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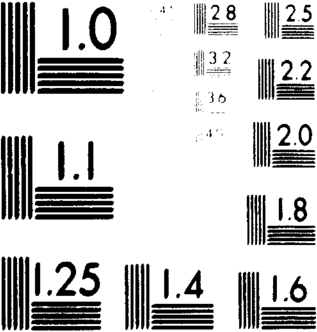
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(1 of 2)

FINAL REPORT

Zambia. FEASIBILITY STUDY ON PRODUCTION OF IRRIGATION EQUIPMENT

Project No. DP/Zam/78/008

VOLUME I

POLYTECHNA [illegible]

PRAGUE - CZECHOSLOVAKIA

June 1981

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I. EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Project background and history /Chapter II/

Project initiator:	The Government of Zambia, the Ministry of Agriculture
Project promoter:	not any
Market orientation:	domestic

Economic and industrial policies, supporting the project and project background:
The Third National Development Plan 1979 - 1983, giving a new industrialization strategy, the main features of which are:
- balanced development,
- generation of more and fuller employment,
- the diversification of the economic structure,
- the import substitution and export orientation.

Operation Food Production 1980 - 1990, the basic objectives of which are:
- to become the grainery of Africa and the world,
- to make agriculture the basis for industrialization,
- to increase employment and to spread incomes.

The Zambian government entrusted the Ministry of agriculture and water development with this project and, in the year 1979, requested UNIDO to elaborate a Feasibility study on the production of irrigation equipment. UNIDO Vienna invited Polytechna Praha, Czechoslovakia to elaborate this study. In October 1980 Polytechna's team of experts came to Zambia to collect all necessary data and elaborated this Study.

Market and plant capacity /Chapter III/

As the demand for irrigation equipment would not be even in 1990 sufficiently high as to make full use of the capacity of a viable plant engaged in this line of manufacture, there was taken into account the demand existing in the other sectors that is, in the industry, mines, dwelling houses etc.

Demand for hand-operated pumps	in 1980	2 360 pumps
	in 1990	4 880 pumps

The Ministry of Industry and Commerce decided that the manufacture of hand-operated pumps will not be included in the production programme of the new Irrigation Equipment Manufacturing Plant.

Demand for deep well pumps	in 1980	690 pumps
	in 1990	1 080 pumps

This quantity is not sufficiently high for economical production, therefore, it was not contemplated to introduce production in the new Irrigation Equipment Manufacturing Plant.

Demand for centrifugal pumps	in 1980	590 pumps
	in 1990	2 250 pumps

The Irrigation Equipment Manufacturing Plant is designed so as to enable the whole demand of the given pumping sets including pipeline, fittings etc., in the year 1990 to be met by the above given Plant in one shift operation.

Production Programme and Plant Capacity

Item		Annual production pieces	tones
1.	Pumping units	2 250	657,1
2.1	Flanged suction pipe x/	9 000	168,6
2.2	Flanged elbow 90° x/	2 250	25,9
2.3	Suction strainer with flange	2 250	17,1
3.1	Closing valve	1 310	17,6
3.2	Flanged connecting	1 310	8,5
3.3	Irrigation suction pipes	242 950	2 120,3
3.4	Valve with branch pipe	14 970	201,6
3.5	End piece	6 805	14,3
3.6	Pipe connection	4 180	12,5
3.7	Redneer	1 055	5,4
3.8	Irrigation gate valve with branch	3 345	73,6
3.9	Y-piece for branch pipes	1 410	11,1
3.10	Connection piece	705	11,4
3.11	Sprinkler closing element	5 630	56,3
3.12	Lengthening pipe with trifod for sprinkler	37 030	220,2
3.13	Sprinklers	37 030	55,4
		373 480	3 676,9

x/ Cooperation in existing plants in Zambia.

Materials and Inputs /Chapter IV/

For the full capacity of the Plant, the following materials and inputs are required:

Steel profiles, sheets and pipes	1 112,8	tones
Grey iron castings	634,8	"
Aluminium and copper-alloy castings	41,4	"

Pipes-aluminium alloys	1 217,0 tones
Copper alloys, metallurgical zinc	105,4 "
Combustibles-paints, thinning agents, greases	44,6 "
Components made of rubber, plastics and leather	55,0 "
Connecting materials /bolts, nuts, washers/ and springs	59,6 "
Welding electrodes and wires	4,5 "
Fittings, pressure gauges	2,1 "
Electric motors and electric instruments	434,7 "
Auxiliary materials	16,0 "
Spare parts, tools etc.	15,0 "
T o t a l	3 742,9 tones

Utilities

Electricity /max. demand 660 kVA/	840 000 kWh
Water	5 625 m3
Acetylene, oxygen	1 500 m3

The majority of these materials and inputs is imported /69,2 % of tonnage, 84 % of costs/. It is presupposed that many items will be produced in Zambia in the near future.

Location and site /Chapter V/

The Zambian authorities have not yet decided either the site, or the location of the Irrigation equipment manufacturing plant.
Polytechna's team of experts recommend to locate the site of the Plant in the belt around the railway line and highway from Livingstone to Lusaka, Ndola and Kitwe, preferably in Lusaka or the Copper Belt Province.

Project engineering /Chapter VI/

The selection of equipment should follow the determination of design of products and technology as these two are closely linked.

The main diferences of design and technology in the production of irrigation equipment are in the production of irrigation suction pipes. In Zambia at present are mostly used aluminium pipes with aluminium couplings. This Feasibility study envisages the production of aluminium pipes with couplings made of steel sheets. This system is used mostly in Central Europe and is substantially cheaper.

The best form of technology acquisition is technology licencing and the transfer of related know-how on mutually-agreed upon terms. Documentation should be elaborated in the metric system. Project documentation /project charts and layouts/ should be elaborated in two stages:

1. Detailed project report
2. Working drawings

Selected machines are of universal nature, i. e. operation is simple and also maintenance is less complicated. Universal machine tools could be employed for production of other items, if necessary.

Estimate of investment cost of equipment is 7 910 000 Kwacha incl. energetical centres, furniture, cars and trucks and first set of common utility tools and special tools.

Civil engineering works -

Area /acreage/

Land	37 000 m2
built-up area	6 000 m2
communications, side-walks, compacted area	6 000 m2
greenery	25 000 m2

At the site there are 14 buildings mostly of light design, production buildings without cranes, some of them without side walls.

Plan organization and overhead costs /Chapter VII/

This chapter gives the summary of shops and sections in the Plant, their location in different buildings.

Organization chart gives all departments, sections and shops, their organizational link-up with the number of staff and labour.

Shops of main production:

Material preparation section, pressing shop, machining shop, mounting of joints, heat treatment and forge shop, hot galvanizing shop, assembly shop and testing room, paint shop.

Auxiliary shops:
tool room and maintenance shop, tool grindery, mechanical handling, energy centres.

A part of the commercial department is an irrigation systems designing office - a very important section not only for the Plant itself, but also for the whole Zambian economy. It will design new irrigation systems for Zambian farms.

Manpower /Chapter VIII/

The labour inputs for the Plant is based on the following working regime:

Number of working hours per day in one shift	9
Number of shifts per day	1
Number of working days per week	5
Number of working hours per week	45
Effective working days per year	224

Workers

Total number of workers	190
from this - general workers	30
- grade I and II /trained/	70
- grade III and IV /qualified/	90

Supervisory and managerial staff -	
total number	69
out of this: engineers and technicians	49
administrative staff	20

Ratio: total manpower : staff	3,75 : 1
workers : staff	2,75 : 1

Both ratios are high due the fact that the organization chart of the Plant is elaborated to suit the second stage of construction of the Plant after 1990 and that the Plant has its own designing department of irrigation systems.

It is presupposed that in the first period of start-up 5 - 6 foreign experts will be employed in the Plant.

Implementation scheduling /Chapter IX/

The attached time schedule stipulates 2 years and 6 months for construction period and 4 years and 6 months for start-up period. In the 8th year i. e. after 5,5 years of production the Plant will reach full capacity.

Financial and economic evaluation /Chapter X/

Total investment costs:

Land and site preparation	110 000 K
Civil engineering works	1 860 000 K
Technology cost-lump-sum	120 000 K
Plant machinery and equipment	7 110 000 K
Pre-production capital costs	1 630 000 K
Working capital /total/	4 285 000 K
To t a l	15 115 000 K

/see tables 10 - 1/2, 10 - 2/1 and 10 - 6/2/.

Project financing /assumed/

Equity capital	7 000 000 K
Collaborators'deferred credits	4 500 000 K
Loans	3 620 000 K
Current liabilities	1 150 000 K
T o t a l	16 270 000 K
From this - foreign currency	9 230 000 K
- local currency	7 040 000 K

/see table 10 - 8/2/

The maximum of loans, collaborators' deferred credits and current liabilities will be at the end of the third year - 5375 000 K, i. e. 76,8 % of equity capital.

Total production costs /at full capacity/

Factory costs	15 060 000 K
Operating costs	17 560 000 K

Total production costs 18 670 000 K.

/see tables 10 - 31, 10 - 11, 10 - 12/.

Ratios at full capacity /table 10 - 9/

gross profit: sales %	31,8 %
net profit: sales %	20,2 %
net profit: equity %	79,0 %

Financial evaluation

Net present value /NPV/

The discount rate of this Project is 15 %, the discounting period is 15 years /equal to the life of the Project/

NPV of the project	+11 030 000 K
NPV of the equity capital	5 060 000 K
Present value of the investment /PVI/	5 700 000 K

Net present value ratio /NPVR/

$$NPVR = \frac{NPV}{PVI} = 1,935$$

Total investment costs will be recovered in 6 years and 3,4 months including the construction period or 3 years and 9,4 months of start-up production. The pay-back period is short, which is very advantageous.

Simple rate of return

Simple rate of return on total investment costs - R in the 9th year

$$R = 29,5 \%$$

Simple rate of return on equity capital Re in the 9th year $Re = 63,8 \%$

Both rates are very good.

Break-even analysis

Break-even point /BEP/ would be reached at a capacity utilization of 36,4 %.
BEP is low - this is very good for the plant and its viability under conditions of inadequate market.

All results of different methods of financial evaluation given above prove that the Irrigation equipment manufacturing plant will be viable and will be excellent from the financial point of view.

National economic evaluation

Project exchange rate at full capacity	45,8 %.
Savings of foreign currency at full capacity	14 840 000 k/year

Both indicators are very good.

CONCLUSIONS

Major advantages of the project

1. Improvement of agriculture:
   The Irrigation equipment manufacturing plant is of vital importance for the improvement of the situation in agriculture in Zambia. Products of this Plant will help substantially rise the production of agricultural products, first of all those that need irrigation.

2. Reduction of imports of irrigation equipment:
   Once full capacity is reached, the Plant will reduce the import of complete irrigation equipment to minimum /only the biggest units, deep well pumps and submerged pumps will be imported/. Some raw materials and subdeliveries will be imported, but it is expected that some raw materials and subdeliveries will be produced in Zambia in the future /see Chapter IV/.

3. Project exchange rate and savings of foreign currency:

Project exchange rate at full capacity	45,8 %
Savings of foreign currency at full capacity	14 840 000 K/year

   Both indicators are very good.

4. Employment of local manpower:
   The Plant will provide employment for 190 workers and 69 technicians and administrative staff.

5. Corporate tax:
   Corporate tax, paid in the first ten years /7.5 years of production/ represents 16 925 000 K and 32 000 000 K in the next ten years.

6. Reduction of retail prices:
   The Plant will reduce retail prices by 10 p. c. on average.

7. Versatility of the Plant:
   Selected machines are of universal nature, i. e. they could be employed for production of other items, if necessary /for example hand operated pumps, special centrifugal pumps etc./.

8. From the financial point of view the Plant is very good not only in presupposed conditions, but also under conditions of inadequate market.

Drawbacks

There are no drawbacks of this project.

Chances of implementing the project

It is presupposed that this project will be implemented very soon.

II. PROJECT BACKGROUND AND HISTORY

PROJECT BACKGROUND ANL HISTORY

Project Background

Project Idea

The new Plant for production of irrigation equipment should create employment opportunities, income possibilities and considerably diminish the import of irrigation equipment from abroad.

The Government of Zambia has adopted, in connection with formulation of the Third National Development Plan 1979 - 1983, a new industrialization strategy, the main features of which are:

- balanced development having regard to linkages between industry agriculture and other sectors of the economy;
- generation of more and fuller employment, and, to that end, to adopt technology which is labour-intensive;
- the diversification of the economic structure in order to reduce the economy´s dependence on copper and to undertake an economic programme of promoting agriculture and industry based on use of local raw materials and the establishment of the necessary capital goods industries;
- the import substitution and export-orientation, by establishment of industries based on maximum use of local mineral raw materials.

Pumps and irrigation equipment project has been identified and is recommended for launching during the Third National Development Plan by private investors, co-operatives or parastatals on a small - or medium scale .

industry level in the category of Industries based on local mineral resources and for manufacturing capital and intermediate goods.

Strategy for the rural sector will aim at the following objectives:

- to increase agricultural production so as to achieve self-sufficiency in staple foods, and to provide raw materials for agro-industries;
- to stimulate and increase production for exports;
- to increase the contribution of rural sector to GDP and to promote diversification of the rural economy;
- to create new employment and income opportunities in the rural areas in order to counter rural urban migration.

The implementation of the strategy given in the Third National Development Plan /TNDP/ will call for /inter alia/

- development of irrigation resources as a major infrastructure and at an all year round production of particular crops.

The above mentioned strategy is elaborated in more details in "Operation Food Production 1980 - 1990". The document was worked out by His Excellency Dr K. Kaunda, President of Zambia and Zambian Government.

The basic objectives of "Operation Food Production" are:
- to become the grainery of Africa and of the world
- to make agriculture the basis for industrialization and industrialization the basis for agriculture
- to increase employment and to spread incomes as well as meaning full development to all people with special emphasis to the rural masses.

The "Operation Food Production" will involve the following institutions:

1. Large Scale Commercial State Farms. It is contemplated to establish in each Province two state farms to cover an average of 20.000 hectares each.

2. Rural reconstruction Co-operative Centres. The scale of production of these centres will increase to a minimum of 1.000 hectares.

3. The Zambia National Service Production Units - large scale commercial undertakings will reduce the esealating cost of food through increased supply of a wide range of agricultural products.

4. Producer Co-operatives.

5. Peasant and Family Farms - the sizes of their plots will the aid of the adequate equipment will be increased.

6. Private Commercial Farms.

Closely linked to this agricultural offensive is the question of establishing industries, such as production of electric motors, the iron and steel programme must go ahead in order to ensure the creation of machine tools sector, the manufacture /not the assembly/ of water pumps, small engines and tractors, mainly for agriculture.

The Major Project Parameters

The major project parameters that served as the guiding principles, are:

1. Irrigation equipment project should be on a small or medium scale industry level /see the TNDP/.

2. It should cover the demand of Zambia in irrigation equipment as much as possible.

3. Production mix should cover pumps not only for irrigation, but also for other purposes /dewatering, farms and dwelling houses, industry etc./, fittings, sprinklers etc., but only those sizes, which are most frequently used.

4. Plant capacity in one shift operation should suit the demand of the above mentioned products in the year 1990; after this year the second shift will be introduced.

5. Irrigation equipment project should cooperate as much as possible with existing, mostly underutilized factories, producing components and parts for irrigation equipment

6. Machinery and equipment, mainly machine tools at the Irrigation equipment manufacturing plant should be universal, to secure the versability of the production mix.

Orientation of the Project

Project is domestic market oriented; export orientation is not taken into consideration, as at present and in near future there are no conditions for successful export to neighbouring countries due to high prices of raw materials, subdeliveries and transport costs.

Part of raw materials and subdeliveries in the first stage of production will be imported. After the completion of Steel rolling mill from imported billets, Integrated steel mill for production of pig iron and steel semi-finished products and Electric motors manufacturing plant the majority of raw materials and subdeliveries will be supplied by local firms.

Project Initiator

The Government of Zambia, the ministry of agriculture.

Project Promoter

Not any.

Project History

For the first time the Irrigation equipment project was officially mentioned in the TNDP and then in the "Operation Food Production 1980 - 1990" - see above.

There were prepared neither oportunity studies, nor prefeasibility studies for the Irrigation equipment project in the past.

Related investigations:
Mission Report - Joint FAO/German/Dutch Consultarcy Mission on Irrigation Potential in Zambia /1979/
Preliminary Inventory of Irrigation Development in Zambia by C. A. Lewy /1979/.

The Zambian government entrusted with this task the Ministry of agriculture and water development and in the year 1979 requested UNIDO to elaborate Feasibility study on the production of irrigation equipment. UNIDO Vienna invited Polytechna Praha, Czechoslovakia to elaborate this study.

In October 1980 Polytechna's team of experts, namely, Mr. Jan Semsch M.Sc., team leader
Mr. Ivan Podešva, M.Sc., chief designing engineer of irrigation systems
Mr. Petr Špilík, M.Sc., chief designing engineer of mechanical engineering plants
came to Zambia to collect all necessary data.

