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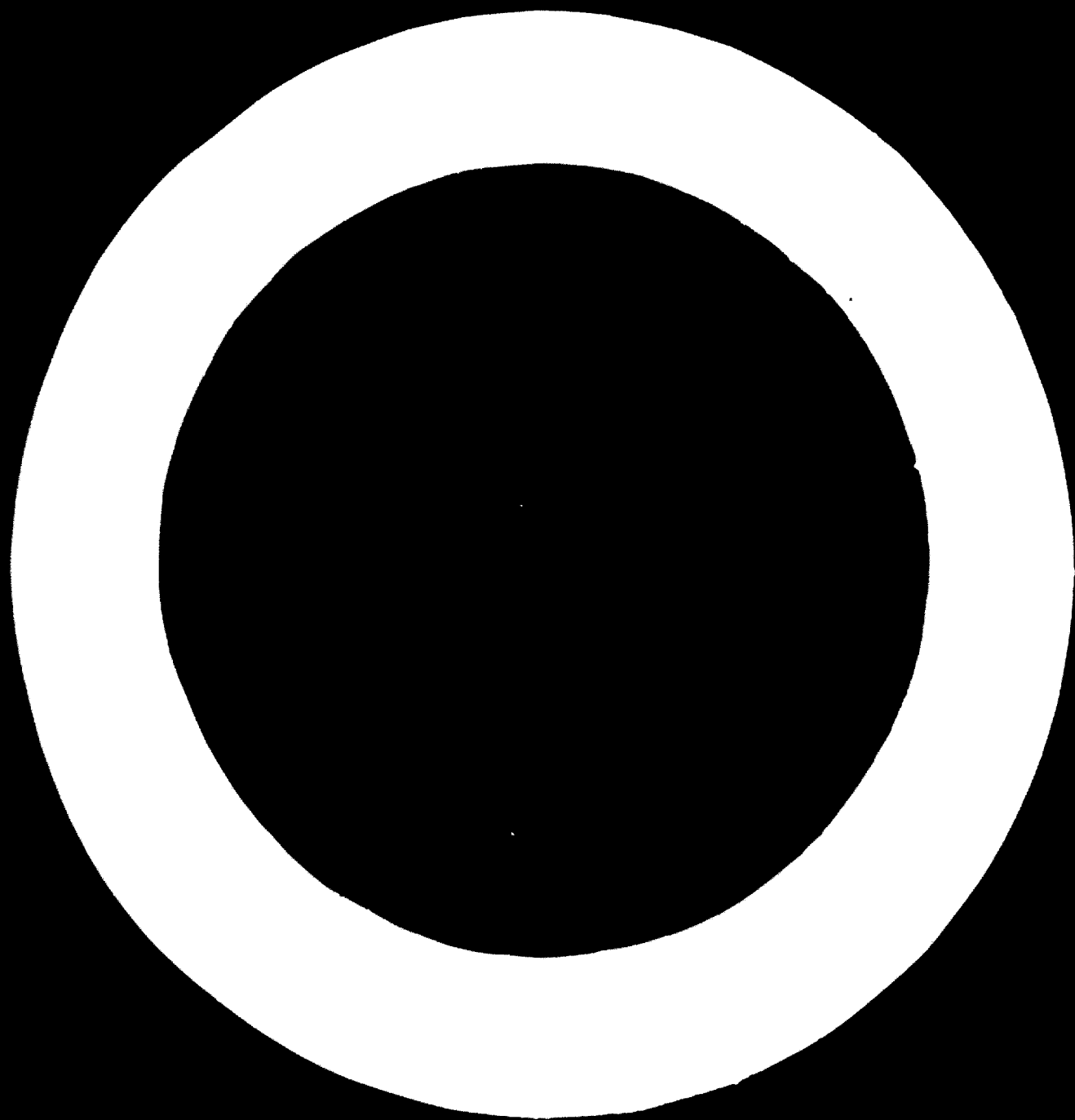
CASE STUDY OF THE MANUFACTURE OF GEARBOXES WITH INTERCHANGE  
OF PARTS AND COMPONENTS BETWEEN BRAZIL AND ARGENTINA <sup>2/</sup>

presented by

ZF DO BRASIL S.A.

