from country to country and also by type of fibre. In some countries, e.g. New Zealand and India, protection by the tariff is supplemented by the control of imports by import licensing.

7 C) Taxation relief

Numerous forms of taxation relief are practised to assist the industry from the date of establishment. These measures include:

a) Tax holidays for up to six years depending on plant location and use of indigenous raw material (Pakistan)
b) Investment allowance (Australia)
c) Research and development allowance (Australia)
d) Relief on machinery for: development and modernisation, new technology, research and development (Japan)
e) Reduced taxation an pilot plants (Japan)
f) Tax exemption for three to five years during establishment pesied, and at 50% of normal rate during ensuing 5 years (Japan)
g) Reduction of taxation on royalty payments (Japan).

7 D) Export incentives

Export incentives for industry are common in many countries and government measures cover:

Exemption of import duties,
Payroll tax allowances,
Export bonus schemes,
Export insurance and guarantees.

7 E) Other measures

A variety of other government measures assist in the development of domestic industry, for example;

a) The awarding of government contracts to domestic industry (Japan)
b) Productivity centres
c) Design centres
d) Investment advisory services (including economic, engineering financial and marketing advice)
e) Encouragement of industry concentration in several large companies (Japan)

As indicated earlier, the incidence, scope and extent of these measures vary from country to country. Nevertheless it is true that the man-made fibre industry within most developing countries is assisted and encouraged to some extent by government action and policy.

The factors inhibiting the growth of industries in developing countries have generally been identified as:

Lack of technical know-how in production and marketing
Limited markets
Lack of capital
Lack of trained manpower.

In the case of the man-made fibre industry, in addition to these general factors, there are certain difficulties peculiar to the industry. The technical know-how for processes, plant construction and operation is in the hands of a limited number of producers in a relatively small number of developed countries.

8) Capital investment, manufacturing costs and production costs for man-made fibres

In chapter 6 I have given my best present estimates of the minimum economic plant sizes for the production of PE, PA, and PAC staple fibre and continuous filament, in this chapter shall be presented the corresponding figures for capital investment and manufacturing costs for such minimum size installations. Evidently these figures differ from country to country and, in one country, even from location to location and it was, therefore, necessary to use certain representative averages. The capital investment and production cost data refer to a plant in one of the industrial areas of Western Europe such as England, Germany, France or Belgium and in the USA such as New Jersey, Virginia, Texas or Louisiana.