The programme of visits etc. was organized by the Ministry of agriculture and water development, namely by Permanent secretary Mr. A. Hamaamba and liaison officer for the team, Mr. L. Aked, chief agriculture engineer.

The ministry of agriculture and water development has rendered all help to the team of experts and enabled them the visit of many farms, research centres, importers of irrigation equipment etc.

The ministry of industry, namely permanent secretary K.S.B. Nyirenda made possible the visit of many existing factories.

Polytechna and the experts wish to express their thanks to both ministries for all help rendered to the team during its stay in Zambia. Many thanks also belong to Mr. K. C. Sen Ph.D., senior industrial development field adviser and staff of UNDP in Lusaka, Zambia.

Table 2 - 1

ESTIMATE OF INVESTMENT COST

Pre-investment studies and preparatory investigations

Source : Team's estimates

No	Item description	Quantity	Unit	Unit cost	Cost Foreign	Cost Local	Cost Total
1	Pre-investment studies						
	Opportunity studies				-	-	-
	Pre-feasibility studies				-	-	-
	Feasibility study				-	-	-
	Partial studies				-	-	-
	Experts, consultant and engineering fees			K	-	2000	2000
2	Preparatory investigations						
	Land surveys - site survey and soil investigation			K	-	6000	6000
	Quantity surveys (quantification of building materials is part of DPR)				-	-	-
	Other investigations and test				-	-	-
	Others				-	-	-
	Total				-	8000	8000

III. MARKET AND PLANT CAPACITY

IRRIGATION EQUIPMENT

Definition of the Term

Irrigation equipment is a term with a relatively broad scope of interpretations. For the purpose of the present study this term has been defined as the technological part of an irrigation system.

Irrigation systems are divided into two principal parts:
- constructional part
- technological part

Thus, an irrigation system comprises the following elements:

1. Technological outfit of the structure envisaged for water intake, i. e. a gate structure, trash-racks, cleaning installation, admission pipeline to pump sump.

2. Technological outfit of pumping station - pumping set, i. e. pump with engine/motor and, where necessary, a gearbox, suction piping including shaped pieces and fittings /slide valve, swing--check valve, insert for assembly/; besides, electrical switchboard, instruments of automatic operation, regulation, measurement, low-voltage connection, pressure vessels /air chambers/ and compressors.

3. Irrigating section

3.1 underground network of pipelines, pipelines made of asbestos-cement, PVC, polyethylene, steel, cast iron, including fittings and adapting pipes

3.2 surface network of pipelines - pipelines made of steel, plastic materials, aluminium or asbestos--cement, open channels made of concrete or asbestos-cement, including baffle plates, syphons or similar elements.

4. Irrigating detail - portable pipeline, including adapting pipes and fittings, sprinklers. Portable pipeline usually made of aluminium,or lightweight steel pipeline.

5. Irrigation machines - of a simpler type with trailed hose, or else of a complex type with coiled-up hose.

6. As an indirect component of the technological part of irrigation equipment there also figures a high--voltage connection line with transformers and a switchgear station.

DEMAND AND MARKET STUDY

Data and Alternative Projection Methods

At present, Zambia is experiencing a time of financial difficulties.

The export figures of the principal export commodi..y - copper - continue to decline as a result of restriction of use of copper at the world markets.

Another cause of economic troubles is motivated by the situation in the country's agriculture. As a result of the drought that prevailed in the course of these last two years, the crops of the kinds of produce that are cultivated without irrigation and among which there also figures maize as staple food of both the humans and the animals, were extremely meager, and Zambia was thus obliged to spend considerable sums of money in order to import these kinds of agricultural produce.

These unfabourable phenomena also motivated negative development trends in the industry, and production declined as a result of shortage of imported raw materials and low sales figures.

All the basic indices that could be used in working out a market study by a time trend method or by a regression method are negative, i. e. they show a declining trend in recent years /see the tab. 3-16/ and, in view of this, they have been used in isolated instances only.

The project of demand for irrigation equipment is based on the end use method.

The government is well aware of the importance of agriculture and regards its development in the coming years as a problem of paramount importance /see Chapter II/; it is fully aware of the significance of introduction of irrigation systems to a far greater extent than this has been done up to the present.

The present-day state of the demand for irrigation equipment has been ascertained not only according to import statistics, but also through research conducted in the records of all imports of this kind of equipment and in those of most of its manufacturers. The starting data can thus be regarded as fairly reliable ones.

Less reliable is, on the other hand, the division of certain products, primarily that of pumping sets, among the different sectors.

Pumping sets are used not only in the agriculture for irrigation, but also in the industry, in mines, for supply of dwelling houses and other buildings with water. The division into individual sectors was extremely difficult, and even with all the endeavour displayed by all partners involved in the problem, there might have been some inaccuracies that found their way into the picture presented. As the increase of demand for irrigation equipment is substantially faster here than in the other sectors, such an error cannot materially influence the ultimate demand in the 1990 year.

As the demand for irrigation equipment would not even in 1990 be sufficiently high as to fully tax the capacity of a viable plant engaged in this line of manufacture, there was taken into account the demand existing also in the other sectors, that is, in the industry, in mines, in supply of apartment houses with water etc.

In the project of demand of pumping sets for other sectors there was adopted, until the 1983 year /the end of the TNDP/ the end-use method, and, from that year onwards, for

the mining industry - the time trend
the industry - the time trend
supply of apartment houses with water - the regression method.

The state of manufacture of irrigation equipment in Zambia is a relatively non-uniform one. In certain lines there exist capacities that not even in the 1990 year will be utilized to the full /manufacture of pipes/, whereas in some other sectors the production is far from satisfactory as regards both the quantity; in other sectors the production is entirely non-existent /such as in the line of centrifugal pumps etc./. Thus there had been reviewed the demand for the different basic installations according to their types and arrangements and from these there was selected a suitable production programme for the Irrigation Equipment Manufacturing Plant. The remaining elements, which only serve to supplement the technological equipment of an irrigation system and are envisaged to be provided under a cooperation programme from other factories in Zambia or abroad, are only defined in figures and will serve as a basic for elaboration of more studies /such as a study of the Electric Motor Manufacturing Works, a Transformer Factory etc./.

1. TECHNOLOGICAL OUTFIT OF WATER INTAKE STRUCTURE

As has been stated above, this comprises an admission pipeline to the pumping sump, thrash-racks, regulator structures, cleaning installations and the like. The admission pipeline to pumping sump can be made of various materials, such as reinforced concrete, steel, cast iron. Most of these pipelines are being already manufactured in Zambia; the quality is excellent and the capacity of the manufacturing establishments will not be taxed to the full even in the 1990 year /see Appendix B on manufacturing firms/.

The trashracks for small irrigation equipment are made for the most part of wood by the farmers themselves.

Large trashracks and regulator structures are only seldom needed in the irrigation systems in Zambia, for the most part only in multi-purpose projects where a combined power engineering and irrigation system is contemplate. Notwithstanding, it is possible to manufacture certain parts of these installations in the new Irrigation Equipment Manufacturing Plant.

The cleaning equipment, such as suction strainers etc., is included in the production programme of the Irrigation Equipment Manufacturing Plant.

2. TECHNOLOGICAL OUTFIT OF PUMPING STATION

The most important part of the technological outfit of a pumping station is a pumping set. This is a pump with an engine and possibly also with a gearbox.

The selection of pumps for irrigation is influenced by a number of factors, first of all by

a/ the amount of the liquid in l or in m3 pumped per unit of time /second, minute, hour/

b/ the total delivery head /suction and impulsion/

c/ the kind of drive - such as electric motors, Diesel engines, gasoline combustion engines, hydraulic motors, drive by hand etc./

d/ the set arrangement /in a dry sump, submerged in the liquid etc./.

According to overall /total/ head irrigating pumps are divided into:

- low-pressure pumps - commonly used for delivery of a large amount to a low head, such as pumping wheels, water elevators /paternosters/, screw pumps /hydraulic screws/ and horizontal, vertical and diagonal propeller pumps,

- high-pressure pumps - are used for medium and high heads to which small, medium and large amounts of a liquid are conveyed. These are primarily centrifugal, radial and diagonal pumps of horizontal or vertical arrangement, with one or various stages /articulated type/.

Other kinds of pumps are hand- or power-operated piston pumps, the same as vertical submersible pumps for drilled wells.

Pumping Wheels, Water Elevators /Paternosters/

Pumping wheels and water elevators /paternosters/ are simple pumps for conveyance of medium-sized amounts of water to a low head. They are used in particular in surface-type irrigation systems for pumping water from a river or from a basin /lake, pond/ into the trunk canal of an irrigating set.

Various kinds of drives are used - from manual drive through drive by animals up to water wheels, drives by wind /by propellers etc./, or else by a Diesel engine, a gasoline engine or an electric motor. Their efficiency is a low one, but they are cheap and can be made of locally available raw materials /such as wood/ by local craftsmen. They are frequently used in developing countries.

Although the team visited a large number of farms, these wheels were never found in operation and it is not assumed either that this kind of pumps will ever become an object of interest in Zambia in the future.

Screw-Type Pumps /Hydraulic Screws/

Screw or worm pumps are used in surface-type irrigation systems for conveyance of large amounts of water from surface water sources to a low head /conveyance from a river to the trunk canal etc./.

As this type of surface irrigation is used in Zambia only in isolated instances /Nakambala Sugar Estate/, and no substantial increase of its use is reckoned with for the future, the manufacture of screw pumps in the new Irrigation Equipment Manufacturing Plant is not contemplated /also see Appendix A to Chapters VI and IX/.

Propeller Pumps

Horizontal, vertical and diagonal propeller pumps are used in surface-type irrigation systems for conveyance of the largest amounts of water from surface water sources to a low head.

All that has been said about screw pumps applies also to this type.

Hand-Operated Piston Pumps

Piston pumps operated by hand can be used for irrigation in Zambia only to a limited extent. One pump can irrigate 0.4 + 0,5 ha as a maximum.

The advantages of these pumps consist in that they are cheap and do not require the supply of electric power or any fuels.

The demand for hand-operated pumps will thus be confined to larger gardening establishments and to the smallest farms that are irrigated in part only, and this in the areas where electric power distribution system has not been installed yet.

Utilization of hand-operated pumps on a larger scale in Zambia is envisaged for other applications, particularly for water supply to villages or to individual apartment houses, for supply of drinking water to cattle etc.

Hand-operated pumps are already being manufactured in Zambia. The Irrigation Pumps Co. currently makes simple hand-operated pumps; in 1980 it made 300 pumps of this type annually; other firms manufacture or fit in pumps of their manufacture occasionally. It is estimated that in the 1980 year some 300 pumps were made in this way.

By visiting individual importers the members of the team found out that hand-operated pumps are imported primarily by Prago Ltd., Robert Hudson /Zambia/ and by E. W. Tarry.

Demand for hand-operated pumps

Year	1978	1980
Manufacture and fitting-in		600 pumps
Imports	1800 pumps	1560 pumps
Demand that has not been met	80 pumps	200 pumps
T o t a l	1880 pumps	2360 pumps

Within a period of 3 years the annual increase of the demand amounts to 7,8 %.

According to individual importers' estimate, they could sell in the year 1980 about 200 additional hand-operated pumps.

Based on the Second and Third Five-Year Plan in respect of water supply to villages /see the table B-21 A/ and based on the number of newly constructed houses /particularly of those of higher categories/ /see tables 3-25, 3-26 A, B/, an estimate was worked out of the demand for hand--operated pumps for the 1990 year by means of the time trend method, combined with the regression method.

On the basis of these calculations, the following result was obtained:

Total demand for hand-operated pumps in the 1990 year - 4 880 pieces.

Within a period of 10 years, the annual increase of the demand amounts to 7,5 %.

At the meeting held at the Ministry of Industry and Commerce on Nov. 26, 1980 it was decided that the manufacture of hand-operated pumps will not be included in the production programme of the new Irrigation Equipment Manufacturing Plant, but it is envidaged to be reserved for the sector of small--scale industry.

It is recommended to build, in the line of the small-scale industry, a new factory with a capacity of some 4000 pumps of the hand-operated type turned out in one working shift a day within one year.

In the case new factory for production of hand--operated pumps would not be constructed within the framework of the small-scale industry, the team of experts recommends to include the production of hand-operated pumps, capacity 4000 pieces/year into production programme of Irrigation Equipment Manufacturing Plant. Additional investment costs will be low /special tools, few machine tools, one additional production building/ and also production costs would be reduced to minimum.

Deep Well Pumps and Submerged Pumps

In Zambia, ground water sources are often situated at considerable depths - see the Appendix A to Chapter V - 2 - Underground Water Resources.

In the instances where water sources situated at great depths are to be utilized, it is necessary to use deep well pumps, that is, either the pumps envisaged to be installed in a dry compartment - pumps for drilled wells - or else submerged pumps.

Where the first-named pumps are dealt with, the pump itself is submerged in water on a long shaft, with the drive arranged usually by means of a Diesel engine situated at the $\pm$ 0 level. In the second instance, an electric motor is submerged along with the pump below the water surface. These latter pumps are used in the areas where an electric power distribution system is available.

Deep well pumps are only seldom used for irrigation in Zambia. What accounts for this is that pumping of water from great depths is expensive, particularly where Diesel engines are used for the purpose /the costs of fuels are 8 to 10 time higher than those of electric power drawn from a public service network/.

By visiting the importers, the members of the team found out that deep well pumps are imported primarily by Robert Hudson /Zambia/ Ltd., and also by Irrigation Pumps Ltd. and AFE Ltd. - small amounts of these are also imported by Amiran Ltd., Prago Ltd. and E. W. Tarry.

The imports of all deep well pumps in 1980 totalled 690 pumps; of these, some 280 pumps for drilled wells and 410 submerged pumps. Most of these pumps are envisaged for service in mines and for water supply to villages - /see table below/. The largest importer of deep well pumps, the R. Hudson Co., that imports more than one-half of the total of pumps imported, supplies these pumps practically only to the mining industry.

<u>Demand for Deep Well Pumps in 1980 according to Application</u>

Pumps for irrigation /new irrigation projects/	25
Replacements	5
Pumps for supply of water to apartment houses, villages and towns	240
Pumps for mines and industrial applications	420
T o ta l	690

The use of deep well pumps for irrigation in 1990 was assumed to feature a substantially lower annualy increase than that of centrifugal pumps used for irrigation where it amounts to 31 %, wheras the deep well pumps show an increase of only 16 %. This is in line with the general situation in Zambia in this respect - irrigation by means of deep well pumps is, as a matter of fact, substantially more expensive.

For the pumps used in supply of drinking water to dwelling houses, villages and towns it was reckoned with an increase of 5.5 per cent each year, that is, in keeping with the Second and the Third National Development Plan for supply of villages with water /see tables 3-21-A/ and on the basis of an increase of the number of houses, primarily of those of higher categories /see tables 3-25, 3-26-A, B/. For subsequent years calculation based on the time trend was used.

The estimate of demand for pumps envisaged for mining applications was made on the basis of an actual growth rate 2,1 % in the Second National Development

Plan 1972-1976 /SNDP/ in mining /calculation based on the table 3-23/; planned annual growth rate 2,5 % in the TNDP /1979-83/ - actual annual growth rate is substantially lower; and on the basis of a long-term estimation of an increase of mining exploitation up to year 2000, given in the TNDP, which was estimated at 3 %, but it seems to be over estimated. From these reasons the estimate of increase of mining activities up to the year 1990 was modified to 2 % annualy.

The demand for pumps envisaged for industrial applications was made on the basis of an actual annual growth rate 3,9 % in all sectors of industry in the SNDP /see tables 3-22, 3-23/ and the increase of industrial activities up to year 1990 was estimated to make 4 %.

For both sectors, i. e. mining and industry the annual increase of 2,5 % up to the year 1990 was adopted.

<u>Total Demand for Deep Well Pumps in the 1990 Year</u>

Pumps for irrigation - new ones	110 pumps
- replacements	25 pumps
Pumps for supply of drinking water to apartment houses, villages and towns - new ones and replacements	410 pumps
Pumps for mines and industry - new ones and replacements	535 pumps
T o t a l	1 080 pumps

The above quantity is not sufficiently high for economical production /in advanced European countries the minimum annual production is about 5000 pieces, in Zambia it will range from 2000 to 3000 pieces a year/; therefore, there was not contemplated an introduction of production in the new Irrigation Equipment Manufacturing Plant. Should there be required a larger number of one type of deep well vertical centrifugal pumps, it would then be possible to start partial production of these pumps, that is, to import some of the components, to manufacture the rest and to assemble the whole complex in the factory. Othe wise it will only be possible to manufacture these pumps in the second stage of construction of the factory, that is, after the 1990 year, provided the machinery has been conveniently supplemented by then.