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- <sup>1/</sup> Organized jointly by the Economic Commission for Latin America (ECLA), the Inter-American Development Bank (IDB) and UNIDO.
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## Introduction

The present study was based on assumptions and conclusions stemming from research into the Brazilian and Argentine motor-vehicle market. The product selected and the assumptions regarding production volumes are based on real situations and in principle correspond to internal plans already implemented by the company.

Certain simplifications were made for purposes of the present study, which can be considered representative of a sector of industrial planning, although neither the product chosen nor the volumes used correspond to actual plans.

### I. Description of the market situation of the company

The parent company is located in Germany and owns or has shares in a number of large plants in Europe. It has a subsidiary in Brazil whose manufacturing programme comprises products suitable for the Brazilian market which are marketed freely and without restriction from the manufacturing programme of the parent company. The present study is based exclusively on the situation of the Brazilian subsidiary.

In Argentina, the company has made available a number of licences for products being manufactured by companies in Argentina. To date, the licensing company has not made any capital contribution. Some thought is being given to setting up a subsidiary company in Argentina, and one of the factors being considered with respect to the establishment of a production line is the possibility of having complementary manufacturing arrangements with the Brazilian subsidiary (the subject of the present study).

The present company's general manufacturing programme includes the following items.

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✓ The roman numerals heading each section follow the numbering given in "Objetivos y contenidos relativos a la definición de una serie de estudios de caso sobre las economías de escala en la fabricación de vehículos motorizados y sus partes y piezas", provided by the Industrial Development Division of ECLA for use in the preparation of the case studies.

1. Standard gearbox, synchronized and hydramatic gearboxes with coupled transmissions (auxiliary)
2. Fluid-drive gearboxes
3. Gearboxes for earth-moving equipment
4. Foettinger torque converters
5. Axles
6. "Lok-o-matic" differentials
7. Transmissions for tractors
8. Transmissions for harvesters and other self-propelled agricultural machinery
9. Reduplan transmissions
10. Mechanical steering gear
11. Hydraulic steering gear
12. Hydrostatic steering gear
13. Hydraulic pumps
14. Marine reversing gearboxes
15. Transmissions for aeronautical uses
16. Electromagnetic clutches, hydraulic disc clutches, pneumatic clutches and mechanical clutches
17. Transmissions for machines operating with electromagnetic clutches

The Brazilian subsidiary manufactures the following products on the list:

1. Standard gearboxes, synchronized with coupled transmission (auxiliary)
2. Hydraulic steering gear.
3. Hydraulic pumps for hydraulic steering gear
4. Marine reversing gearboxes

Within the motor-vehicle industry, the company's products are used in the following applications:

/(a) Gearboxes

- (a) Gearboxes for passenger cars, lorries, buses, agricultural machinery, earth-moving machines, excavators and hoists, and special vehicles
- (b) Auxiliary transmissions for various purposes
- (c) Drive shafts
- (d) Steering gears and steering systems
- (e) Engines
- (f) Differentials and clutches (torque convertors)

## II. The product

The product selected for the study was a gearbox with the following specifications:

Four-speed gearbox (see section III)

Weight of the standard version: 26.5 kg.

Maximum entry torque: 18 mkp

Gearshift lever, either direct-action or mounted on the steering column

All parts of the casing are made of aluminium. The gearbox may be expanded to five gears using virtually all the parts of a three-speed gearbox produced on the same production line.

The standard version gearbox is a four-speed gearbox with direct gearshift. By eliminating some parts, the same gearbox can be used with a column-mounted gearshift. It can be used in various types of vehicles by modifying the coupling system (more details on this are given in section III). The gearbox is applicable to medium-size passenger cars, where it would account for about 5 per cent of the total cost of the vehicle (e.g. Opala in Brasil and the Peugeot 404 and Torino in Argentina).

## III

1. The standard gearbox can be adapted to various uses by adding parts or changing components. This yields a high degree of standardization but, nevertheless, a wide variety of possible modifications. The gearbox forms part of a single line of production in which complete components can be used in three-speed and five-speed gearboxes of the same line, both with a wide range of possible modifications. The gearbox can therefore be adapted to a great many different applications. The cost of adapting the gearbox is low and was not taken into account in the present study.