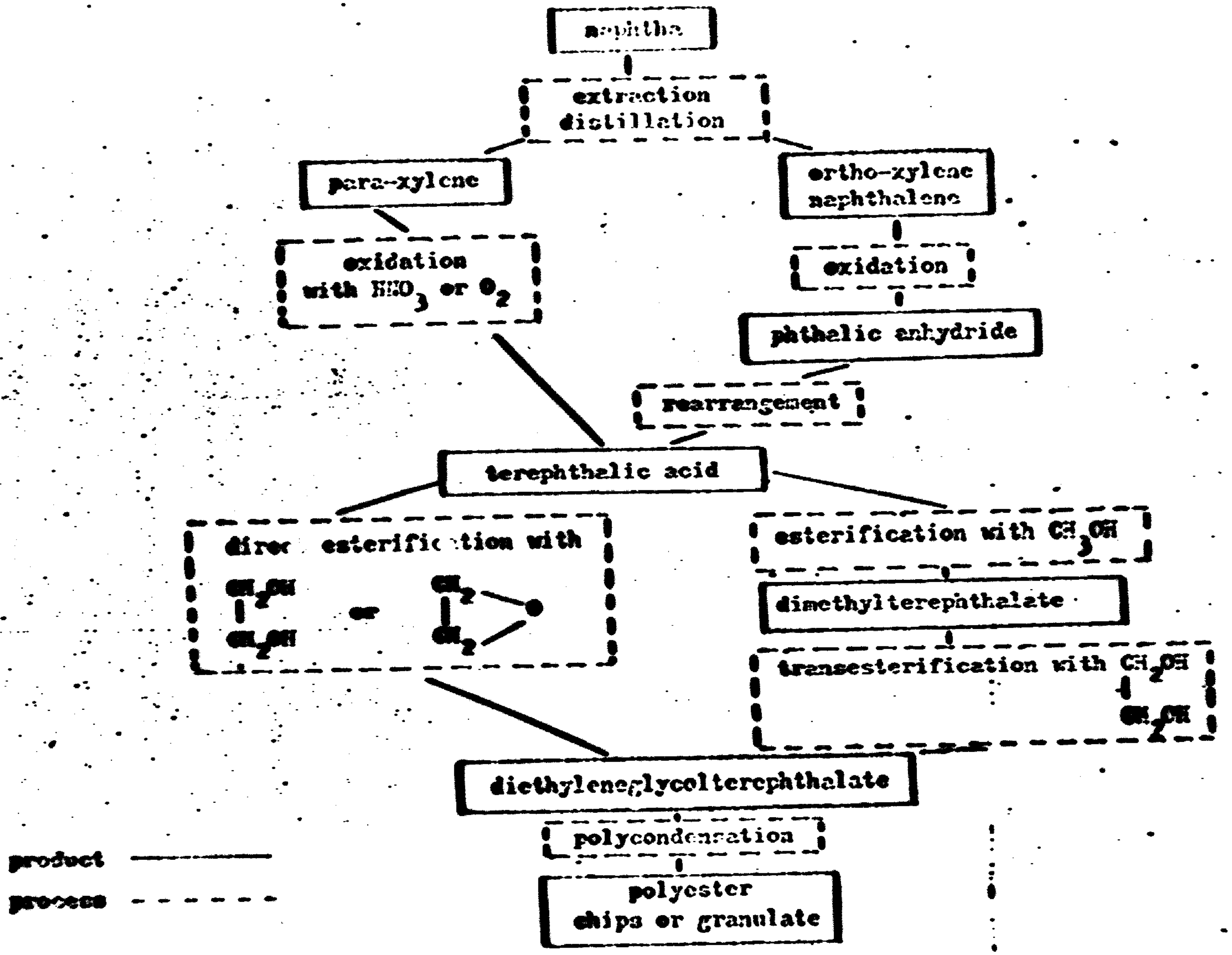
8 A) Polyester staple fibre

8 A1) Process details:

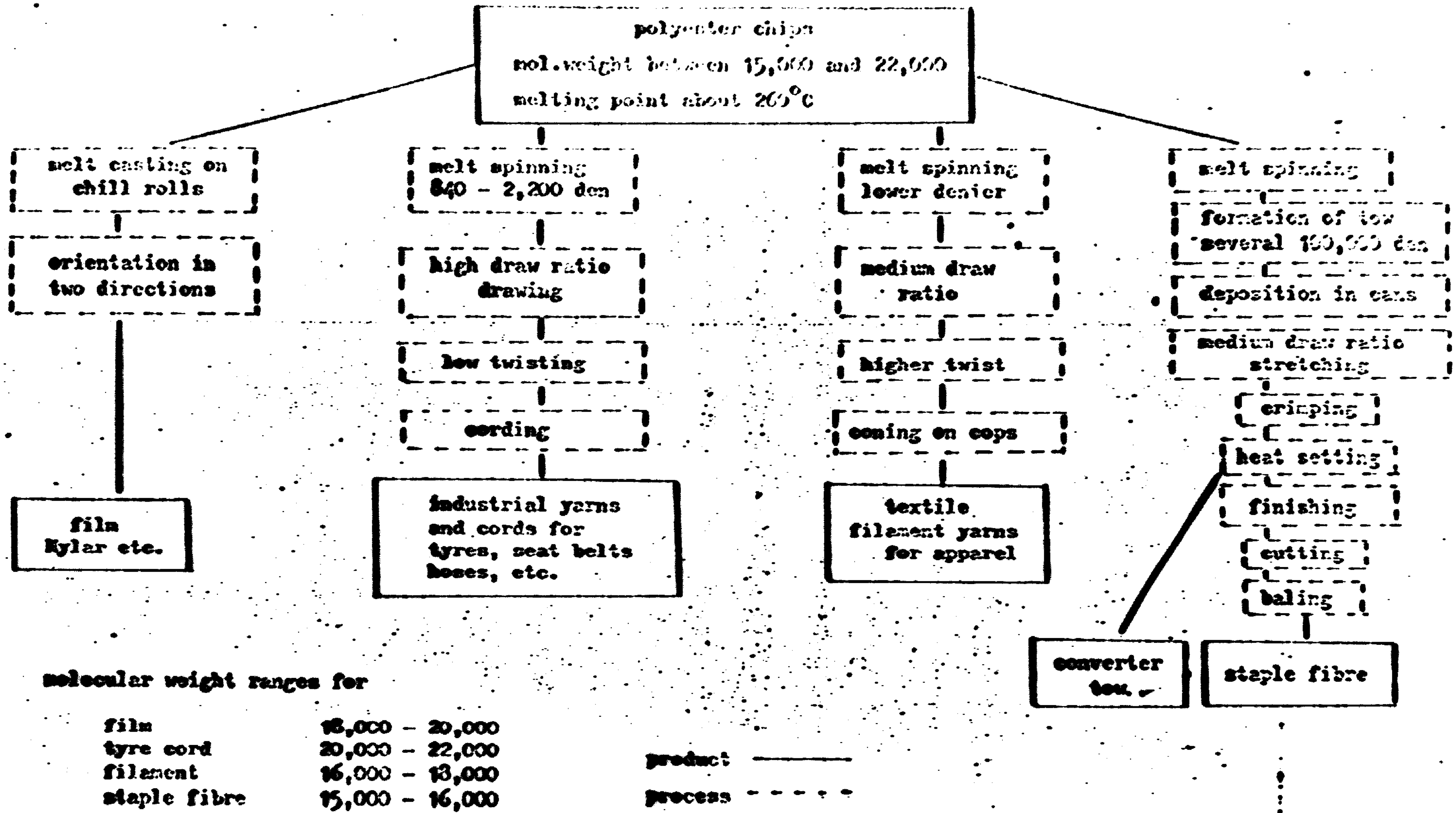
Flow sheets A and B describe in detail the individual process steps and the individual intermediate products for the production of PE filament and staple according to those products which are actually used in PE fibre technology, namely two alternative routes from naphta to terephtalic acid to the polyester chips.