Centrifugal Pumps

A detailed analysis of the demand for these pumps was undertaken in Appendix A, Chapter XII/1 of the present study.

The team of experts found out, after visiting individual importers, that the most important importers of pumps are the firms R. Hudson /Zambia/ Ltd., Prago Ltd. AFE and E. W. Tarry. Manufacture of centrifugal pumps is non-existent.

The largest number of both simple and articulated centrifugal pumps is imported for industry, mines and water works, apartment houses etc. According to estimates voiced by individual importers, the demand for a total of about 180 pumps/year is not met /inadequate imports/. A relatively small part of single-stage centrifugal pumps are used for irrigation, either for new projects or for renewal.

Demand for Centrifugal Pumps in 1980

Pumps for irrigation	- new ones	80 pumps
	- replacements	10 pumps
Pumps for other applications		320 ppmps
Unsatisfied demand		180 pumps
T o ta l		590 pumps

The demand for centrifugal pumps in 1990 has a substantially different make-up. According to the calculation, annual increase of the number of pumps for irrigation shall be 31 %, whereas in the line of pumps for other applications maximum annual increase amounts to 5 % /mines 2 %, industry by 4 %, houses, breeding of cattle, water works and other applications about 6,6 %/.

Demand for Centrifugal Pumps in 1990

Pumps for irrigation	- new projects	1 190 pumps
	- replacements	80 pumps
Pumps for other applications and replacements		980 pumps
T o t a l		2 250 pumps

The Irrigation Equipment Manufacturing Plant is designed so as to enable the whole demand of the 1990 year to be met in the line of the given pumping sets by national production facilities.

Suction Pipeline with Fittings

Calculations of the irrigation pipeline for the suction part of the pumps, including the fittings, are presented in Appendix A, Chapter XII, paragraphs 2 and 4.

Delivery Irrigation Pipeline including Fittings

Calculations of the delivery irrigation pipeline including fittings are presented in Appendix A, Chapter XII, paragraphs 3 and 5.

Instruments and Other Outfit of a Pumping Station

The irrigating installations used in Zambia usually feature a simple outfit with instruments for regulation, automatic operation and measurement. All these instruments will have to be imported, see Chapter IV.

The electrical switchboards, too, are conveniently equipped. They must be arranged for outdoor climatic conditions.

Electrical switchboards for irrigation equipment in Zambia are already being manufactured of imported components. If the Irrigation Equipment Manufacturing Plant have been built, then the demand for electrical switchboards for irrigation equipment in the 1990 year will total

1 800 pieces/year.

This demand will be fully met by local production.

Irrigation Network

Calculation of both the underground and surface irrigation network is presented in Appendix A, Chapter XII, paragraph 5.

Most of the pipelines - except that made of aluminium - are being made in Zambia - see Chapter IV and Appendix B on manufacture of irrigation equipment components.

Irrigation System Detail

Calculation of a portable pipeline, including adapting pipes and fittings, is presented in an Appendix A, Chapter XII, paragraphs 3 and 5 dealing with manufacture of irrigation system components. A calculation of the demand for sprinklers is also presented in the Appendix A, Chapter XII, paragraph 6.

Irrigation Machines

Simple irrigation machines with trailed hoses have already begun to be used to a limited extent in Zambia. According to data transmitted by the manufacturers and to inspections of farms it is estimated that in Zambia there are installed in total 20 such machines made by different manufacturers. Of the complex irrigation machines with coiled-up hoses there have been imported only two up to the present, but they are not yet in use.

High Voltage Connection and Transformers with Switching Stations

High voltage connections with transformers and switching stations figure only as marginal items in irrigation equipment, although the equipment could not exist without these elements at all.

Based on calculation of the demand for irrigating pumps, there was determined the demand for transformers in 1990 that is equivalent to approximately

1 050 - 1 200 pieces/year

with the corresponding number of switching instruments, measuring instruments and all the necessary outfit of switching and transformer stations. The substantially lower number of transformers than the number of pumping sets with electric motors is due to the fact that some of the transformer will be shared by several pumps.

The transformers will be designed for voltages of 11 000 V/380/220 V, from 30 kVA to a maximum of approx. 600 kVA /some of the transformers will serve as common units for the pumping station and the whole farm/.

It to the above figure there has been added the demand for transformers envisaged for electrification of towns and villages, for industrial applications, mines and other users, there results a quantity that can be manufactured economically. A prerequisite of initiation of manufacture of transformers in Zambia is the manufacture of an adequate number of insulated conductors of the required dimensions, in order that imports may be confined only to transformer sheets, sheets for manufacture of vessels and insulating materials.

The manufacture of transformers belongs to the sphere of electrotechnical industry and, consequently, does not form part of the present study.

Based on the data referred to in this chapter, and, particularly in the Appendix A the production programme of the new plant has been outlined as follows:

Table 3-1

SURVEY OF PRODUCTION PROGRAMME

Pos.	Item	Annual production -full capacity	
		piece	ton
1	Pumping units	2 250	657,1
2	Water intake		
2,1+)	Flanged suction pipe	9 000	168,6
2,2+)	Flanged elbow 90°	2 250	25,9
2,3	Suction strainer with flange	2 250	17,1
3	Irrigating section		
3,1	Closing valve	1 310	17,6
3,2	Flanged connecting	1 310	8,5
3,3	Irrigation suction pipes	242 950	2 120,3
3,4	Valve with branch pipe	14 970	201,6
3,5	End piece	6 805	14,3
3,6	Pipe connection	4 180	12,5
3,7	Reducer	1 055	5,4
3,8	Irrigation gate valve with branch pipe	3 345	73,6
3,9	Y - piece for branch pipes	1 410	11,1
3,10	Connection piece	705	11,4
3,11	Sprinkler closing element	5 630	56,3
3,12	Lengthening pipe, triped for sprinkler	37 030	220,2
3,13	Sprinklers	37 030	55,4
	TOTAL	373 480	3 676,9

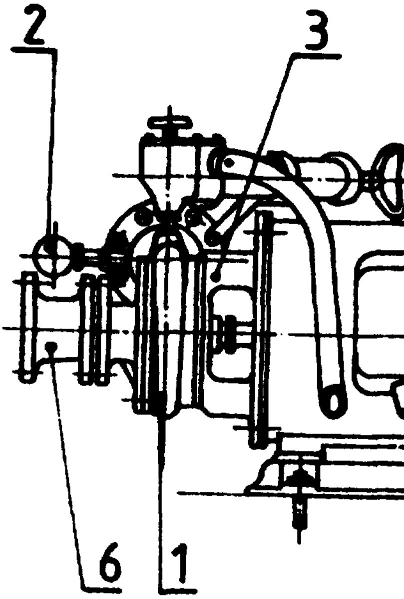
+) Cooperation in existing works in Zambia

1. PUMPING UNITS

UNITS OF HORIZONTAL, CENTRIFUGAL SPIRAL PUMP, DESIGNED AS A MONOBLOCK WITH ELECTRIC MOTOR.

Technical parameters						Annual production	
Q /l/min/	H/m/	Hs/m/	N/kW/	r.p.m.	G/kg/	pieces	tons
450	50	6,5	7,5	2 900	164	935	153,3
800	55	6,5	13	2 900	250	580	145,0
1 500	65	4,5	30	2 900	447	410	183,3
2 750	80	4,5	55	2 900	540	325	175,5
TOTAL						2 250	657,1

Q [1/min] - Delivery + liters per minute
H [m] - Total head in meter
Hs [m] - Suction head in meters
N [kW] - Input of electric motor
n [1/min] - r.p.m.
G [kg] - Weight of set

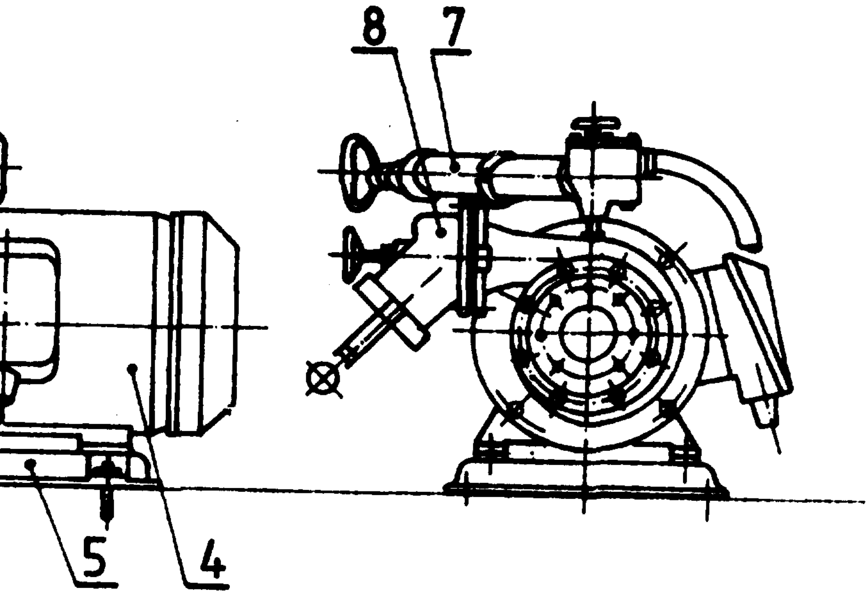


1 – PUMP

2 – PRESSURE GAUGE

3 – INTERMEDIATE PIECE

4 – ELECTRIC MOTOR



5 — BASE PLATE

6 — SUCTION BELL

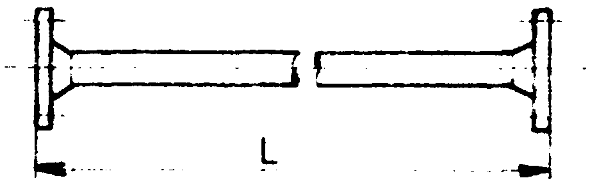
7 — HAND-OPERATED VACUUM AIR PUMP WITH HOSE

8 — 45° DISCHARGE VALVE

2 - INLET PIPELINE FOR SITES

2.1

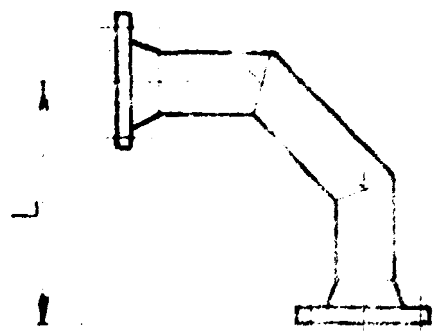
FLANGED SUCTION PIPE				
Rated inner diameter I.D. /mm/	Length L /mm/	Weight G /kg/	Annual production pieces	tons
ø 100	2000	15,5	6 060	93,9
ø 150	2000	25,4	2 940	74,7
TOTAL			9 000	168,6



These pipes will not be manufactured in the projected Plant, but they will be secured in cooperation in existing works in Zambia.

2.2

FLANGED ELBOW 90°				
Rated inner diameter I.D. /mm/	Dimensions L /mm/	Weight G/kg/	Annual production pieces	tons
ø 100	265	9,4	1 515	14,2
ø 150	355	15,9	735	11,7
TOTAL			2 250	25,9

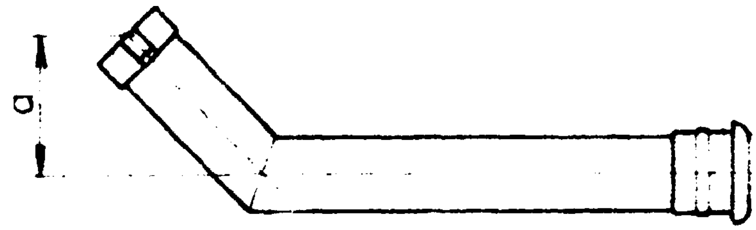


These elbows will not be manufactured in the projected Plant, but they will be secured in cooperation in existing works in Zambia.

3.2

FLANGED CONNECTING PIPELINE WITH ELBOW

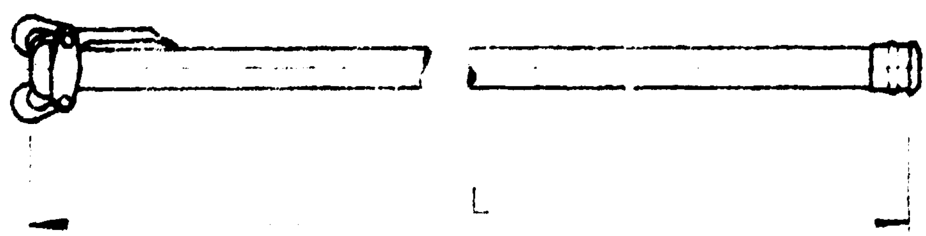
Rated inner diameter I.D. /mm/	Dimensions a / mm/	Weight G /kg/	Annual production pieces	tons
80	60	4,9	700	3,4
100	80	7,1	345	2,5
120	130	8,9	175	1,6
150	280	11,5	90	1,0
TOTAL			1 310	8,5



3.3

IRRIGATION SUCTION PIPES

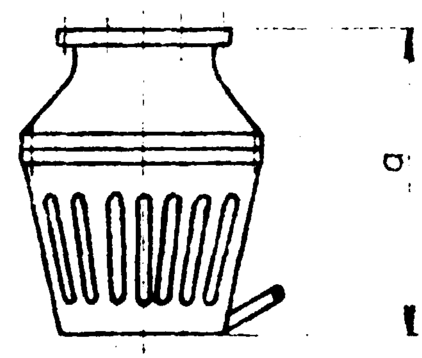
Rated inner diameter I.D. /mm/	Length L /mm/	Weight G /kg/	Annual production pieces	tons
80	6 000	7,5	142 260	1 067
100	6 000	10,-	87 440	874,4
120	6 000	13,5	13 250	178,9
TOTAL			242 950	2 120,3



2.3

SUCTION STRAINER WITH FLANGE

Rated inner diameter I.D. / mm/	Dimensions a /mm/	Weight G/kg /	Annual production pieces	tons
dia 100	260	6,6	1 515	10,0
dia 150	300	9,6	735	7,1
TOTAL			2 250	17,1

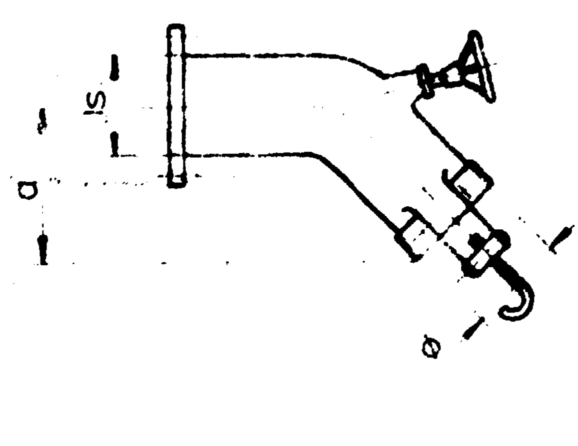


3. DELIVERY PIPELINE

3.1

CLOSING VALVE

Rated inner diameter I.D. /mm/	Dimensions a /mm/	Weight G /kg/	Annual production pieces	tons
70/76	105	11	700	7,7
80/102	120	13,3	345	4,6
100/120	135	18,-	175	3,2
125/150	145	23,6	90	2,1
TOTAL			1 310	17,6



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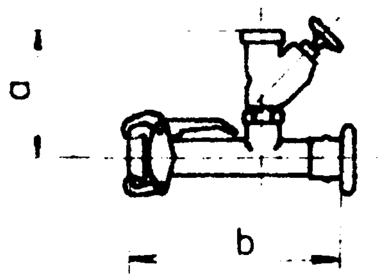
VALVE WITH BRANCH PIPE

Rated inner diameter I.D. /mm/	Dimensions a/mm/	b /mm/	Weight G/kg/	Annual production pieces	tons
80	330	450	10,4	9 080	94,4
100	340	450	18,2	5 890	107,2
TOTAL				14 970	201,6



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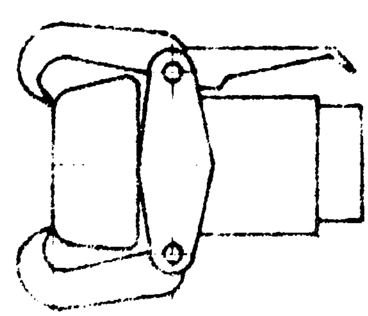
END PIECE

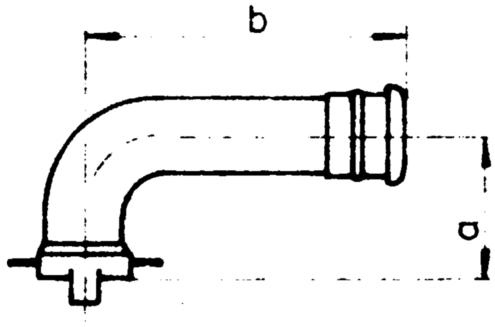
Rated inner diameter I.D. / mm/	Lehgth /L /mm/	Weight G /kg/	Annual production pieces	tons
80	70	2,0	5 580	11,2
100	75	2,55	1 225	3,1
			6 805	14,3