/2. The

2. The gearbox comprises approximately 140 parts which can be divided into groups or sub-groups in terms of their function, for purposes of purchase and manufacture. They can also be classified by the type of material of which the parts are made, as follows:

Type of material

- 0 = Castings
- 1 = Forged parts
- 2 = Steel parts
- 3 = Semi-manufactured parts
- 4 = Manufactured parts
- 5 = Standardised (DIN) parts
- 9 = Imported parts

The parts in the gearbox can then be classified by type of material, as follows (see annex 2):

- Type 0 = 8 parts
- " 1 = 21 parts
- " 2 = 9 parts
- " 3 = 7 parts
- " 4 = 112 parts
- " 5 = 131 parts
- " 9 = 8 parts

The company itself is responsible only for the manufacture or machining of parts coming under types 0 to 3. All the other parts are purchased from outside suppliers.

The reason why the total quantity of parts is considerably higher than the figure given earlier (section III, 2) is that more than one of the same part may be used in a gearbox.

3. The gearbox components purchased from outside suppliers are also standardised on a large scale. The same parts are also usually used in other production lines within the company's manufacturing programme. Standards and specifications exist for parts manufactured or machined by the company and parts purchased from outside suppliers.

/IV. With



IV

With regard to production in the plants covered in the present study, components made of materials types 0 to 3, plus assembly, were considered. The following machining operations are required for the manufacture of these components:

1. Turning

- 1.1 Machining on automatic lathes
- 1.2 Machining on turret lathes
- 1.3 Machining on copying lathes
- 1.4 Machining on engine lathes

2. Gear milling

3. Gear cutting

4. Angle worm-gear cutting (Gleason-Klingelnberg system)

5. Drilling

- 5.1 Bench drilling
- 5.2 Multiple-spindle drilling
- 5.3 Special-purpose drilling
- 5.4 Multi-station drilling

6. Milling

- 6.1 Horizontal milling
- 6.2 Vertical milling
- 6.3 Groove milling

7. Rounding of edges

8. Gear shaving

9. Heat treatment

- 9.1 Annealing
- 9.2 Surface hardening
- 9.3 Surface hardening in circular oven, in chamber oven in oil or in salt bath
- 9.4 Nitriding
- 9.5 High frequency induction quenching

10. Internal grinding

11. External grinding

12. Groove grinding

/13. Flat

13. Flat grinding
14. Teeth grinding by Haag-Minerva-Reishauer system
15. Straightening
16. Angle worm-gear honing (Gleason-Klingelberg system)
17. Noise check on test bench

This means that the following machines are required:

1. Lathes
  - 1.1 Automatic
  - 1.2 Turret
  - 1.3 Copying
  - 1.4 Engine
2. Worm-gear milling machine
3. Teeth-cutting machine
4. Angle-worm gear milling machine
5. Drilling machines
6. Milling machines
7. Edge rounders
8. Gear shaving machine
9. Heat treatment equipment:
  - Circular oven
  - Salt bath
  - Chamber oven
  - Induction machines
10. Internal grinder
11. External grinder
12. Groove grinder
13. Flat grinder
14. Teeth grinder
15. Straightening press
16. Honing machine
17. Test benches

The quantity of machinery and equipment required is discussed in section VI.

/In the

In the manufacture of the gearbox, the following amounts of raw materials and finished products are required:

	Percentage of total value of complete gearbox	Weight in kg	Percentage of total weight
Aluminium castings	15	6.5	25
Forged parts	40	13.0	49
Steel bars	4	2.5	9
Semi-manufactured parts	2	0.3	1
Manufactured parts	21	1.9	7
Standardized parts (DIN)	7	1.7	6
Imported parts	11	0.6	3
	<u>100</u>	<u>26.5</u>	<u>100</u>

V

The volume of production was established on the basis of monthly requirements of

3,000 units for Argentina  
2,000 units for Brazil

These quantities also represent the minimum amounts necessary to make manufacture of the gearbox economically justifiable. Depending on the market situation and competition, these figures may be adjusted upwards. Downward adjustments were left out of account since they would mean that manufacture would no longer be economically feasible.

In these assumptions regarding quantities, it is of no importance if the quantities given for a country are taken up by more than one customer, because no account was taken of the cost of adaptation to different applications (see section III).

The figure of 5,000 units for Brazil and Argentina relates to a standard version gearbox without modifications which will not require technical changes for five to eight years owing to its extremely modern design. It was therefore assumed that modifications would only be made if desired by the customer and that they could be left out of account because of their great variety (see section III).