The most modern - and probably best - route is the direct oxydation of para-xylene (left side of the flow-sheet) and the direct esterification of terephtalic acid with ethyleneoxide (left side of the flow-sheet) and the figures given in this chapter refer to this specific route.

Flow sheet I


naphtha
extraction distillation
para-xylene
ortho-xylene naphthalene
oxidation with HNO3 or O2
oxidation
phthalic anhydride
rearrangement
terephthalic acid
direct esterification with
CH2OH | CH2OH or CH2 CH2 O
esterification with CH3OH
dimethylterephthalate
transesterification with CH2OH | CH2OH
diethyleneglycolterephthalate
polycondensation
polyester chips or granulate
product
process

Flow-sheet B



molecular weight ranges for

film	18,000 - 20,000
tyre cord	20,000 - 22,000
filament	16,000 - 18,000
staple fibre	15,000 - 16,000

8.2) General economic aspects

The sales price of an industrial product can be split up into several recognized components, namely

- the cost price ex plant including:
- cost of materials, energy and utilities, cost of labour, maintenance and plant overhead, depreciation and interest
- cost of research and development and/or royalties
- selling expense, such as cost of marketing, advertising and service
- administrative expense
- earnings
- taxes.

Of these components the cost price ex plant is reasonably well predictable; the other components contain very uncertain factors and may vary widely.

The following figures refer to a PE staple fibre plant based on a yearly production capacity of 4,500 tons. Plants of this size are usually built in developing countries; US, Japanese and European plants operate in much larger units - sometimes about 70 000 tons per year.

8.3) The capital investment for a polyester staple fibre plant with a capacity of 4,500 tons per year corresponding to 13 tons a day in US $ is represented by

a) Real estate purchased (in the USA) about	120,000
b) Real estate improvement	24,000
c) Constructions of buildings	600,000
d) Utilities for the operation of the buildings	60,000
e) Purchase of machinery	2,500,000
f) Installation of machinery	250,000
g) Installation of utilities for the operation of the process	25,000
Total cost of the physical plant	3,589,000
or about	3,600,000
h) Engineering and construction	300,000
i) Contractor's fee	180,000
j) Contingencies	360,000
	4,520,000
The fixed capital investment will therefore be about	4,500,000

This represents an investment of about 100 ¢ per kg of yearly production

Recently more streamlined machinery has become available which lowers this figure to about 38 ¢ per kg of yearly production.

3 A 4) Manufacturing costs

The plant has a daily output of about 13 tons and carries out the following operations:

polymerisation
extrusion, spinning and drawing,
crimping, cutting and finishing.