3.6

PIPE CONNECTION

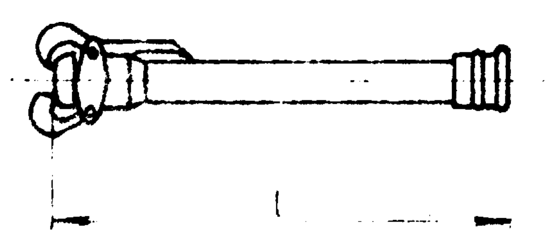
Rated inner diameter I.D. /mm/	Dimensions a /mm/	b/mm/	Weight G/kg/	Annual production pieces	tons
80	75	190	3,0	4 180	12,5
TOTAL				4 180	12,5



3.7

REDUCER

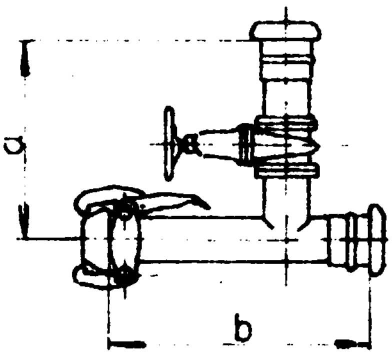
Rated inner diameter I.D./mm/	Length L /mm/	Weight G /kg/	Annual production pieces	tons
102/76	295	4,2	705	3,0
120/150	327	6,8	175	1,2
150/120	316	6,85	175	1,2
TOTAL			1055	5,4



3.8

IRRIGATION GATE VALVE WITH BRANCH PIPE

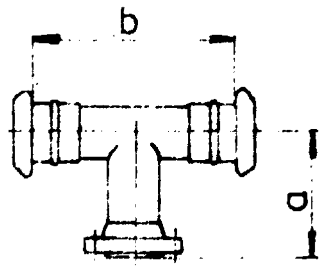
Rated inner diameter I.D. /mm/	Dimensions		Weight G/kg/	Annual production	
	a /mm/	b/mm/		pieces	tons
120/102	390	450	22	3 345	73,6



3.9

Y-PIECE FOR BRANCH PIPES

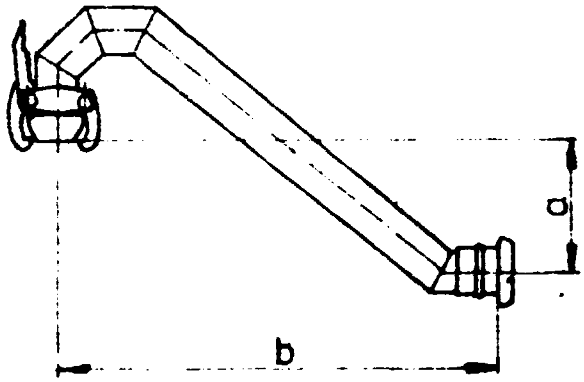
Rated inner diameter I.D. /mm/	Dimensions		Weight G/kg/	Annual production	
	a /mm/	b /mm/		pieces	tons
100	200	450	7,85	1 410	11,1



3.10

CONNECTION PIECE

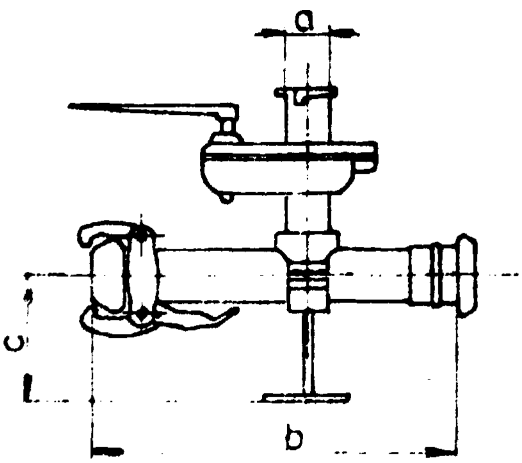
Rated inner diameter I.D./mm/	Dimensions		Weight G/kg/	Anual production	
	a /mm/	b/mm/		pieces	tons
100	385	1020	16,2	705	11,4



3.11

SPRINKLER CLOSING ELEMENT

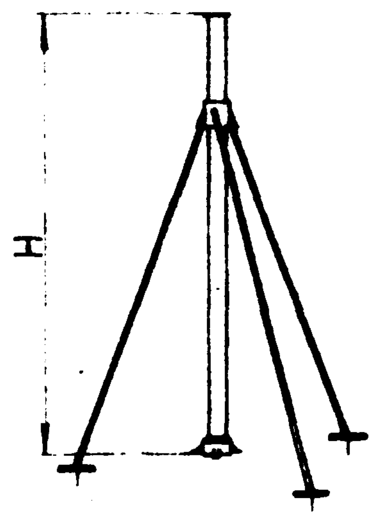
Rated inner diameter I.D./mm /	Dimensions			Weight G/kg/	Annual production	
	a/mm/	b/mm/	c/mm/		pieces	tons
102	42	500	170	10	5 630	56,3



3.12

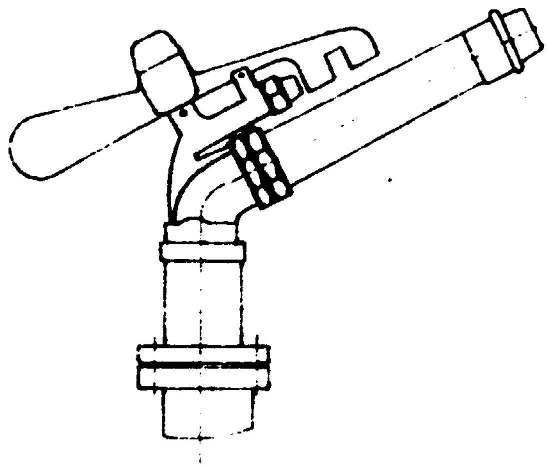
LENGTHENING PIPE WITH TRIPOD FOR SPRINKLER

Rated inner diameter I.D./ mm/	Dimensions H /mm/	Weight G/kg/	Annual production	
			pieces	tons
3/4"	500	5,3	35 620	188,8
2 1/2"	1 200	22,3	1 410	31,4
TOTAL			37 030	220,2



SPRINKLERS

Dia of nozzle / mm/	Pressure /MPa/	Delivery l /min/	Spraying range /m/	Weight /kg/	Annual production	
					pieces	tons
dia 5 ÷ 7	0,3÷0,4	28÷ 62	17÷20,5	1,4	35 620	49,9
dia 16/7	0,35	350	33	3,9	1 410	5,5
TOTAL					37 030	55,4



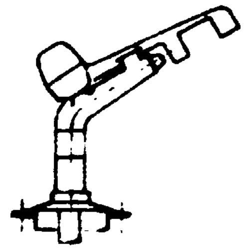


Table 3 - 13

PRODUCTION PROGRAMME IN VALUE TERMS

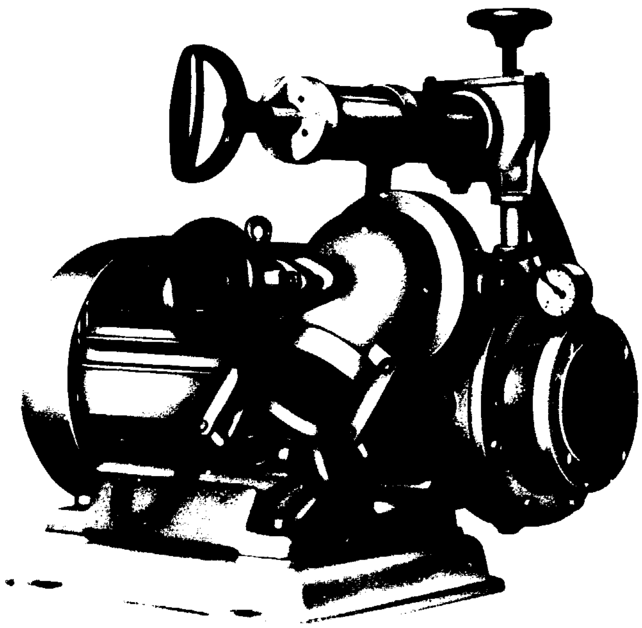
(Constant Prices 1980)

1. Pumping units 657,1 tones á 9800 K	6 439, 6
2,1 Flanged suction pipe 168,6 tones á 2100 K	354,1
2,2 Flanged elbow 90^{o} 25,9 tones á 3000 K	77,7
2,3 Suction strainer with flange 17,1 tones á 4500 K	77,-
3,1 Closing valve 16,6 tones á 4800 K	79,7
3,2 Flanged connecting 8,5 tones á 3000 K	25,5
3,3 Irrigation suction pipes 2120 tones á 8200 K	16.960,-
3,4 Valve with branch pipe 201,6 tones á 4800 K	967,7
3,5 End piece 14,3 tones á 4000 K	57,2
3,6 Pipe connection 12,5 tones á 3000 K	37,5
3,7 Reducer 5,4 tones á 4000 K	21,6
3,8 Irrigation gate valve with branch pipe 73,6 tones á 5000 K	368,-

3.9 Y piece for branch pipes 11,1 tones á 2800 K	31,1
3.10 Connection piece 11,4 tones á 3000 K	34,2
3.11 Sprinkler closing element 56,3 tones á 5800 K	328,3
3.12 Lengthening pipe with tripod for sprinkler 220,2 tones á 3800 K	836,8
3.13 Sprinklers 55,4 tones á 12600 K	9698,-
	27394,-

PRODUCTION PROGRAMME

	Pieces at 100% capacity	Year 3 %	Year 3 Units	Year 4 %	Year 4 Units	Year 5 %	Year 5 Units	Year 6 %	Year 6 Units	Year 7 %	Year 7 Units	Year 8 %	Year 8 Units
Pumping units	2250	20	450	40	900	60	1350	80	1800	90	2025	100	2250
Flanged suction pipe	9000	"	1800	"	3600	"	5400	"	7200	"	8100	"	9000
Flanged elbow 90°	2250	"	450	"	900	"	1350	"	1800	"	2025	"	2250
Suction strainer with flange	2250	"	450	"	900	"	1350	"	1800	"	2025	"	2250
Closing valve	1310	"	262	"	524	"	786	"	1048	"	1179	"	1310
Flanged connecting	1310	"	262	"	524	"	786	"	1048	"	1179	"	1310
Irrigation suction pipes	[illegible]	"	48590	"	[illegible]7180	"	145770	"	194360	"	218655	"	24[illegible]950
Valve with branch pipe	14970	"	2994	"	5988	"	8982	"	11976	"	13473	"	14970
End piece	6805	"	1361	"	2722	"	4083	"	5444	"	6125	"	6805
Pipe connection	4180	"	836	"	1672	"	2508	"	3344	"	3762	"	[illegible]
Reducer	1055	"	211	"	422	"	633	"	844	"	950	"	1055
Irrigation gate valve with branch pipe	3345	"	669	"	1338	"	2077	"	2676	"	3011	"	3345
Y - piece for branch pipes	1410	"	282	"	564	"	846	"	1128	"	1269	"	1410
Connection piece	705	"	141	"	282	"	423	"	564	"	635	"	705
Sprinkler closing element	5630	"	1126	"	2252	"	3378	"	4504	"	5067	"	5630
Lengthening pipe with tripod for sprinkler	37030	"	7406	"	14812	"	22218	"	29624	"	33327	"	37030
Sprinklers	37030	"	7406	"	14812	"	[illegible]	"	29624	"	33327	"	37030
Total	373[illegible]	20	[illegible]	40	149392	60	224088	80	[illegible]	90	336134	100	373480



ZAMBIA - SELECTED INDICATORS - Source : Central Statistical Office

No.	Item discription	Unit	1974	1975	1976	1977	1978	1979
1.	Population	million	4,83	4,98	5,14	5,30	5,47	5,59
2.	Total GDP							
	At current prices	K mill.	1894,6	1583,4	1940,5	2023,6	2258,7	2566,3
	At 1970 prices	K mill.	1473,9	1438,1	1558,2	1448,8	1496,4	1561,5
	At 1970 prices (adjusted for terms of trade)	K mill.	1359,2	1050,9	1111,8	992,6	989,5	968,0
3.	Per Capita GDP							
	At current prices	Kwacha	388	318	377	382	415	454
	At 1970 prices	Kwacha	303	289	302	281	274	241
	At 1970 prices (adjusted for terms of trade)	Kwacha	281	211	216	187	[illegible]	181
4.	National Income							
	At current prices	K mill	1567,1	1262,2	1564,2	1613,8	[illegible]	[illegible]
	At 1970 prices		1239,1	1201,1	1302,1	1245,2	1262,2	[illegible]
5.	Per Capita National Income							
	At current prices	Kwacha	324	254	304	304	[illegible]	[illegible]
	At 1970 prices (unadjusted)	Kwacha	256	241	253	235	230	[illegible]
	At 1970 prices (adjusted)	Kwacha	236	[illegible]	166	141	138	[illegible]
6.	Copper production, Exports, Price							
	Production	1000 tones	702,[illegible]	640,3	712,9	659,8	655,6	[illegible]

No.	Item description	Unit	1974	1975	1976	1977	1978	1979
	Exports	1000 tones	673,4	641,2	745,7	656,6	613,2	[illegible]
	LME cash and settlement price per ton	Kwacha	1325	794	1007	1016	1090	1572
7.	Index of Production							
	Mineral production 1973 = 100		104,3	94,5	103,1	96,2	95,4	96,1
	Manufacturing 1973 = 100		111,2	106,6	101,6	95,9	102,6	105,0
	Electricity 1973 = 100		132,3	191,0	222,8	265,9	240,7	268,[illegible]
8.	External Trade							
	Exports	K. mill	905,1	521,1	751,9	708,0	696,2	-
	Imports	"	506,6	603,0	468,6	530,0	493,[illegible]	..
9.	Prices							
	Consumer Price Index Nos. Highincome 1975=100		92,2	100,0	116,1	136,0	152,6	[illegible]
	Low income		90,8	100,0	118,8	142,3	163,6	[illegible]
	Wholesale Price Index Nos. -Including copper 1966=100		156,8	147,0	175,7	211,6	246,[illegible]	303,0
	Excluding copper " "		166,6	189,7	222,3	276,9	333,7	398,5
10.	Employment and Earnings							
	Number of employees 31.12. - Zambian	1000	352	365	341	344	349	347
	- non Zambian	"	33	32	27	25	26	25
	Average annual earnings - Zambian	Kwacha	1122	1381	1473	1565		
	- non Zambian	"	5389	6799	5858	7086		

SELECTED IMPORTS BY S.I.T.C. DIVISIONS (1000 K)

Source : Central Statistical Office

Divis. Code No	Description	1973	1974	1975	1976	1977	1978
01	Meat and meat preparations	5244	5854	2729	1135	81	439
02	Dairy Products and Eggs	3555	10750	4781	5347	4619	3701
03	Fish and Fish preparations	1536	2838	1887	922	1161	1099
04	Cereals and Cereal preparations	6011	10931	18388	10992	13363	14672
05	Fruit and vegetables	1472	2938	2036	939	1428	773
06	Sugar, sugar preparations and honey	1519	1352	539	308	680	141
07	Cofee, cocoa, speces, tea and manufactures	1555	1947	1423	1212	1332	1036
08	Animal foods (not muilled cereals)	1439	3506	1334	1710	3091	7497
09	Miscellaneous food preparations	2191	2991	2107	1500	2278	1758
11	Beverages	904	999	933	811	947	657
42	Fixed vegetable oils and fats	3503	5084	7514	6761	6023	5543
67	Iron and Stell	17696	40867	27959	17020	26142	[illegible]
68	Non-ferrons metals	2186	2464	3413	2215	2700	2787
69	Metal manufactures N.E.S.	12855	20350	26835	23484	30638	10959
71	Machinery, other than electric	77752	78074	64756	96003	40155	[illegible]
72	Electric machinery, apparatus and appliances	25569	32932	38987	19096	40657	3547
73	Transport Equipment	35590	54889	77557	52822	53994	1553
81	Plumbing, heating and lighting fictures and fittings	915	1971	1866	671	1107	1194