/VI Since

VI

Since the present study is designed to show the saving that could be achieved by separating production, i.e. manufacturing the gearbox in parts in Brazil and Argentina, the cost of investment and manufacture was compared and studied with respect to the following alternatives:

- A 1. Independent manufacture of the gearbox in Argentina and Brazil (given the present trade situation, this is very necessary);
- A 2. Manufacture of 5,000 complete gearboxes in the Brazilian plant.
- B. Separate production of the 5,000 units in relation to the needs, considering where advantage could be taken of the cheapest sources of supply and the manufacturing possibilities of the two countries. If the parts were to be exchanged between the two countries, it was assumed as a basic principle that, for each of the countries, the amount of spare parts exported in the interchange would be equal to the amount imported. An important point to bear in mind when distributing production is the ideal level of investment.

Under both basic alternatives A and B, it was assumed that both countries are in a position to manufacture the gearbox (our company in Brazil, and in Argentina there are companies operating under licence of some other arrangement, with which we have established links), i.e., that in neither of the two alternatives would it be necessary to construct a complete plant, the cost analysis being based on expansion of existing manufacturing capacity.

It was assumed that only existing idle capacity would be used to manufacture the gearboxes, and no account was taken of the basic investment required to set up a plant. Consideration was given, however, to the total capacity required to carry out all the operations depending on the capacity needed for ancillary sectors such as grinding, machining, etc., and to the total investment needed to carry out additional administrative tasks, etc.

In brief, the manufacture of the products under study is based on existing plants in Brazil and Argentina whose production, we think, should be expanded equally in each country to attain the end sought without using any possible existing reserve capacity.

/Since in

Since in Brazil it is not possible to establish the cost of and conditions involved in setting up a plant in Argentina to manufacture 3,000 gearboxes and 5,000 sets of components (alternatives A.1 and B) independently, the study was carried out on the basis of the economic conditions in Brazil. This would seem to be a sufficient basis for evaluating the economic advantage of joint manufacture, since a reduction in costs - irrespective of the difference in economic conditions in the two countries - would be achieved by the combination of a greater volume of demand and production.

#### Alternative A 1

For a monthly output of 2,000 complete gearboxes in Brazil, taking account of the points mentioned in section VI regarding the expansion of the Brazilian plant and on the basis of current costs, the sale price of the complete gearbox in Brazil may be taken as index number 100.

According to the data (see annex 1), the investment required for plant expansion in order to manufacture at this rate would be approximately 18 million cruzeiros. Annex 1 shows how the investment would be used: 70 per cent would be needed for installing the production line and purchasing the necessary machines and equipment. The machines would be virtually all imported, and it was assumed that it would be exempt from customs duties. Some 3.8 million cruzeiros would be required for the ancillary sections, while the remainder would be used for expanding buildings and installations.

The expansion of the Brazilian plant for the manufacture of 2,000 complete gearboxes would yield an additional capacity of approximately 16,400 machine-hours and 4,000 man-hours, plus the staff required for the ancillary sections and for administrative services.

The installations for the expansion of the Argentine plant for the separate manufacture of the remaining 3,000 gearboxes would require, as shown in annex 2, an estimated capital investment of some 24 million cruzeiros, based on conditions prevailing in Brazil.

The same cost factors can be taken into account in comparing monthly outputs of 2,000 and 3,000 units respectively, since there is no significant cost reduction in increasing output from 2,000 to 3,000 units, owing to the special features of gearbox manufacture.

/Additional monthly

Additional monthly capacity in the plant would be approximately 24,400 machine-hours and 6,800 man-hours, plus the staff required for the ancillary sections and administrative services.

#### Alternative B

To install two separate production lines, as under alternative A 1, in Brazil and Argentina, the capital investment required would thus be 18 million plus 24 million cruzeiros, or 42 million cruzeiros, without there being any particular scope for streamlining manufacture because of the small volume of production. If the monthly output of 5,000 gearboxes is divided between the plants (alternative B), each plant, depending on its lines of production could achieve considerable cost reductions; and the maximum investment required could be reduced to approximately 15.9 million cruzeiros for the Brazilian plant (see annex 3) and 22.5 million for the Argentine plant (see annex 4), or a total of 38.4 million cruzeiros - 3.6 million less than the figure given above. Under this alternative, the unit price index mentioned in section would be reduced by 10 per cent to 90.