The total manufacturing costs can be computed from the costs of the raw materials - terephtalic acid (TA) and ethylene glycol (EG) - and the individual costs of the three manufacturing steps. Appendix A gives the list price of TA as 37.5 ¢ per kg and that of EG is 18.7 ¢ per kg. The polymer contains 60% TA and 40% EG which gives a price for the raw materials of 29.7 ¢ per kg polymer.

raw materials	29.7 ¢ per kg	
polymerization	13.0 "	
extrusion etc	26.2 "	
crimping etc	24.1 "	or a total of
	93.0 ¢ per kg.	

3 A 5) Capital service and total production cost

Figuring with 5% interests which have to be paid for the invested capital and with a return of 10% of the invested capital we arrive at a capital investment of 100 ¢ per kg or, with the best available equipment of 80 ¢ per kg. Using 90 ¢ as a realistic figure, we have to take 15% of it and add it to the manufacturing cost in order to get the total production cost for 1 kg of PE staple fibre in the plant

manufacturing costs	93.0
capital service (15% of 90 c/)	13.5
total production cost	106.5 ¢ per kg.

The present list price of PE staple fibre in the USA is between 130 and 140 ¢ per kg which shows, that there would be about 35 ¢ per kg left for sales, taxes and profit.

However it is well known that PE staple can be presently purchased on the world market at prices as low as $ 0.85 per kg, which clearly shows that a plant of the above size could never be able to compete on a world wide export market.

8 B) Polyester filament

This calculation is made for yarns in the range from 70 - 100 denier.

8 B1) Process: Flow sheets A and B also contain the process steps for polyester filament production.

8 B 2) General economic aspects: Same as 8 A2

8 B 3) The capital investment for a polyester filament plant, with a capacity of 4,500 tons = 10,000,000 lbs/year in US $ is given by

a) Real estate purchased (in the USA) about	160,000
b) Real estate improvement	30,000
c) Construction of buildings	800,000
d) Utilities for the operation of the buildings	80,000
e) Purchase of machinery	5,200,000
f) Installation of machinery	800,000
g) Installation of utilities for the operation of the process	50,000
Total of the physical plant	7,120,000
or about	7,200,000
h) Engineering and construction	800,000
i) Contractor's fee	250,000
j) Contingencies	500,000
The total capital investment will therefore be about	9,000,000

This represents an investment of about 200 ¢ kg of yearly production which is about 100% above the corresponding investment for a staple fibre plant. In filament production are many more individual spinning positions which represent the most important and expensive part of the machinery.

8 B 4) Manufacturing costs:

The raw materials used in filament reproduction are the same as for staple but polymerisation is somewhat more expensive than in staple fibre manufacturing because a higher molecular weight of the polymer is needed for filament (16 000 - 18 000) than for staple (15 000 - 16 000), instead of 13.0 ¢ per kg we have now 15.0 ¢ and the manufacturing costs can be computed as

Raw materials	29.7	¢ per kg
Polymerisation	15.0	"
Extrusion, spinning and drawing	92.7	"
Finishing, twisting and coning	26.6	"
total	164.0	¢ per kg

8 B 5) Capital service and total production costs:

As in 8 A 5 but with a larger capital investment gives a capital service of 15% on 200 ¢ per kg which is 30 ¢. This leads to a total production cost for filament yarns in the 70 - 100 dernier range

Manufacturing costs	164 ¢ per kg
Capital service	30 "
total	193 ¢ per kg

List prices for such yarns in Europe, Japan and the USA range from 300 to 420 ¢ per kg but, filament yarns with trade names - Fortrel, Trevira, Terylene - are available today at prices as low as 240 ¢ per kg.

As a consequence, the plant could not successfully compete in export on the world market, unless a substancial Governments subsidy would be granted.

8 C) 6-nylon staple fibre

8 C 1) Process: Caprolactam (compare Appendix A) is continuously polymerised, spun, drawn, crimped, and finished.

8 C 2) General economic aspects: Same as in 8 A 2.

8 C 3) Capital investment for a 6-nylon staple fibre plant with a capacity of 4 500 tons a year, corresponding to 13 tons/per day.

a) Real estate purchased (in the USA) about	120 000	US
b) Real estate improvement	30 000	"
c) Construction of buildings	600 000	"
d) Utilities for the operation of the buildings	60 000	"
e) Purchase of machinery	2 1000000	"
f) Installation of machinery	200 000	"
g) Installation of utilities for the operation of the process	300 000	"
	3 410 000	"
or about	3 400 000	"
h) Engineering and construction	400 000	"
i) Contractor's fee	100 000	"
j) Contingencies	200 000	"
fixed capital	4 000 000	US

This represents an investment of about 88 ¢ per kg of yearly production.