MARKETED PRODUCTION OF IMPORTANT AGRICULTURAL COMMODITIES

Commodity	Unit	1965	1971	1972	1973	1974	1975	1976
Maize	tones	273333	339950	616554	389747	588090	559131	750057
Sorghum (malting)	"	n.a.	102	212	35	325	92	108
Rice (paddy)	"		170	254	345	358	1000	2097
Groundnuts	"	7458	6779	6508	3544	3604	6418	9460
Sugarcane	"	Nil	230737	397363	487693	570[illegible]43	768153	779611
Fruits	"	2400	5600	5900	5550	6000	6400	5400
Vegetables	"	13000	24100	27700	20000	25000	28000	30000
Seed cotton	"	2098	1675	8349	5225	2173	2602	3885
Wheat	"	-	-	-	-	-	1050	3948
Sunflower	"	-	11	124	1331	4257	8498	16097
Soyabeans	"	-	-	-	173	192	583	990
Beef	"	12400	13200	14100	16300	14500	17200	15917
Pork and bacon	"	688	1600	1500	2000	2400	3100	350[illegible]
Poultry (dressed)	"	1230	6700	8000	9000	12200	146[illegible]	21471
Eggs	10^6	23	77	91	102	140	175	13[illegible]
Milk	10^6 litres	19,8	16,4	16,9	17	15,2	1[illegible],5	12,7
Virginia tobacco	tones	6600	5910	5530	6230	6201	6465	6262
Burley tobacco	"	1993	388	385	471	430	50[illegible]	212
Oriental	"	526	4	49	-	-	-	3
Tea	"	-	-	-	-	-	-	9,0
Coffee (roasted)	"	1	7	6	6	3	32	31,[illegible]

DEMAND PROJECTIONS AND ESTIMATES OF PRODUCTION FOR IMPORTANT AGRICULTURAL COMMODITIES IN 1983 (TONNES)

Commodity	Total internal demand	Estimated production
Maize	1403000	1700000
Rice	15000	15000
Wheat	190000	48000
Barley	40000	16000
Sweet potatos and potatoes	54000	100000
Cassava		41753
Dry beans	21000	30000
Groundnuts (in shell)	93000	94000
Sunflower seed	32000	32000
Soya bean	6500	6500
Tea	1200	650
Coffee (ground)	400	400
Seed cotton	27000	32000
Virginia tobacco		12000
Burley tobacco		1100
Oriental tobacco		315
Beef	74370	53460
Pork and bacon	8000	12000
Eggs	5000	13000
Poultry meat	26000	33000
Milk (litres)	92000	38150

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NEW CANALS, WELLS, BOREHOLES AND DAMS

Year	New canals km	No. of dug out wells	No. of well points	No. of boreholes	Village piped water supplies	New Dams
	The Second National Development Plan					
1972	111	287	112	129	30	3
1973	126	348	55	122	20	2
1974	134	341	65	132	16	2
1975	118	264	77	176	20	1
1976	135	291	33	93	14	1
Total	624	1531	342	652	100	9
	The Third National Development Plan					
1979 - 83	650	2500		1000	200	161

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CHANGES IN HARVESTED AREA BY CATEGORIES OF FARMERS

	1974		1983		1974 - 83	
	Estimated area (1000 ha)	%	Estimated area (1000 ha)	%	change area (1000 ha)	%
1. Traditional farmers	1578	78	1136	51	-442	-28
2. Emergent farmers	356	18	944	43	+558	+165
I. Improved village farmers	215	11	637	29	+422	+196
II. Organized small holder schemes	68	3,4	130	6	+ 62	+ 91
III. Emergent middle farmers	73	3,6	177	8	+104	+142
4. Large scale commercial farmers (incl. parastatals)	81	4	135	6	+ 54	+ 67
Total	2015	100	2215	100	+200	+9,9

MANUFACTURING INDUSTRY: GROSS VALUE ADDED IN CONSTANT PRICES

In producers' values at 1969 prices K million — Source: Central Statical Office

	1971	1972	1973	1974	1975	1976	Average growth rate over SHDP
Food, beverage and tobacco	71,3	78,9	76,1	74,3	72,6	71,7	0,2
Textile and wearing apparel	9,8	12,3	14,7	17,5	17,5	17,7	12,5
Wood, wood products and furniture	2,6	3,8	4,8	5,8	4,3	3,8	7,9
Paper, paper products, publishing and printing	5,2	5,3	5,9	6,0	6,8	5,3	0,4
Chemicals, petroleum, plastic and rubber products	[illegible]	[illegible]	25,5	38,6	27,5	26,1	18,9
Non - metalic and mineral products	9,2	9,8	9,3	10,5	11,3	10,1	1,9
Basic metal products	2,2	2,9	2,7	3,3	2,6	2,6	3,4
Fabricated metal products, machinery and equipment	21,8	23,2	25,8	26,6	25,5	23,9	1,9
Others	0,4	0,1	0,5	0,5	0,5	0,5	5,3
Total	123,7	152,1	159,3	175,2	168,6	161,7	3,2
Percentage change over year	4,3	16,0	2,7	10,0	-3,9	-4,1	

INDEX OF INDUSTRIAL PRODUCTION (COMMODITY GROUPING)

Chained index 1969 = 100 Source : Central Statistical Office

Year	Total Manufacturing	Food, beverages and tobacco	Basic metals industries	Metal products and other	Electricity	Total mining
1970	111,3	117,0	101,9	99,3	137,9	92,0
1971	122,5	125,2	100,6	119,3	171,0	85,0
1972	133,8	132,2	93,5	140,2	457,8	94,4
1973	142,2	150,3	90,4	142,1	460,0	92,3
1974	157,3	159,8	110,9	147,2	836,7	96,3
1975	150,0	156,3	[illegible]	138,0	878,7	87,2
1976	144,5	152,6	90,8	135,0	1024,9	95,2
1977	140,1	147,4	99,3	116,4	1219,0	88,1
1978	145,9	149,2	109,4	104,9	1107,2	83,0
1979	149,3	146,5	98,5	97,6	1234,6	79,5

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EMPLOYEES IN INDUSTRY

Source : Central Statistical Office

Industry	1972	1973	1974	1975	1976	1977	1978	1979
Agriculture, forestry, fishery	31140	31720	33610	36100	32500	30800	32600	34590
Mining and quarrying	60650	61740	65110	64750	64360	64800	62770	[illegible]
Manufacturing	43300	43600	44070	44330	[illegible]	45770	50120	50700
Electricity and water	4530	4680	4750	5130	6970	7420	7670	7810
Construction and allied repairs	72320	70490	70590	71750	[illegible]	49770	40190	40130
Distribution, restaurants and hotels	33690	34630	35580	32960	34200	33280	32700	33370
Transport and communications	25040	24210	22150	22050	20540	20770	[illegible]	21900
Finance, insurance, services, business	14310	15010	16450	18700	18900	17970	[illegible]	20520
Community, social and person. services	82950	87120	92590	97720	97970	[illegible]	[illegible]	103740
Total	367930	373440	384890	393190	368790	370450	368460	[illegible]

ASSEMENT OF THE HOUSING STOCK

Housing category	Total		Large urban		Small urban		Rural	
	No.	%		%	No.	%	No.	%
AS PER 31. 12. 1971								
High / medium cost	36900	4,1	25000	11,6	1900	10,9	10000	1,5
Low - cost	140100	16,2	118100	54,9	7500	43,1	19500	2,9
(Servants' houses)	(16600)	(1,9)	(12000)	(5,6)	(8000)	(4,6)	(3400)	
Serviced sites	11300	1,3	10500	4,9	800	4,6	-	-
Improved units	-	-	-	-	-	-	-	-
Total "formal"	193300	21,6	153600	71,4	10200	58,6	29500	4,4
Squatter /traditional	703300	78,4	61400	28,6	7200	41,4	634700	95,6
Total stock	896600	100	215000	100	17400	100	664200	100
AS PER 31. 12. 1978								
High /medium cost	46400	4,2	23200	9,9	2200	8,7	11000	1,5
Low - cost	175800	16,0	144500	43,1	8700	34,2	22600	3,0
(Servants' houses)	(20700)	(1,9)	(16100)	(4,8)	(900)	(3,5)	(3700)	(0,5)
Serviced sites	36000	3,1	33600	10,0	1900	7,5	500	0,1
Improved units	22600	1,5	22000	6,6	600	12,4	-	-
Total "formal"	280800	25,5	233300	70,0	13400	52,8	34100	4,6
Squatter /traditional	819300	74,5	99900	30,0	12000	47,2	707400	95,4
Total stock	1100100	100	232200	100	25400	100	741500	100

Source : Third National Development Plan

ASSESSMENT OF DWELLING UNITS DEMAND 1979 - 83

	Total	Urban Large	Urban Small	Rural
Estimated demand XII. 1978	1124000	350100	26400	747500
Estimated stock XII. 1978	1100100	353200	25400	741500
Estimated shortfall XII.1978	23900	16900	1000	6000
Estimated new 78-83	391200	116000	8600	266600
New dwellings demand 1979-83	415100	132900	9600	272600

Source : Third National Development Plan (Both tables)

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ASSESSMENT OF HOUSING DEMAND BY COST CATEGORY 1979 - 83

Gross monthly household income K	Dwelling category	Total demand	Urban Large	Urban Small	Rural
		1000 Units			
0-60	Settlement / traditional	314,9	49,8	5,5	259,6
60-100	Partly serviced / self-help and squatter upgrading	110,9	102,4	1,8	6,7
100-160	Fully serviced / self-help and core housing	14,6	8,0	1,4	5,2
100-250	Low-cost housing	54,6	53,6	0,5	0,5
250-500	Medium cost	24,3	23,6	0,3	0,4
500	High cost	3,0	2,7	0,1	0,2
Total		415,1	132,9	9,6	272,6

ESTIMATE OF PRODUCTION COST

Sales and distribution costs

No	Item description	Quantity	Unit	Unit Cost K	Cost 1000 K Foreign	Cost 1000 K Local	Cost 1000 K Total
1	Sales costs						
	Training of salesmen and merchants				-	30	30
	Advertising				-	80	80
	Trevel expenses				-	90	90
	After sales services, communication					140	140
2	Distribution costs						
	Packaging - included in materials and inputs						
	Freight, communications				-	85,-	85,-
	Total					425,-	425,-

IV. MATERIALS AND INPUTS

MATERIALS AND INPUTS

Materials and inputs for the Irrigation equipment manufacturing plant are derived from the production programme and capacity given in the chapter III, and from technology given in the chapter VI.

In order to reduce the quantity of imported aluminium pipes to minimum, aluminium pipes with steel couplings are envisaged /this system is most frequently used in the Central Europe/. It is the cheapest solution of production of irrigation pipes in Zambia.

For the full capacity of the Plant, the following materials and inputs are required:

1. Unprocessed and semi-processed raw materials

nil

2. Processed industrial materials

Rolled steel - profiles	27,7 tones
- sheets	700,0 tones
Steel pipes - welded etc.	369,6 tones
Drawn steel - profiles	15,5 tones
Castings - grey iron I. - IV. grade	634,8 tones
- aluminium alloys	22,1 tones
- copper alloys	19,3 tones

Semi products, non-ferrous metals

- copper alloys /pipes, profiles,sheets/	14,4 tones
- aluminium alloys /pipes/	1217,0 tones
- zinc /metallurgical/	91,0 tones

Combustibles

- paints	35,6 tones
- thinning agents	7,0 tones
- greases	2,0 tones

3. Subdeliveries and components

- components made of rubber	51,4 tones
- components made of plastics	2,3 tones
- components made of leather	1,3 tones
- connecting material /bright and black bolts, nuts, washers etc./	58,6 tones
- springs	1,0 tone
- welding electrodes and wires	4,5 tones
- fittings, pressure gauges	2,1 tones
- electrical apparatuses	84,7 tones
- electric motors	350,0 tones

4. Auxiliary materials

Paper, packing materials, chemicals, degreasing materials, additives etc.	16,0 tones

5. Factory supplies

Maintenance materials /spare parts, cleaning material, oil, greases, common utility tools, grinding tools etc./	15,0 tones
T o ta l	3 742,9 tones

6. Utilities

Electricity /max. demand 660 kVA/	840 000 kWh
Acetylene	600 m3
Oxygene	900 m3
Water	5 625 m3
Petrol for high-lift trucks	36 000 litres

The majority of these materials and inputs is imported /69,2 % of tonnage, 84 % of costs/. It is presupposed that many items will be produced in Zambia in the near future - for example steel profiles, sheets, electrical apparatuses, eventually aluminium pipes.

Prices of these materials and inputs, construction materials and services are given on pages IV-4 till IV-9.

PROCESSED INDUSTRIAL MATERIALS PRODUCED IN ZAMBIA

Ex factory prices at November 1980

Source : Price lists of different firms

Item	Unit	Price	Unit	Price
Grey iron castings				
Circular drain grates dia 356 mm	piece	8,-	ton	1000,-
Square drain grates 457 x 457 mm	"	43,30	"	1140,-
Manhole covers and frames 648x648mm	"	221,16	"	1140,-
Sluice valve and stop cock boxes (surface) dia 114 mm x 152 deep	"	13,75	"	1250,-
Grey iron castings, grade I.				1000,-
grade II.			"	1250,-
grade III.			"	1500,-
grade IV.			"	1750,-
Steel castings grade I.			"	1100,-
grade II.			"	1400,-
grade III.			"	1700,-
grade IV.			"	2000,-
Non - ferrons castings				
- Bronze			"	5000,-
- Manganese bronze			"	7000,-
- Aluminium bronze			"	7000,-
- Aluminium			"	4800,-
- Phosphor copper			"	8000,-
Pipes				
Black welded steel pipes in 20' length (6,1 m)				
- dia 1/2" - 15 mm NB	piece	8,4	ton	1075,-
- dia 1 1/2" - 40 mm NB	"	24,87	"	1119,-
- dia 3" - 80 mm NB	"	56,60	"	1132,-
Galvanised welded steel pipes in 20 length (6,1 m)				
- dia 1/2 " - 15 mm NB	piece	9,33	ton	1194,-

Item	Unit	Price	Unit	Price
- dia 1 1/2" - 40 mm NB	piece	27,3	ton	1173,9
- dia 3" - 80 mm NB	"	61,98	"	1176,1
Fencing tubes - 1 1/2" O.D. - 42,5mm	"	15,84	"	1077
- 3" O.D. - 75,5 mm	"	29,1	"	1077
Spiral welded pipes wall thickness				
4,5 mm upwards dia 175 mm up to 1380 mm				
different surface treatments (spin				
bitumen with			"	1200*
fibre glass wrap, coal tar epoxys etc				*
P.V.C pipes rigid, nuplasticised				
- dia 1/2" x 6 m class E	piece	1,84	"	2042
- dia 2" x 6 m, class D	"	12,60	"	2524
- dia 8" x 6 m, class C	"	88,89	"	1777
- dia 10" x 6 m, class D	"	177,76	"	1777
- dia 12" x 6 m, class D	"	253,96	"	1777
Asbestos - cement pressure piping				
4 metre length				
- dia 75 mm, class D	"	14,26	"	550
- dia 150 mm, class C	"	34,70	"	578
- dia 250 mm, class D	"	65,09	"	562
- dia 375 mm, class B	"	122,00	"	487
- dia 450 mm, class D	"	264	"	518
Asbestos - cement fluid - tite joints				
- dia 75 mm, class A-D	"	3,57	"	3570
- dia 150 mm, class A-D	"	8,20	"	2050
- dia 250 mm, class A-B	"	11,50	"	1643
- dia 375 mm, class A-B	"	16,90	"	1408
- dia 450 mm, class C-D	"	31,40	"	952
Asbestos - cement sheeting				
Straight sheets			covered m^2	
cover width 87,6 cm width 92 cm length 300 c-m	"	15,41	"	5,86
cover width 102 cm, nom. width 112 cm				
length 300 cm	"	18,00	"	5,88

Item	Unit	Price	Unit	Price
Carved sheets, different width			ton	5,85÷
and length			"	÷ 6,76
Technical gases				
Oxygen 1 bottle = 6 ÷ 8 m^3	bottle	24,00	m^3	3,90
Acetylene 1 bottle = (6,2 m^3)	bottle	40,00	m^3	6,50
(plus rent 72 K/year/bottle)				
Combustibles				
Fuel oil, diesel oil			litre	0,35
Petrol			litre	0,74
Oil	210 litres	343	litre	1,63
Grease			kg	6,-
Latex	5 kg	13 - 15	kg	2,60÷ 3,-
Oil paints	5 kg	20 ÷ 22	kg	4 ÷ 4,40
Thinning agents	5 kg	12	kg	2,40
Char.coal 1 bag ≐ 30 kg	bag	1,8	ton	60
Screws, rivets, washers, nails				
Galvanised drive screws 120 x 14 sg	100 pcs	16,00		
Copper disc. rivets	100 pcs	5,00		
Felt round washers	100 pcs	3,-		
Galvanised nails 14 gge	"	0,40		
Galvanised hook bolts and nuts				
100 x 8	"	37,00		
220 x 8	"	56,50		
Sundries				
Hand operated pump			piece	150,-
Switchboard 380/220 V, 25 kV			"	750,-
Aluminium scrap	kg	0,1	ton	100,-
Refuse bins 0,09 cu. m.			piece	16,13
Geysers 90 litres			"	158,20
135 litres			"	180,05
Z purlins				
5" x 2" x 3/4" x 14 SWG	piece	28,42	ton	966
6 1/2" x 2 x 3/4" x 14 SWG	"	37,13	"	1077

Item	Unit	Price K	Unit	Price K
LIP Channels, 61 m long				
2" x 1" x 1/2" x 18 SWG	piece	6,72	"	995
3" x 2" x 1/2" x 14 SWG	"	17,62	"	969
Welved wire mesh for reinforced concrete				
Conforce 86 2,4 m x 60 m	roll	131,15	m^2	0,91
Conforce 193 2,4 m x 48 m	"	233,32	m^2	2,02
Utility doors and frames				
725 x 1960 mm			piece	37,35
825 x 1960 mm			"	39,77
Single and double doorframes				
825 x 1960			piece	16,40
1425 x 1960			"	20,47
Galvanised washing baths				
30 litres			"	9,80
100 litres			"	24,15

ZAMBIA - TANZANIA ROAD SERVICES Ltd. LUSAKA

Transportation of Goods Lusaka - Dar Es Salaam

Rates:

1. Class A - High Rated Goods

Freight charges to be calculated according to actual weight or volume weight of the consignment whichever is greater.