However, there would be additional costs for transport by land between Sao Paulo and Buenos Aires amounting to 15 cruzeiros per set of components or gearbox. These would represent 1.5 per cent of the price of the gearbox, but the cost savings and possible economies from streamlining are more than 8 per cent under alternative B, compared with alternative A 1.

#### Alternative A 2

If trade and politico-economic relations in Latin America were such that it was possible to manufacture all the monthly requirements of 5,000 gearboxes in a single plant, and exports to the other country were duty-free and did not involve compensatory arrangements, this alternative should be preferred, for it would yield advantages, noted under alternative B, namely cost reductions owing to economies of scale.

The volume of investment would be higher than that given for alternatives A 1 and B, owing to the installation of highly automated installations, but there would be economies from streamlining in manufacture and administration which might result in a lower selling price.

The actual costs of this alternative were not studied since it is not feasible given the current market situation in Latin America.

VII + X + XII

The cost analysis was based on current Brazilian data, for want of information on the situation in Argentina. All the data given in the present section relate to alternative A 1 (see section VI), under which the Brazilian company would produce 2,000 gearboxes per month.

1. Cost of materials

The calculations made show the cost of materials purchased from outside suppliers to be approximately 30 per cent of the sale price. The share of the various types of materials in the total cost has already been shown (see section IV), with raw materials accounting for 60 per cent in relation to finished parts.

Prices for the most important raw materials used in the manufacture of a gearbox in Brazil are as follows:

Between 9 and 11 cruzeiros per kg. for cast aluminium (Alu Al Si Cu 3)

Between 4 and 6 cruzeiros per kg. for forged parts

Between 2 and 3 cruzeiros per kg. for steel bars.

These prices include 17 per cent Circulation of Goods Tax (ICM). Parts not yet manufactured domestically and hence imported account for 11 per cent of the materials used in manufacture.

2. Manufacturing costs

The cost of manufacturing the gearbox (excluding cost of materials, sales, administration, taxes and other items) represents 25 to 30 per cent of the sale price and can be broken down as follows:

(a) Staff costs

1. Wages for staff directly engaged in manufacture ..... 9%

2. Wages for staff engaged in ancillary sections and maintenance ..... 5%

3. Compulsory and voluntary social welfare costs ..... 14%

Total staff costs 28%

The compulsory social welfare costs included under item 3 amount to 75 per cent of the basic wage (without overtime) and comprise the following:

/Contribution to

Contribution to the National Institute of Social Welfare (INPS).....	8%	
Contribution to the National Industrial Apprenticeship Service (SENAI) .....	1.2%	
Contribution to the Industrial Social Welfare Service (SESI) .....	1.5%	
Contribution to National Institute for Agrarian Development (INDA) .....	0.4%	
Industrial accident insurance .....	1.4%	
Family allowances .....	4.3%	
Education allowances .....	1.4%	18.2%
<hr/>		
Sunday pay, including social welfare charges .....	18.0%	
Holiday pay, including social welfare charges .....	5.5%	
Vacation pay, including social welfare charges .....	9.0%	
Justified absences, including social welfare charges .....	1.0%	
Work-associated illness and accidents, including social welfare charges .....	2.0%	
Notice, including social welfare charges .....	1.2%	36.7%
<hr/>		
Legal thirteenth month's wage, including social welfare charges .	10.6%	
Length of service guarantee fund (FGTS) .....	9.0%	19.6%
Over-all total .....		(74.5%)

The company also pays other voluntary social welfare costs, such as:  
 Medical care and hospitalization

Restaurant

Official transport

Special clothing, etc.

which represent 25 per cent of wages and salaries. Total social welfare charges represent 100 per cent of wages and salaries.

(b) Expenditure on energy

The Brazilian plant's expenditure on energy averages 0.08 cruzeiros per kilowatt. The share of energy costs in total manufacturing costs is about 3.5 per cent, or approximately 135 kilowatts per unit.

/(c) Another



(c) Another important component of manufacturing costs is the cost of machining tools and equipment, including maintenance, which accounts for close to 16 per cent of total manufacturing costs.