8 C 4) Manufacturing costs:

The plant has a daily output of 13 tons and carried out the following operations:

polymerisation

extrusion, spinning and drawing

crimping, cutting and finishing.

To obtain the total manufacturing costs we have to add to this the cost of the raw material, namely caprolactam, according to Appendix A. Then we obtain

Raw material	33.0 ¢ per kg.
Polymerisation	10.0 "
Spinning etc	20.0 "
Recovery of monomer	4.0 "
Crimping etc	21.0 "
	88.0 ¢ per kg

8 C 5) Capital service and total production costs:

Similar to 8 A 5 with 5% interests and 10% return on a capital investment of 88 ¢ per kg of yearly production, we arrive at the total production costs

Manufacturing costs	88.0 ¢ per kg
Capital service	13.2 "
Total	101.2 "

or about 1.00 US$

The present list prices for 6-nylon staple are in the range of 150-130 ¢ per kg which would make out plant profitable. However also if in the 6-nylon field there are dumping prices they could be so low as to permit no competition on the world market.

8 D) 6-nylon filament

This computation is made for yarns in the range from 50 - 100 denier

8 D 1) Process Same as in flow sheet B for polyester filament.

8 D 2) General economic aspects: Same as in 3 A 2.

8 D 3) Capital investment for a 6-nylon filament plant with a capacity of 4 500 tons a year or 13 tons a day in US $

This plant is supposed to produce multifilament yarns in the denier range from 50/16 to 100/32.

a) Real estate purchased (in the USA) about	150 000
b) Real estate improvement	30 000
c) Construction of buildings	700 000
d) Utilities for the operation of buildings	80 000
e) Purchase of machinery	5 000 000
f) Installation of machinery	700 000
g) Installation of utilities for the operation of the process	50 000
	6 710 000
or about	6 700 000
h) Engineering and construction	750 000
i) Constructor's fee	250 000
j) Contingencies	400 000
Total fixed capital will be	8 810 000
or about	9 000 000

This represents an investment of about 200 ¢ per kg of yearly production.

8 D 4) Manufacturing costs:

Raw material and polymerisation are the same but spinning, drawing and finishing are different (compare 8 A 4 with 8 B 4) and we arrive at the following manufacturing costs

Raw material	33.0 ¢ per kg
Polymerisation	10.0 "
Extrusion, spinning, drawing	91.0 "
Finishing, twisting, coning	27.0 "
Total	161.0 ¢ per kg

8 D 5) Capital service and total production costs (as in 8 B 5 and 8 C 5):

Capital service (15% on 200¢)	30.0
Manufacturing	161.0
Total production cost	191.0

List prices in Europe, Japan and the USA on 6-nylon yarns range from 350 to 450 ¢ per kg, which shows that this plant could successfully compete with list prices even in export.

[illegible] 2) Polyacrylic staple fibre

[illegible] 2 1) Process: The process consists of polymericing liquid acrylonitrile in suspension to polyacrylonitrile, dissolving the polymer, spinning the solution either dry or wet, drawing and crimping the resulting tew of filaments with ultimate cutting and finishing of the fibre.

[illegible] 2 2) General economic aspects: Same as in A 2 and C2.

[illegible] 2 3) Capital investment for a polyacrylonitrile staple fibre plant with a capacity of 4,500 tons a year in US$ or 13 tons a day

Fixed Capital

a) Real estate purchased (in the USA) about	200,000
b) Real estate improvement	40,000
c) Construction of buildings	1,400,000
d) Utilities for the operation of the buildings	140,000
e) Purchase of machinery	2,900,000
f) Installation of machinery	430,000
g) Installation of the utilities for the operation of the process	30,000
	5,140,000
Total physical plant cost about	5,200,000
h) Engineering and construction	1,000,000
i) Contractor's fee	260,000
j) Contingencies	700,000
	7,160,000
The total fixed cost will therefore be about	7,200,000

This means a capital involved of about 158 ¢ per kg of yearly production.