Below 99 kgs	K 30,00 fixed minim. charge
100 to 499 kgs	K 0,264 per kg
500 to 4999 kgs	K 0,218 per kg
5000 to 9999kgs	K 0,175 per kg
over 10000 kgs	K 0,132 per kg
Tanker rate	K 0,1434 per litre
Full unit rate	K 3960 per truck and trailer

2. Class B - Normal Rated Goods

Freight charges to be calculated according to actual weight or volume weight of the consignment whichever is greater.

Below 99 kgs	K 18,00 fixed minim. charge
100 to 499 kgs	K 0,164 per kg
500 to 4999 kgs	K 0,132 per kg
over 5000 kgs	K 0,098 per kg
Full unit rate	K 2940 per truck and trailer

Cargo which by virtue of its length, weight or size cannot be loaded on the normal truck or trailer combination will be regarded as abnormal cargo. In that event, the following vehicles shall be provided at the rates stated below:

a/ Semi-trailer	K 0,180 per kg
b/ Low-loader /standard/	K 0,331 per kg
c/ Low-loader /special/	K P.444 per kg

calculated on carrying capacity of the vehicle.

ZAMBIA ELECTRICITY SUPPLY CORPORATION LTD.

TARIFFS

Tariff D - Maximum Demand Tariff

a/ Tariff D1 - Consumers Maximum Demand in kVA below 300

Fixed monthly charge in Kwacha - 16.90

Maximum demand charge per kVA per month in Kwacha - 2.90

Unit charge in Ngwee - 1.30

b/ Tariff D2 - Consumers Maximum Demand in kVA 300 to 2000

Fixed monthly charge in Kwacha - 325.00

Maximum Demand charge per kVA per month in Kwacha - 2.60

Unit charge in Ngwee - 1.00

c/ Tariff D3 - Consumers Maximum Demand in kVA over 2000

Fixed monthly charge in Kwacha - 3250.00

Maximum demand charge per kVA per month in Kwacha - 2.22

Unit charge in Ngwee - 0.65

The maximum demand for the first year is either the declared maximum demand or the recorded maximum demand whichever is the higher.

Subsequently the maximum demand charge for any month is based on the highest recorded maximum demand in the previous twelve months.

Table 4 - 1/1

ESTIMATE OF PRODUCTION COST

Materials and inputs

No	Item	Quantity	Unit	Unit cost K	Cost 1000 K Foreign	Local	Total
1	Unprocessed and semi-processed raw materials	-	-	-	-	-	-
2	Processed industrial materials						
	Rolled steel - profiles	27,7	ton	410	11,4	-	11,4
	- sheets	700	ton	420	294,0	-	294,0
	Steel pipes - welded etc.	369,6	ton	1170	-	432,4	432,4
	Drawn steel - profiles	15,5	ton	880	13,6	-	13,6
	Castings						
	- grey iron I. - IV. grade	634,8	ton	1650	-	1047,4	1047,4
	- aluminium alloys	22,1	ton	5000	-	110,5	110,5
	- copper alloys	19,3	ton	5200	-	100,4	100,4
	Semi-products, non ferrons metals						
	- copper alloys (pipes, profiles, sheets)	14,4	ton	5300	76,3	-	76,3
	- aluminium alloys (pipes)	1217	ton	6400	7788,8	-	7788,8
	- zinc (metallurgical)	91	ton	610	55,6	-	55,6
	Combustibles						
	- paints	35,6	ton	4400	-	156,6	156,6
	- thinning agents	7	ton	2500	-	17,5	17,5
	- greases	2	ton	6000	12,-	-	12,-
3	Subdeliveries and components						
	Components made of rubber	51,4	ton	5800	298,1	-	298,1
	Components made of plastics	2,3	ton	4300	-	9,9	9,9
	Components made of leather	1,3	ton	2800	-	3,6	3,6
	Connecling material (bright and black bolts, nuts, washers etc.)	58,6	ton	5200	82,-	222,7	304,7
	Springs	1	ton	6200	6,2	-	6,2
	Welding electrodes and wires	4,5	ton	3200	14,4	-	14,4

No	Item	Quantity	Unit	Unit cost K	Cost 1000 K Foreign	Local	Total
	Fittings, pressure ganges	2,1	ton	5800	12,2		12,2
	Electrical apparatuses	84,7	ton	6200	525,1		525,1
	Electric motors	350,0	ton	6400	2240		2240
4	Auxiliary materials						
	Paper, packing materials, chemicals, degreasing materials additives etc	16	ton	2500	35,-	5,-	40,-
5	Factory supplies						
	Maintenance materials (spare parts, cleaning material, oils, greases) common utility tools, grinding tools etc				120-	40,-	160,-
6	Utilities						
	Electricity	840000	kWh	0,01	-		
	(incl. monthly charge and max. demand charge)					35,-	35,-
	Acetylene (incl. rent. 72 K /year/bottle)	600	m^3	6,5	-	4,3	4,3
	Oxygene (incl. rent 72 K/year/bottle)	900	m^3	4,-	-	4,3	4,3
	Petrol for high - lift trucks	36000	litre	0,74	-	26,7	26,7
	Water	5625	m^3	0,15	-	8,4	8,4
	Total				11584,7	2224,7	13809,4

V. LOCATION AND SITE

LOCATION AND SITE

1. LOCATION

The Zambian authorities have not yeat decided either the site, or the location of the Irrigation equipment manufacturing plant.

Consequently the assessment of demand, production programme, capacity and input requirements, mainly subdeliveries, power supplies and transport facilities, the site should be located in provinces, where the infrastructure is mostly developped, i. e. in the most populated belt starting from the Eastern Province, via the Central Province to the Copper Belt Province.

The determination of location and site should take into considetaion these principal criteria:

- material versus market orientation
- local conditions: infrastructure and socio-economic environment

2. MATERIAL VERSUS MARKET ORIENTATION

For the location of the Irrigation equipment manufacturing plant are factors such as the availability of raw materials and inputs, the existence of basic infrastructure facilities, more important than the proximity of centres of consumption.

As the Irrigation equipment manufacturing plant should cooperate as much as possible with the existing factories, producing components and parts for irrigation equipment, it is important to locate the above mentioned Plant in the vicinity of grey iron foundry and other cooperating plants, i. e. plants producing pipes of different types, fittings, undercariages, forgings etc.

Centres of consumption are big towns around the railway line from Livingstone to Lusaka, Ndola and Kitwe. From these towns products are distributed to different consumers, i. e. farmers, industry, dwelling houses etc.

3. LOCAL CONDITIONS

3.1 Infrastructure

The existence of infrastructure is vital to the operation of the Irrigation equipment manufacturing plant, therefore this Plant should be built in the place, where this infrastructure is available in full extent:

Transport facilities

Roads - The majority of materials and inputs to the Plant and products from the Plant will be transported by trucks; therefore the location of

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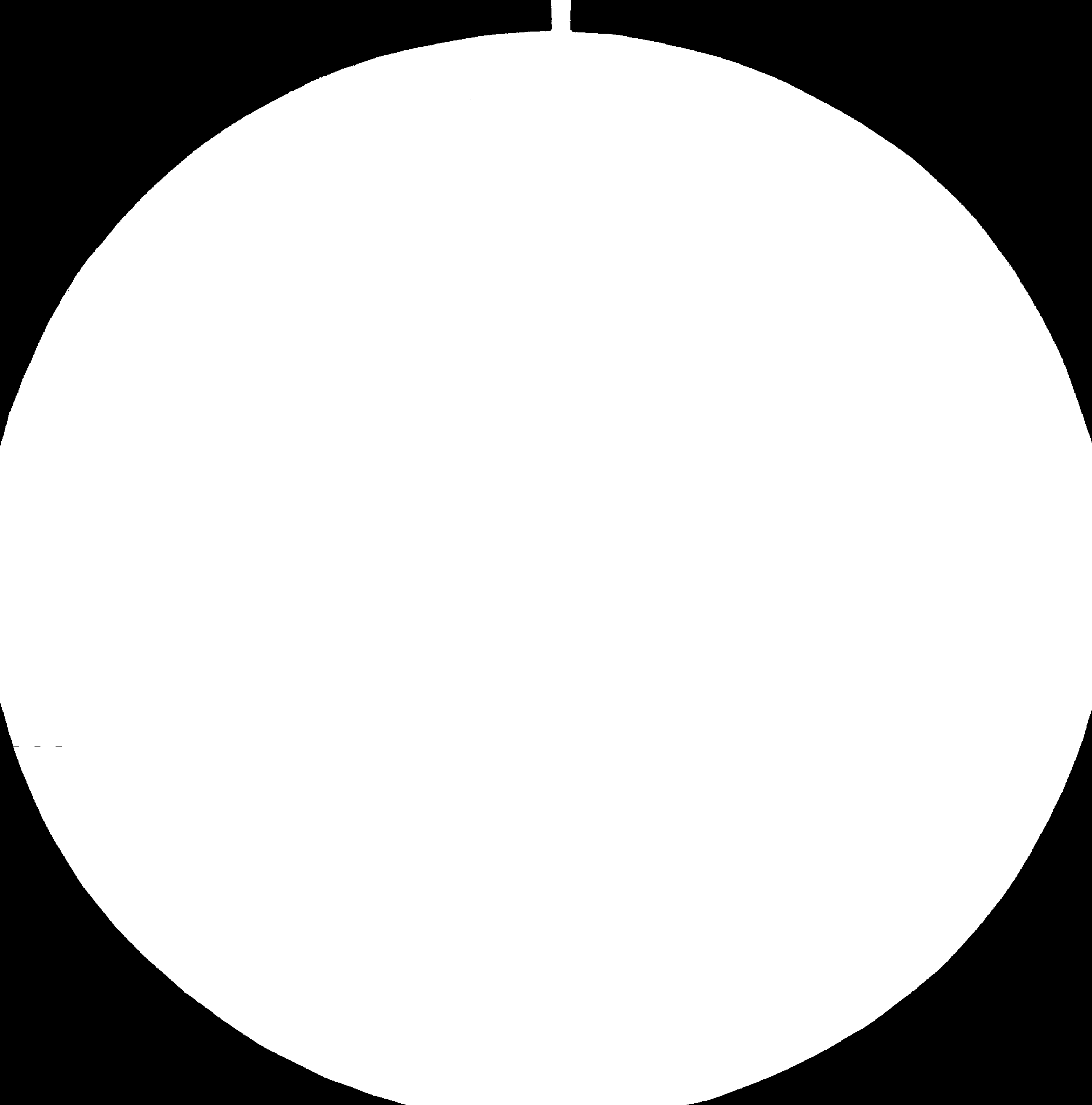
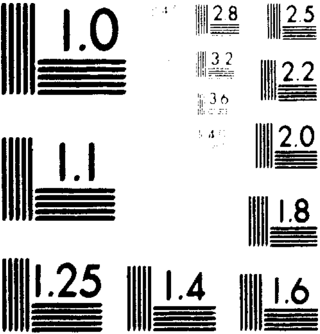




MICROCOPY RESOLUTION TEST CHART

the Plant on the first class road is of the important significance.

Railway - Though the minority of materials and inputs to the Plant and products from the Plant will be transported by railway, it will be convenient to place the Plant in the town with railway station.

Other transport facilities - are not significant for the Irrigation equipment manufacturing plant.

Power supply

Electricity from public utilities. The location of the Plant in the vicinity of the public high tension live is of utmost importance. Electricity from public line /ZESCO/ is the cheapest one in Zambia.

Fuel oil, coal, coke, gases - Consumption is neglectable, therefore for the location of the Plant not important.

Water Supply

Water supply will be either from public utilities or from private development of sub-surface suplies or surface supplies. The water for project is ascertained from the Plant capacity and technology /Chapter IV-3/.

Public utilities: Determination of the availability of the requisite quantities that could be obtained with the conditions of supply and price.

Private development of sub-surface or surface supplies:
Determination of separate facilities and their estimated costs that would have to be provided. The assessment of the quantity and determination of the quality of the water.

3.2 Socio-economic environment

Availability of labour - Labour requirements are given in Chapter VIII. The availability of skilled and semi-skilled workers is the most important factor of socio-economic environment. It is advisable to locate the Irrigation equipment manufacturing plant to the town with a training centre or with a technical college.

Waste disposal - Irrigation equipment manufacturing plant produces only solid waste materials and liquid emissions.

Classified solid waste materials /scrap/ are stored in concrete bins and sold to other plants. They are used as scrap in foundries etc.

Liquid effluents are not dangerous and therefore do not require special treatment.

Construction facitilites - The facilities available for civil construction, machinery erection or installation are good in big, industrial towns. This depends on the availability and quality of contractors and building materials. The best conditions in this respect are in Lusaka and in big towns in the Copper Belt Province.

Fiscal and legal regulations - In Zambia, fiscal and legal regulations are the same in different Provinces of the country, only land and personal levy are different. The level of this levy depends on the area and the location of the site, the existing infrastructure /roads, water main, sewerage, railway siding etc./ and manpower.

List on Local Conditions Existing and Required

Climate

Air temperature and precipitation in Zambia see Annex A - II.

Climatic conditions in Zambia are suitable for normal execution of machinery and equipment /i. e. without tropicalisation/. There is no need of heating in all places in Zambia and airconditioning is used only exceptionally in some offices.

Wind - There are no destructive winds /hurricanes etc./ or dust winds in Zambia.

Flooding from surface sources - There are no flooding seasons in Zambia.

Earthquakes - There are no earthquakes in Zambia.

Site and Terrain

Location of site - not given.

Site description - Ideal layout of the Plant with dimensions and geographical orientation - see Chapter VI.

Transport Facilities

Roads - The Plant should be placed on the first class road and the access road to the Plant should be also good. Transport rates Lusaka - Dar Es Salaam - see table.

Railway - We assume that the majority of raw materials to the Plant and products from the Plant will be transported by trucks and therefore the Plant will have not a siding of its own.

Water transport - Nil

Air transport - Not significant for the Plant. Airports are in all big towns in Zambia.

Passenger transport systems - Buses in big towns.

Water Supply

Characteristics

Dissolved content:	Potable water
Suspended matter:	hardness max. 7 pH, temperature
Temperature:	max. 20°C
Pressure:	maximum/minimum 0,4/0,3 MPa

Sources:

From public utilities: In big towns from public water main, pressure 0,3 - 0,4 MPa.

By private development of: sub-surface suplies /dug-out wells, deep wells, artesian wells/ or surface supplies /river, brook etc./.
Method of treatment: removal of suspended matter, removal of dissolved matter, biological treatment /if necessary/.

Power supply

Electricity from public utilities:

Supplier: ZESCO Zambia Electricity Supply Corp.Ltd.
Power avalable: 2000 kVA /incl. second stage of construction/
Voltage V: /high/low/ 11 000 V/380/220 V

Point of lie-in: The distance of the high-voltage line from the site /the point of tie-in/ should be the shortest possible.

Price /tariff/: Tariff D2

Fuel oil, gas oil

Consumption neglectable.

Coal, coke

Consumption: Nil

Gases

Acetylene: Small quantity, supplied in bottles from existing plant in Zambia

Oxygen: Small quantity, supplied in bottles from existing plants in Zambia

Carbon dioxide:
Small quantity, supplied in bottles from existing plants in Zambia

Steam Nil

Communication systems:

Telephone system:
automatic capacity 2 - 3 outside lines, 20 - 30 interna lines point of tie-in the distance should be the shortest as possible

Telex: preferably yes

Wireless: Nil

Waste disposal

Dumps Nil - stores of classified waste material in concrete bins

Sewage system

Type: Separated rainwater I.D. 300 mm material of pipes in the network - reiforced concrete; sewage - I.D. 200 mm, material of pipes stoneware

Sewage treatment plant - Neutralization tank in the vicinity of hot galvanizing shop

Manpower

Administrative Staff

Education background: Foreign and local universities, technical colleges /for example Northern Technical College Ndola, Zambia Institute of Technology Kitwe etc./.