In addition, the cost of the special tools and equipment required to start production amounts to 883,000 cruzeiros, as follows:

Moulds for aluminium casting	350,000 cruzeiros
Moulds for forged parts	75,000 cruzeiros
Dies for stamped parts	85,000 cruzeiros
Equipment	235,000 cruzeiros
Special tools for machining and assembly	138,000 cruzeiros

(d) Manufacturing costs also include expenditure for the maintenance of machining equipment, including the necessary installations, which represents about 8 per cent of the total.

(e) Machinery is amortized over a period of 8 - 10 years and represents 16 per cent of manufacturing costs.

(f) Because of the high standards required in the manufacture of a gearbox, and the many complicated operations involved in gear-making, a great deal must be spent on quality control, representing approximately 10 per cent of total manufacturing costs.

(g) The other components of manufacturing costs include expenditure on complementary materials, plant maintenance, and technical administration such as industrial engineering (design and engineering of tools and equipment) production and planning.

### 3. General sales costs

Based on experience in recent years, the cost of marketing, including technical assistance, represents 15 to 20 per cent of the sale price. Since gearboxes are delivered directly to the motor-vehicle manufacturer, there is no need for a distribution network.

### 4. Sales tax

The sales tax includes the 17 per cent Circulation of Goods Tax (ICM).

XI

The amount of working capital required for the manufacture of 2,000 complete gearboxes in the Brazilian plant is approximately 7.1 million cruzeiros, which covers immediately related needs such as purchases of raw materials and other materials, production time-lags and the financing of sales.

XIII

Transport costs were considered under alternative B in section VI. There are no storage costs, as indicated above under general sales costs. Assembly schedules and delivery dates are fixed a long time in advance. This does not exclude, for purposes of guaranteeing delivery, the maintenance in stock of a certain number of complete gearboxes. However, these costs are covered in the cost analysis above.

Prices on the international market were not studied, since this would require much more comprehensive research.

Annex 1

	<u>2,000 gearboxes</u>	<u>Cruzeiros</u>
I. <u>Machinery for production - Total</u>		12 920 400
II. <u>Machinery for ancillary sections</u>		
Tools		2 240 000
Tool grinding		1 260 000
Maintenance		280 000
III. <u>Investment in buildings and facilities</u>		
	<u>Square metres</u>	
Production	1 360	
Heat treatment	210	
Tools	240	
Tool grinding	140	
Maintenance	200	
Storage of raw materials	90	
Storage of parts for assembly	100	
Assembly and control	150	
Office space	70	
	2 560	966 000
Installations		<u>420 000</u>
	<b>Total investment</b>	<b>18 068 400</b>

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/Annex 2

Annex 2

	<u>1,000 gearboxes</u>	<u>Cruzzing</u>
<b>I. Machinery for production - Total</b>		17 102 400
<b>II. Machinery for ancillary sections</b>		
Tools		3 220 000
Tool grinding		1 820 000
Maintenance		280 000
<b>III. Investment in buildings and facilities</b>		
	<u>Square metres</u>	
Production	1 820	
Heat treatment	210	
Tools	320	
Tool grinding	180	
Maintenance	200	
Storage of raw materials	100	
Storage of parts for assembly	100	
Assembly and control	150	
Office space	80	
	3 160	1 120 000
Installations		<u>190 000</u>
<b>Total investment</b>		<b>24 032 400</b>

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/Annex 3

Annex 3

5,000 different parts

		<u>Cruzeiros</u>
I.	<u>Machinery for production - Total</u>	11 492 600
II.	<u>Machinery for ancillary sections</u>	
	Tools	1 988 000
	Tool grinding	1 149 400
	Maintenance	280 000
III.	<u>Investment in buildings and facilities</u>	
	<u>Square metres</u>	
	Production	1 220
	Heat treatment	210
	Tools	220
	Tool grinding	100
	Maintenance	100
	Storage of raw materials	100
	Storage of parts for assembly	100
	Assembly and control	150
	Office space	80
	2 280	792 000
	Installations	<u>210 000</u>
	Total investment	15 911 000