[illegible] 2 4) Manufacturing costs:

Raw material	(acrylonitrile)	24.0 ¢ per kg
Polymerication		14.0 "
Dissolution		9.0 "
Spinning and drawing		18.0 "
Crimping, cutting, finishing		21.0 "
Solvent recovery and losses		8.0 "
Total		94.0 ¢ per kg

S E 5) Capital service and total production costs

As in B 5 and D 5.

Capital service (15% on 158 ¢)	23.7 ¢ per kg
Manufacturing costs	94.0 "
Total	117.7 ¢ per kg.

List prices are 150 - 170 ¢ per kg.

9) Report on field trip

9 A) Programme of visits

It was very interesting for me and of great value for the accomplishment of my report that I was given the opportunity to visit several man-made fibre plants and other textile operations in Brasil. In comparison with many similar installations which I have visited in developing countries and even more frequently in Western Europe, Japan and USA I was very much impressed by the modern machinery, the straightforward organisation and the excellent housekeeping in the Brazilian mills. All staff members whom I met were obviously thoroughly competent and very communicative. My conversations with them made it evident to me that they have to display special skill to overcome existing, infavourable conditions such as lack of adequate electric power sources, difficulties in getting pure chemicals for the plant operation, high import taxes on the intermediates and scanty availability of skilled labor.

In spite of all these difficulties the output of all mills, which I had the privilege to visit, is of a remarkable high quality, which is not only a consequence of effective plant operation but also of strict process and product control and supervision.

The detailed programme of visits was as follows:

PROGRAMA DE VISITA AO NORDESTE

Dr. Maurício Pinheiro	Coordenador G-8 - CDI
Dra. Elfie Braunsteiner	Técnica-Fibras Sintéticas - UNIDO
Dr. Mário Soute Lyra	Cons. Des. Ind. - MIC
Dr. Roger Haour	Técnico Ind. Têxtil

Sexta-feira 19 de maio 14:00	Visita a fábrica SAFRON-TEIJIN S.A. - Aratu-Bahia
Segunda-feira 22 de maio 10:00	Visita a fábrica - RHODIA NORDESTE S.A condução fornecida pela Rhodia
14:30	Visita a SUDENE
Terça-feira 23 de maio 10:30	Visita a fábrica MOINHO SANTISTA em Recife condução fornecida pelo Moinho Santista

PROGRAMA DE VISITA A SÃO PAULO

Sra. Elfried Braunsteiner	Técnica - Fibras Sintéticas - UNIDO
Dr. Mario Souto Lyra	Cons. Des. Ind. - MIC

Entrevista na sede da Associação Brasileira de Produtores de Fibras Artificiais e Sintéticas
Av. São Luis no. 50 - 17º - cj. 171 B

Segunda - feira
8 de maio

9:00	Celanese do Brasil Fibras Quimicas Ltda.	Sr. Bruno Beer
10:00	Fiação Brasileira de Raion - Fibra S.A.	Sr. Carlo Grego
14:30	Cia. Brasileira de Sintéticos	Sr. S.Rotemberg
15:30	Rhodia Inds. Quimicas e Texteis S.A. Rhodia Nordeste S.A.	Sr. T.Stahel
17:00	Polyquimica S.A. Ind. Textil	Sr. G.Matter

Terça - feira
9 de maio

9:30	Safron Teijin S.A. Ind. Bras. de Fibras	Sr. O.Ratto
11:00	S.A. Inds. Reunidas F.Matarazzo	Sr. C.A.Vivona
14:30	Hercules USA	Sr. R.C.Bogott
15:00	Cia. Bras. de Fibras Sintéticas-NAILONSIX	Sr. Cipolat
16:30	Spumar, Espuma de Nylon S.A.	Sr. C.Villa

Quarta-feira
10 de maio

8:30	Visita a fábrica Cia. Brasileira de Sintéticos - Osasco	Sr. R.Ovegoor Sr. S.Rotemberg
	Visita a fábrica d Moinho Santista Osasco	Sr. M.Multiterno Sr. A.Viviani

Quinta-feira
11 de maio

9:30	Visita a fábrica Celanese do Brasil Fibras Quimicas Ltda. - São Bernardo do Campo	Sr. B.Beer Sr. J.Berne
14:00	Visita a fábrica - Rhodia Inds. Quimicas e Texteis - Santo André	Sr. T.Stahel

Sexta-feira
12 de maio

9:30	Visita a fábrica - Rhodia Inds. Quimicas e Texteis - São José dos Campos	Sr. T.Stahel Sr. Wanderley . F.Vargas

9 B) General comments on trip and summary

One obvious conclusion of my report is that an ideal condition for man-made textile fibre production in Brazil by 1975 would be:

For PE: Two plants for staple fibre production each with a capacity of 40 000 tons per year and two plants for filament each with a capacity of 25 000 tons per year.