Labour

Level of skill:	Grade I - IV
Availability:	Trainees of different training centres /for example Trade Training Centre Lusaka etc./

Construction, erection and maintenance facilities

Civil and mechanical contractors: Many firms in different towns with good or medium level of skill.

Building materials - see Annex B - name of firms, their products, quality etc.

Living conditions

Housing
Food
Recreation
Schools
Places of workship
Shopping facilities
Medical welfare

depends on the location of site.

Recommendation

Polytechna's team of experts recommends to locate the site of the Irrigation equipment manufacturing plant in the most populated belt around the railway line and highway from Livingstone to Lusaka, Ndola andKitwe, preferably in Lusaka or in the Copper Belt Province. All big towns on this line are suitable for this Plant.

ESTIMATE OF PRODUCTION COST

Land

No	Item	Quantity	Unit	Unit Cost K	Cost 1000 K		
					Foreign	Local	Total
	Annual payments for land (services)				-	9	9
	Total				-	9	9

VI. PROJECT ENGINEERING

6.1 SCOPE OF PROJECT,CHARTS, PROJECT LAYOUTS

Project charts and layouts define the scope of the entire project and serve as a basis for detailed engineering work.

Irrigation equipment manufacturing plant is typical case, when technology has to be independently acquired the selection of equipment should follow the determination of design of products and technology as these two are closely linked.

Before the elaboration of project documentation it should be determined:

- production programme and capacity
- location of the Plant
- selection of the site
- means of technology acquisition
- extent of documentation within the framework of know-how

Production programme and capacity, based on the demand and market study see Chapter III.

Location of the Plant and selection of the site see Chapter V.

Means of technology acquisition: The best for, of technology acquisition is technology licencing. A licence gives the right to use patented technology and the transfer of related know-how on mutually - agreed upon terms.

Extent of documentation provided within the framework of licence and related know-how.

Design and technological documentation for the manufacture of items stated in Chapter III will be provided within the framework of licence and related know-how in the following extent:

1. Specification of all parts, subgroups and groups, list of parts

2. Drawings of all manufactured parts, subgroups, groups and units, including wiring diagrams

3. Drawings of packings

4. Specification of castings - list of parts

5. Drawings of forgings

6. Specification of standardized parts including respective State Standard /BSS, DIN, GOST, CSN etc.

7. Technical conditions for manufactured products

8. Operating instructions

9. Precision certificates

10. Technological process sheets and instruction cards to all manufactured parts, subgroups and groups

11. Standards of materials consumption

12. Drawings of special tools

13. Lists of special tools
14. Lists of standardized tools
15. Relevant State Standards

Extention of documentation:

Documentation should be elaborated in the English language and supplied in one reproducible copy. It should use the metric system.

6.2 SCOPE OF PROJECT DOCUMENTATION

Project documentation /project charts and layouts/ should be elaborated in two stages:

1. Detailed project report
2. Working drawings

1. Detailed Project Report

This project documentation should contain:

1.1 General layout

General functional layout of the Plant in the scale 1 : 1000, showing the interrelationship between buildings and civil works, coordination of outside roads, sidewalks, service network systems, area of buildings, elevation of the site with indication of the extent of earthwork.

Technical report contains principles of architectonic design, and technical layout of Plant, description of site, description of connection of site to outside network of roads and various service lines /electricity, water, telephone, sewage/, principles of transportation system on the site, the elevation of the site, description of protective zones, description of fire fighting system.

1.2 Technological part

Technical report contains the following data:

- characteristics of shops and departments, production programme and capacity, working regime

- selection and description of technological process

- inputs of main and auxiliary materials

- specification of employees with indication of their professions

- solution of interplant transport

- solution of storing

- possibilities of extension of production

Drawings will contain:

- placing of machines and equipment in respective shops and departments, with indication of built-up area and execution of buildings

- materials flow diagrams

Specification of machines, equipment and inventory incl. all technical parameters for biding.

1.3 Energetical part

Energetical part will contain:

Drawings and technical report solving energy system incl. the layout of electric distribution system, compressed air, water etc.

- specification of machinery and equipment of energy system
- solution of routes /lines/ and dimensions of main outside energy systems
- main routes /lines/ of inside buildings

1.4 Civil engineering part

Civil engineering part will contain:

- architectonic and construction design of all buildings, ground plans and cross-sections and views of all buildings in the scale of 1 : 200
- technical report will contain:
- description of construction design of all buildings
- routes /lines/ and dimensions of outside and inside energy systems
- finishing of terrain /ground/ greenery
- roads, side walks and compacted areas

- detailed description of respective buildings incl. the type of structures, foundations, side walls, inside sewerage system,

- water mains /hygienic installations/, social amenities, lighting, and telecommunication system

- detailed description of respective civil engineering items, their execution and quality

- specification and quantity of raw materials, which will serve for bidding

The second stage of project documentation - Working Drawings

2.1 Technological and energetical part

Technological and energy part will contain:

- Detailed layout of machines and equipment in the scale of 1 : 100 for separate workshops or departments with dimension figures for each item /machine, equipment/ and indication of place of operator and indication of places of connections of all utilities, outlet of harmful matters etc.

- layout of flow of raw materials, components and parts

- layout scheme of power distribution system

- drawings of water and compressed air mains

- detailed specification of machines and equipment incl. special accessories

- technical report containing description of production and supplementing the drawing

2.2 Civil engineering part

Civil engineering part will contain:

- detailed working architectonic and construction drawings in the scale of 1 : 50 or 1 : 100

- shuttering drawings of concrete and reinforced concrete parts

- reinforcement drawings of reinforced concrete structures

- drawings of steel structures /but not production working drawings/

- calculation of consumption of concrete, reinforced concrete and steel structures

- drawing of architectonic or construction details in the scale of 1 : 50 or bigger

- diagrams and details of water mains, sewerage system, lighting and telecommunication lines

- technical reports and calculations of different jobs in respective buildings

- detailed specification of materials and technical specifications of all items for respective buildings

- specification of materials for all buildings

2.3 Utility mains

- Detailed drawings of utility mains and their coordination

- length and cross-sections

- details of crossing of different mains and other details

- calculation of details

- technical reports and calculations for respective mains

- detailed description of material and specification for all items of materials for respective mains

6.2 TECHNOLOGY OF PRODUCTION - SHORT DESCRIPTION

Production of irrigation equipment involves the following processes:

Cutting of materials:

Cutting of steel profiles, bars and sections on hack saws; sheets and strips are cut on table shears,eccentric and hydraulic presses.

Machining:

Components and parts are machined on machine tools: turning is performed on universal centre lathes and turret lathes, drilling on bench and column drilling machines and radial drilling machines, slotting on slotting machines, milling on universal and vertical knee-type milling machines, external and internal threading on external or internal threading machines, grinding on double wheel grinding machines,surface grinding machine and universal cylindrical grinding machine.

Hand operations:

Chamfering of machined or pressed parts, filing etc.

Heat treatment:

Annealing of components, parts and subassemblies in electric furnaces, hardening in oil and water tanks.

Surface treatment:

Painting by airless spraying, normal spraying or by dipping in electrostatic field for minor parts. Pickling before zinc, galvanizing, galvanizing in molten zinc, rinsing after galvanizing.

Mounting of joints on tubes:

Complete line, comprising pipe magazine with chute, pipe feeding equipment, machine for pipe chamfering and pressing of joints from both sides, machine for joints marking and pressure equipment for pipes pressure testing; flanging machine, special equipment for coating of sealing agent on internal wall of joints.
As already mentioned, tubes are made of aluminium, joints of steel.
In the case of joints these will be made of aluminium, there will be great changes of technology, mainly in pressing shop and mounting of joints.

Assembly and testing:

Assembly of parts to subassemblies by welding, pressing, riveting, screwing etc.

Testing:

Testing of pumps, pipes and sprinklers on equipment for testing of pumps, sprinklers and hand-operated pressure tester.

6.3 SUMMARY OF MACHINES AND EQUIPMENT

In the study there are specified essential machines and equipment of the main and auxiliary production. The study does not specify the equipment of store handling system, workshop equipment /shelf stands, work benches, vices and the like/, office furniture etc. This equipment and inventory are estimated generally by one item in the Estimate of Investment Cost-Equipment.

1/ Material preparation shop

		No. of pieces
1	Metal hacksawing machine max. dia of cut stock 280 mm, input: 2,2 kW	1
2	Metal hacksawing machine max. dia of cut stock 200 mm input: 0,7 kW	1
3	Table shears shearing length 2000 mm max. sheet thickness 4 mm input: 7,5 kW	1
4	Hand-operated lever shears shearing length 160 mm max. dia of cut material dia 13 mm flat iron 50 x 5 mm	1

2/ Pressing shop		No.of pieces
1	Eccentric press nominal forming force 250 kN No. of effective ram strokes 45 per minute input: 2,2 kW	1
2	Eccentric press nominal forming force 400 kN No. of effective ram strokes 45 per minute input: 3 kW	1
3	Eccentric press nominal forming force 630 kN No. of effective ram strokes 45 per minute input: 4 kW	1
4	Eccentric press nominal forming force 1000 kN No. of effective ram strokes 30 per minute input: 5,5 kW	1
5	Eccentric press nominal forming force 1600 kN No. of effective ram strokes 30 per minute input: 11 kW	3
6	High-speed hydraulic press nominal pressure 2500 kN, table dimensions 900 x 660 mm input: 15,5 kW	8

7	Special cutting off machine for joints cutting with device for flash rolling out input: 4 kW	2
8	Hydraulic press nominal pressure 400 kN table dimensions 500 x 560 mm input: 8 kW	2
9	Hacksawing machine max. dia of cut stock 200 mm input: 0,8 kW	1

3/ Machining shop	No. of pieces
1 Universal centre lathe swing over bed 380 mm distance between centres 750 mm input: 6,2 kW	2
2 Universal centre lathe swing over bed 500 mm distance between centres 1000 mm input: 7,5 kW	3
3 Universal centre lathe swing over bed 655 mm distance between centres 1250 mm input: 18,5 kW	1
4 Universal centre lathe swing over bed 840 mm distance between centres 1250 mm input: 18,5 kW	1
5 Turret lathe with vertical axis of turret head swing over bed 510 mm max. spindle capacity 50 mm input: 7,5 kW	8
6 Turret lathe with horizontal axis of turret head swing over bed 530 mm max. spindle capacity 63 mm input: 6,0 kW	4

7	Bench drilling machine max. drilling capacity 10 mm input: 0,4 kW	1
8	Bench drilling machine max. drilling capacity 20 mm input: 1,5 kW	3
9	Column drilling machine max. drilling capacity 32 mm input: 2,2 kW	3
10	Radial drilling machine max. drilling capacity 25 mm distance of spindle axis to column 230 to 800 mm input: 1,5 kW	3
11	Radial drilling machine max. drilling capacity 50 mm distance of spindle axis to column 320 to 1250 mm input: 7,0 kW	2
12	Pedestal drilling machine max. drilling capacity 80 mm input: 7,8 kW	2
13	Slotting machine slotting height 290 mm table diameter 500 mm input: 6,9 kW	1

14	Universal knee-type milling machine table clamping surface 450 x 2000 mm input: 21,0 kW	1
15	Vertical knee-type milling machine table clamping surface 350 x 1600 mm input: 8,6 kW	1
16	Table internal threading machine range of cut threads M6 to M 16 input: 1,0 kW	1
17	External threading machine range of cut threads 1/8" to 3 1/2" input: 3,5 kW	1
18	Pneumatic handling equipment loading capacity 150 kg	7
19	Pedestal double-wheel grinding machine grinding wheels diameter 250 mm input: 2,2 kW	3

4/ <u>Mounting of joints for tubes</u>	No. of pcs
1 Complete line for mounting of joints on long irrigation pipes comprising: - pipe magazine with chute - pipe feeding equipment - machine for pipe chamfering and pressing of joints from both sides simultaneously - machine for joints marking on pipe from both sides simultaneously - pressure equipment for pipes pressure testing of finished irrigation pipes input: 34 kW	2
2 Hydraulic press, nominal pressure 400 kN table dimensions 300 x 560 mm input: 8 kW	1
3 Flanging machine, max. sheet thickness 2 mm, throat 700 mm input: 1,5 kW	1
4 Special equipment for coating sealing agent on internal wall of joints	1
5 Drying table for sealing agent drying input: 2 kW	1
6 Bench drilling machine max. drilling capacity 20 mm input: 1,5 kW	1

	5/ Assembly shop and testing room	No. of pcs
1	Column drilling machine max. drilling capacity 32 mm input: 1,5 kW	1
2	Bench drilling machine max. drilling capacity 10 mm input: 0,4 kW	1
3	Hydraulic press nominal forming force 100 kN input: 2,2 kW	1
4	Flame welding unit, complete acetylene + oxygen	2
5	Mobile welding rectifier, semi-conductive type permanent welding current 250 A input: 24,3 kVA	3
6	Welding table with exhaustion input: 0,6 kW	2
7	Double-wheel grinding machine grinding wheel diameter 250 mm	1
8	Table lapping machine input: 1,2 kW	1
9	Pneumatic handling equipment loading capacity 250 kg	2

10 Equipment for testing of pumps consisting of:
- metal-made welded tank of dimension 3000 x 4000 x 1500 mm
- cast iron clamping plate for aggregate clamping
- measuring facilities and piping connections 1

11 Equipment for sprinklers adjustment consisting of piping system and measuring facilities 1

12 Hand-operated pressure tester testing pressure 10 MPa

6/ Paint shop | No.of pcs

1	Equipment for paint application by dipping in electrostatic field for minor parts, complete including exhaustion equipment and paint preparation unit input: 20 kW The equipment embraces these processes: - degreasing - priming paint application by dipping - drying - top paint application by dipping - drying	1
2	Bench spraying booth, complete incl. exhaustion of turntable etc. input: 5 kW	1
3	Complete equipment for paint application by spraying, airless, incl. spraying guns hose magazine, cleaner, paint mixer in packings and the like	

7/ Heat treatment and forge shop — No.of pcs

1	Electric oil-fired annealing furnace muffle dimensions 1500x x1200x1500 mm, rated temperature 960°C, working in protective atmosphere incl. generator of protective atmosphere input: 60 kW	1
2	Electric chamber furnace working space dimensions 600x450x900 mm temperature 960°C input: 34 kW	1
3	Electric chamber silit furnace working space dimensions 540 x 620 x 800 mm temperature 1350°C input: 37 kW	1
4	Electric shaft furnace working space dimensions dia 500 x 600 mm temperature 650°C input: 18 kW	1
5	Oil hardening tank internal dimensions 1050x400x760 mm capacity: 530 liters	1
6	Water hardening tank, internal dimensions 1050 x 400 x 750 mm capacity: 530 liters	1

7	Hardening table for air hardening input: 0,6 kW	1
8	Apparatuses for hardness measurement	2
9	Degreasing machine, working space dimensions 960 x 560 x 450 mm tank capacity: 165 liters bath temperature 70 - 90°C input: 16,5 kW	1
10	High-frequency generator for heating of material for forging incl. transformer max. input: 50 kW	1
11	Hydraulic press nominal pressure 400 kN table dimensions 500 x 560 mm input: 8 kW	1
12	Pedestal double-wheel grinding machine grinding wheel diameter 250 mm input: 2,2 kW	1
13	Tumbler drum dimensions dia 500x600 mm input: 1,1 kW	1

8/ Hot galvanizing shop

		No. of pieces
1	Electric resistance furnace with metallic tank for zinc melting tank dimensions dia 2000x1500 mm input: 3 x 150 kW	1
2	Tank for pickling, rubber-lined internal dimensions 2250x800x950 mm with exhausting frame exhausted quantity of air 4000 cu.m./hr.	1
3	Rinsing tank after pickling, rubber-lined, internal dimensions 2250 x 800 x 950 mm	1
4	Tank for cooling after zinc coating, rubber-lined, internal dimensions 2250 x 800 x 950 mm	1
5	Pneumatic handling equipment loading capacity: 200 kg	1

9/ Tool grindery		No.of pieces
1	Universal tool grinding machine swing 290 mm input: 2,2 kW	1
2	Twist drill sharpening machine range of sharpened drills 2 to 100 mm, point angle 80°-170° input: 3,0 kW	1
3	Grinding and lapping machine for turning tools grinding wheel diameter 175 mm input: 0,65 kW	1
4	Pedestal double-wheel grinding machine, grinding wheel diamtere 250 mm input: 2,2 kW	1
5	Bench-type double-wheel grinding machine, grinding wheel diameter 175 mm input: 0,5 kW	1

10/Tool room and repair shop

		No.of pieces
1	Centre lathe swing over bed 400 mm distance between centres 1000 mm input: 5,5 kW	1
2	Centre lathe swing over bed 635 mm distance between centres 2000 mm input: 18,5 kW	1
3	Tool room milling machine table clamping surface 400 x 1000 mm input: 3,1 kW	1
4	Vertical milling machine table clamping surface 450x2000 mm input: 18,5 kW	1
5	Bench drilling machine max. drilling capacity 20 mm input: 1,5 kW	1
6	Radial drilling machine max. drilling capacity 50 mm distance of spindle axis to column 300 - 1250 mm input: 7,0 kW	1

7	Universal cylindrical grinding machine swing 280 mm distance between centres 1000 mm input: 6,6 kW	1
8	Surface grinding machine table clamping surface 400 x 1000 mm input: 10,5 kW	1
9	Universal tool grinding machine swing 290 mm input: 2,2 kW	1
10	Double-wheel grinding machine grinding wheel diameter 250 mm input: 2,2 kW	1
11	Mobile welding rectifier, semi-conductive permanent welding current 250 A input: 24,3 kVA	1
12	Welding table with exhaustion input: 0,6 kW	1

11/ <u>Mechanical handling</u>		No.of pieces
1	High-lift truck with side loading width of loading platform 1200 mm lift 4000 mm loading capacity: 1200 kg drive: internal combustion engine	1
2	High-lift truck loading capacity 1000 kg lift 3300 mm drive: internal combustion engine	2
3	Hand trucks high-lift, low-lift, platform, sidecars, flat pallets, box pallets and the like	

6.4 GENERAL LAY-OUT, PRINCIPLES OF ARCHITECTONIC DESIGN

As the location and site of the Irrigation equipment manufacturing plant is not known, an ideal architectonic design was worked out.
The Plant is projected in three zones:

- entrance zone
- production zone
- zone of auxiliary shops

The Entrance zone includes these buildings:
- entrance with door keepers' lodge for inflow of materials and entrance of employees
- administration building
- social amenities - cloakrooms, lavatories, WC
- parking lot for cars, motorcycles and bicycles

Production zone:
- main production building with stores
- mounting of joints with stores

Zone of auxiliary shops:
- transformer station
- compressor station
- hot galvanizing shop
- heat treatment shop
- garages
- store of combusti' les
- scrap yard

Area /aereage/:

Land	37 000 m2	/100 %/
Built-up area	6 000 m2	/ 16%/
Communications, side-walks, compacted area	6 000 m2	/ 16%/
Greenery	25 000 m2	/ 68%/

BUILDINGS

Main production building /Building 1 and 2/

Light steel structure without cranes, with light roofing /carved asbestoscement sheets/ outside walls made of steel sheets, floor made of concrete. Building has 6 bays, span 12 m, height to the trusses 6 m. Side walls are executed only around the area 60 x 48 m, the remaining part of the building is only roofed.