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/Annex 4

Annex 4

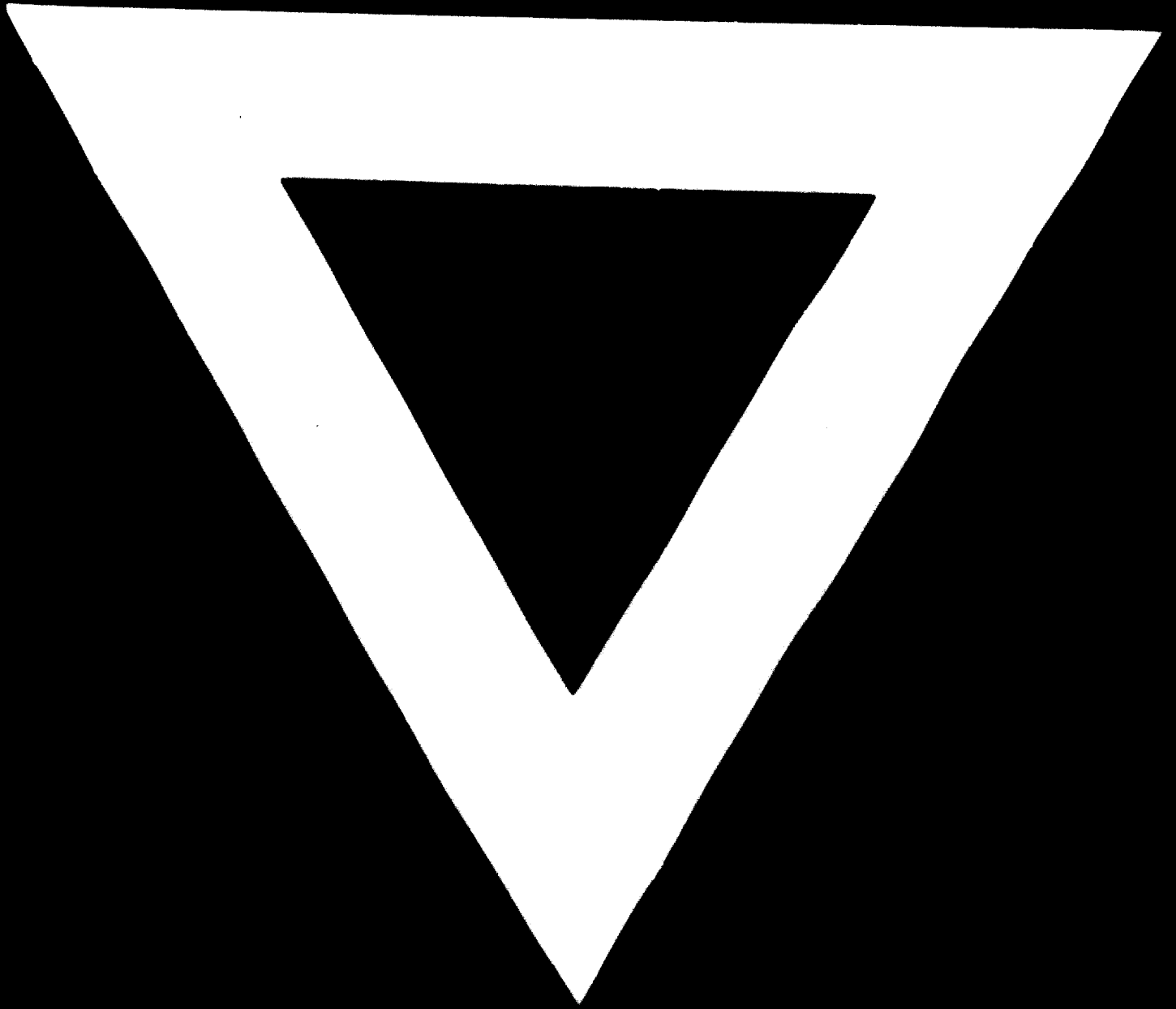
5,000 different parts

Cruzeiros

I.	<u>Machinery for production - Total</u>		16 175 600
II.	<u>Machinery for ancillary sections</u>		
	Tools		2 800 000
	Tool grinding		1 617 000
	Maintenance		280 000
III.	<u>Investment in buildings and facilities</u>		
		<u>Square metres</u>	
	Production	1 840	
	Heat treatment	210	
	Tools	320	
	Tool grinding	180	
	Maintenance	200	
	Storage of raw materials	100	
	Storage of parts for assembly	100	
	Assembly and control	150	
	Office space	80	
		3 180	1 120 000
	Installations		<u>190 000</u>
		<b>Total investment</b>	<b>22 482 600</b>

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