For 6-nylon: Two plants for filament production each with a capacity of 25 000 tons per year.

For 66-nylon: One plant for staple fibre production with a capacity of 5 000 tons a year and one plant for filament with a capacity 25 000 tons per year.

For PAC: Two plants for staple fibre each with a capacity of 10 000 tons a year.

Each of these 10 installations would be well above the minimum economic size, would produce efficiently for the domestic market and could even be capable to enter the expert market with part of its production.

10) Acknowledgements

It is a distinct pleasure for me to express my sincerest gratitude and appreciation to Dr. Roger Hacur, UNIDO textile industry advisor, who guided me during my entire stay in the most efficient and pleasant manner and without whose untiring help I could not possibly have finished my report in the short period of two months.

I also want to express sincerest thanks to Dr. J.L.de Almeida Bello, Secretary General of CDI, Ministry of Industry; to Dr. Mauricio M.Pinheiro, Chief, Group-8, Division of Light Industries, (CDI); and to Dr. Mario Souto Lyra, Industrial Development Council Advisor, for their guidance and advice; their personal and professional assistance made my stay in Brazil most interesting, stimulating and pleasant.

11) Appendices

11 A) USA prices of important raw materials in $ per kg

Ethylene glycol	18 - 19
Terephtalic acid	37 - 38
Caprolactam	32 - 34
Acrylonitrile	23 - 25

11 B) USA prices of man-made staple fibre in $ per kg

Polyester

Am. Enka	1.5 - 15 den	1.34 - 1.43
FIC	15. - 6 "	1.34 - 1.47
Beaunit	3 - 15 "	1.34 - 1.78
Celanese	1.5 - 16 "	1.34 - 1.67
DuPont	1.5 - 12 "	1.39 - 1.67
Eastman Kodel	3 - 15 "	1.34 - 1.63
Hoechst	1.5 - 15 "	1.34 - 1.63

Nylon

Allied 6	6 - 15 den	1.43 - 1.58
Am. Enka 6	6 - 15 "	1.39 - 1.89
Beaunit 6 & 66	6 - 15 "	1.69 - 1.89
Celanese 66	18 "	1.78 - 1.83
DuPont 66	1.5 - 18 "	1.69 - 2.60
Wellman 66	3 - 18 "	1.23 - 1.87

Acrylics

Cyanamid	2 - 15 den	1.67 - 1.72
Dow BASF	2 - 15 "	1.80
DuPont	2 - 10 "	1.67 - 1.72

Modacrylics

Eastman Verel	2 - 40 den	1.65 - 1.76
UCC Dynel	3 - 24 "	1.65 - 1.87

11 C) Textile fibre production trend in the USA 1970 - 1980 in thousands of tons per year:

	cotton	rayon	PA	PE	PAC	PP
1970	2200	400	620	470	230	95
1975	2400	660	910	800	335	200
1980	2600	770	1180	1260	500	360

Source: Modern Textiles (January 1972)

11 D) Actual requirements for synthetic fibre production:

The manufacturing costs presented in chapter 8 are valid for the local conditions under which the plants work in the USA. In order to permit the user of this report to get an estimate of the manufacturing costs under different conditions a table is added here, which gives the actual requirements of a plant. These requirements are given in quantities (not in costs) of raw material, utilities and labor and can be readily computed for any special local condition.

11 D a) Actual requirements of a 5 000 tons per year PE staple fibre plant:

	yearly demand
raw materials:	
Dimethylterephtalate	5 5000 tons
Ethylene glycol	1 000 "
Utilities:	
Electricity	4.5 million kWh
Steam	25 000 tons
Labor:	
Men in shift	40
Men per day	5

11 D b) Actual requirements of a 5 000 tons a year 6-nylon plant which produces filaments in the denier range between 40 and 50.

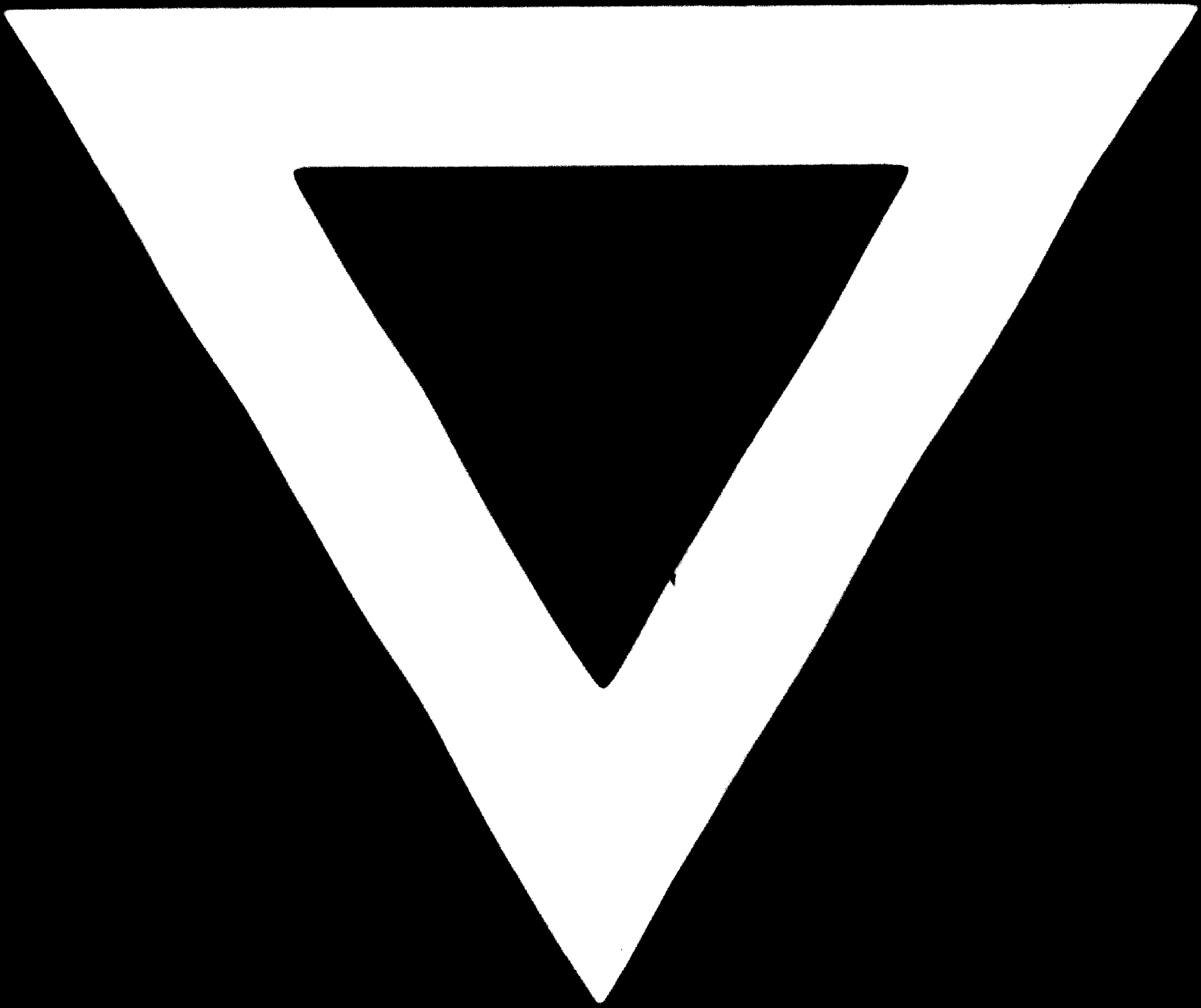
	yearly demand
Raw material: caprolactam	5 500 tons
Utilities:	
Electricity (110 Volt AC)	35 million kW hrs
Steam (4 atm)	15 000 tons
Cooling water (8°C)	18 million cbm
Demineralised water	20 " "
Nitrogen (99.98%)	500 000 cbm

	yearly demand
Labor:	
Men in shift	40
Men per day	5

11 D e) This table presents the actual requirements for a 20 000 tons per year PAC staple fibre plant.

	yearly demand
Raw material: acrylonitrile	20 400 tons
Utilities:	
Electricity	37 million kW hrs
Steam	400 000 tons
Cooling water	17.5 million cbm
Demineralised water	650 000 cbm
Compressed air (3 atm)	900 000 cbm
Labor:	
Men in shift	75
Men per day	20

G-585



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