Total built-up are 4 320 m2

Building 3 and 4 - Mounting of joints

Light steel structure, without cranes, with light roofing /carved asbestoscement sheets/, without side walls, flooe made of concrete.
The first and third bay have span 12 m, the second bay has 9 m span.
Around this building is free area with concrete floor for stores of pipes.

Total built-up area	540 m2
Free area with concrete floor	2 260 m2

Hot galvanizing shop, heat treatment shop, Bldg. No.5

One-bay building, steel structure, span 12 m, with light roofing /carved asbestoscement sheets/, and concrete floor without side walls.

Total built-up area	360 m2

Store of combustibles - Bldg. No. 6

Brick walls, light roof steel structure, floor made of concrete.

Total built-up area	108 m2

Transformer station and compressor house - Bldgs. No.7,8

Structure reinforced concrete skeleton with brick walls, floor made of concrete.

Built-up area	2 x 54 m2

Garages - Bldg. 9

Light steel structure, with light roofing /carved asbestoscement sheets/, without side walls.

Built-up area	162 m2

Scrap yard - Bldg. No.10

Free area with concrete flooring and side walls made of concrete.

Built-up area	36 m2

Social amenities - Bldg. 11

Three-storeys building; reinforced concrete skeleton, with brick walls. Modulus 6 x 9 m. Height of one storey 3 m.

Built-up area	216 m2
Floor area	648 m2

Gate house - Bldg. 13

Building 4 x 8 m, brick walls, light roof /carved asbestoscement sheets/-

Built-up area	32 m2

Parking lot

Free area with concrete floor.	300 m2

Roads and sidewalks

Width of main roads is 6 m, width of other communications is 3 - 4 m.
Width of side walks is 3 - 4 m.

Fencing

The fence is 780 m long. In the entrance area there is gate made of bricks and steel, other parts is wire mesh with steel fencing tubes.

IMPORT DUTY

Item	Percentage of Foreign Price
Machine tools and presses	10 %
Wood working machine	10 %
Electric motors	10 %
Furnaces	10 %
Cranes	10 %
Fork lifts	10 %
Trucks	10 %
Transformers and equipement	10 %
Compressors	10 %
Pumps	10 %
Valves, fittings	Ø
Ball bearings	10 %
Bolt, nuts and washers	10 %
Aluminium in blocks	Ø
Aluminium pipes	Ø
Aluminium fittings	25 %
Steel rods, sections etc.	Ø
Electrodes for welding	Ø
Measuring equipment	30 %
Hand tools	Ø
Electric portable tools	10 %
Cutting and pressing tools	10 %
Paints	30 %
Cables	Ø
Telephone sets	10 %

CIVIL ENGINEERING WORKS

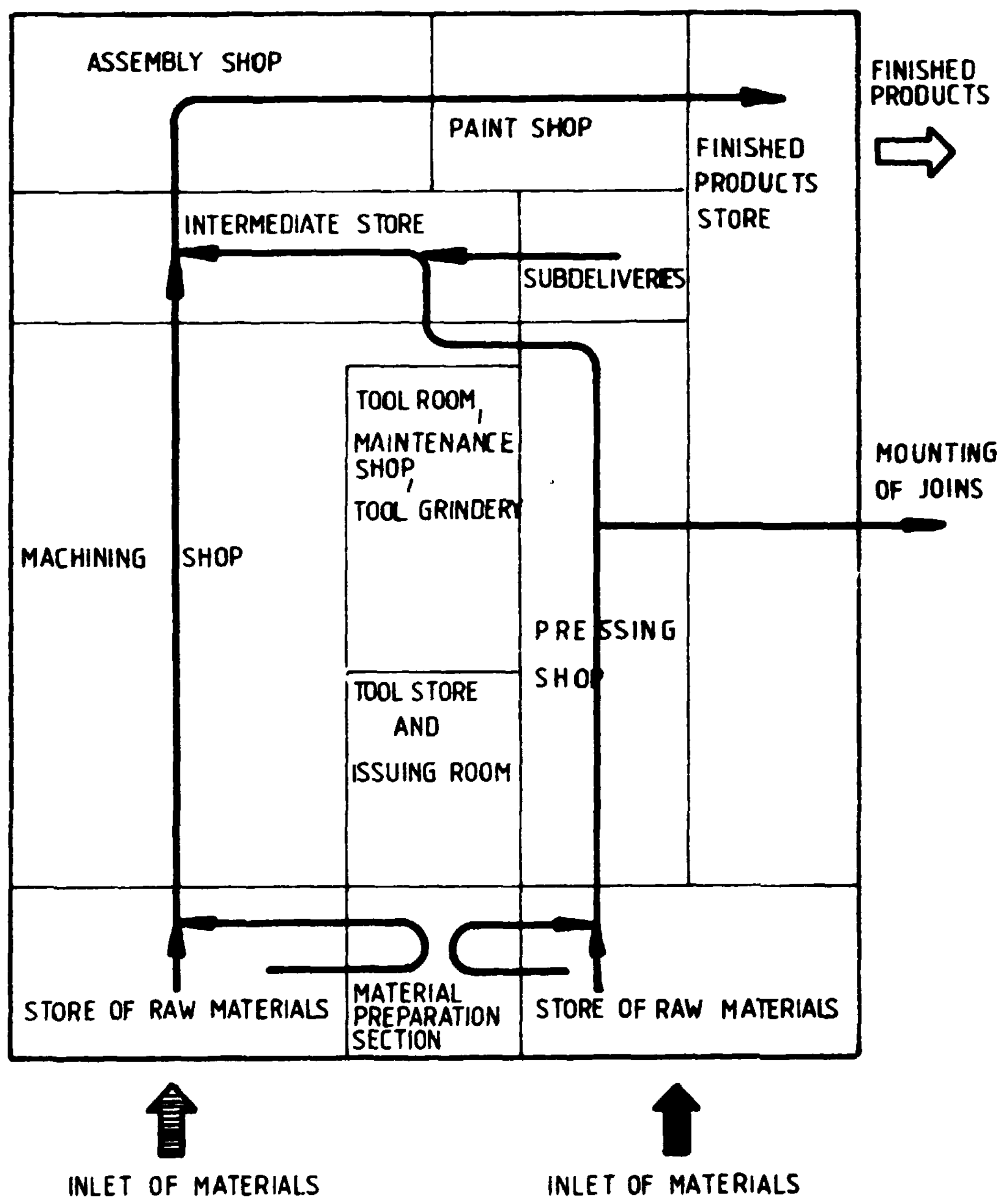
Estimated Unit Rates as per 31.12.1980

Source : INDECO Ltd, ZESCO Lusaca and other firms

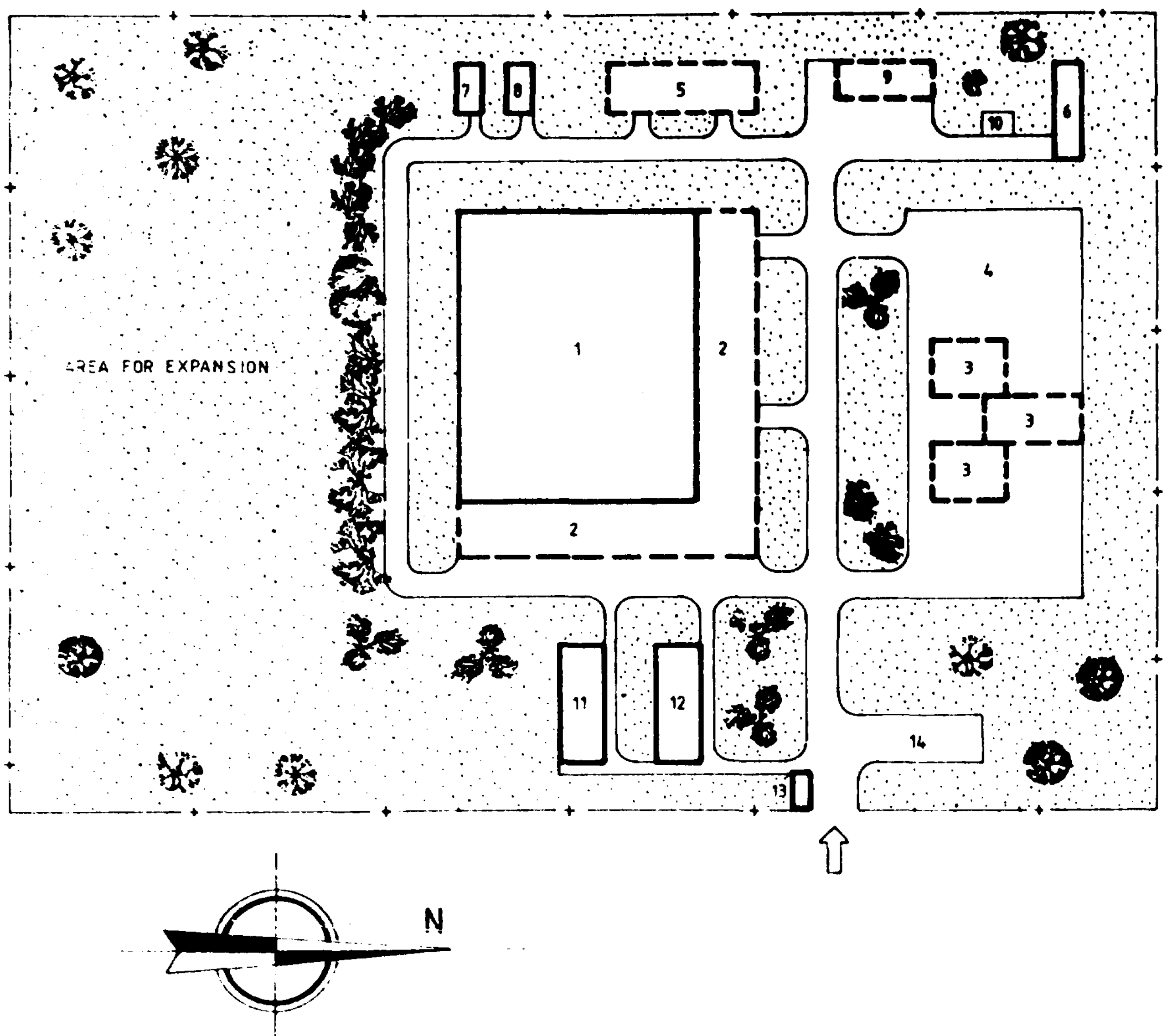
Item	Unit	Rate K
Excavation	m^3	3
Earthwork	m^3	5 - 6
Laterite Fill	m^3	3
Ant-repellent	m^2	2
Concrete in foundation	m^3	100
Concrete in plinth beams	m^3	100
Concrete in floor : 200 mm	m^2	20
: 500 mm	m^2	24
Formwork (shuttering etc.)	m^2	20
Steel reinforcement	kg	2
Mesh steel reinforcement in floor	m^2	3
Blockwork	m^2	21
Structural steel incl. erection	ton	1500
Asbestos in roofing and cladding	m^2	10
Fibre glass transluent sheets	m^2	25
Roads - asphalt couted	m^2	12 - 15
- sidewalks	m2	10 - 12
Fence (incl. gate)	m	35
Foundations for machines - with reinforcing	m^3	150
- without reinforcing	m3	100
<u>Buildings</u> - incl. erection of steel structures, flooring, side walls, ventilation, lighting conductors and rods, lighting installation		
Workshop buildings, steel structure		
- span of bay 18 m, without cranes	m^2	220
- span of bay 18 m, with crane of 5 Mp capacity	m^2	270
Administrative 3 storey building - each storey	m^2	350

Item	Unit	Rate K
Social and administrative annex	m^2	300
Store of inflammables	m^2	200
Garages	m^2	180
Entrance building and door keepers lodge	m^2	250
Canteen incl. equipment	m^2	350
Bicycle and motorcycle shed	m^2	150
Compressor house	m^2	250
Water distribution / Sewerage system / Compressed air distribution: price of pipes plus 100 % plus price of excavation	m	
Source : INDECO Ltd.		
11 kV line	m	10
Transformer 500 kVA 11 kV/380/220 V (incl. erection)	piece	18500
High - tension cables (incl. erection)	m	30
Low - tension cables	m	30
Outdoor lighting	m	20
Subdistribution board 200 kVA (incl. erection)	piece	2000
Source : ZESCO Lusaka		

FLOW OF MATERIALS IN MAIN PRODUCTION BUILDING



IDEAL LAYOUT



LEGEND

1 MAIN PRODUCTION BUILDING
2 STORES
3 MOUNTING OF JOINTS
4 STORES
5 HOT GALVANIZING SHOP, HEAT TREATMENT
6 STORE OF COMBUSTIBLES
7 COMPRESSOR HOUSE
8 TRANSFORMER STATION
9 GARAGES
10 SCRAP YARD
11 SOCIAL AMENITIES
12 ADMINISTRATIVE BUILDING
13 GATE HOUSE
14 PARKING PLACE

OPEN ROOFED BUILDINGS

BUILDINGS WITH SIDE WALLS

COMPACTED AREA, ROADS, SIDE WALKS

FENCING

Table 6 - 1

ESTIMATE OF INVESTMENT COST

Technology costs - lump - sum payments

See page X - 4

No	Item	Quantity	Unit	Unit cost K	Cost 1000 K		
					Foreign	Local	Total
	Technology costs - lump - sum payments				120	-	120
	Total				120	-	120

Table 6 - 2

ESTIMATE OF INVESTMENT COST

Equipment

No	Item	Quantity	Unit	Unit CostK	Cost 1000 K Foreign	Local	Total
1	Material preparation shop				34,-	3,5	37,5
2	Pressing shop				1180,-	72,7	1252,7
3	Machining shop				1360,-	76,3	1436,3
4	Mounting of joints				870,-	62,5	932,5
5	Assembly shop and testing room				145,-	9,-	154,0
6	Paint shop				340,-	35,8	375,8
7	Heat treatment and forge shop				270,-	14,7	284,7
8	Hot galvanizing shop				105,-	6,2	111,2
9	Tool grindery				33,-	2,9	35,9
10	Tool room and repair shop				310,-	16,4	326,4
11	Mechanical handling				110,-	15,-	125,-
	Transformerstation incl. switching station				45,-	6,-	51,-
	Compressor house incl. cooling micro-tower				105,-	10,-	115,-
	Subdistribution boards low tension, cables	700	m		-	37,-	37,-
	Common utility tools, portable electric tools, gauges				480,-	--	480,-
	Special tools				720,-	-	720,-
	Spare parts				180,-	-	180,-
	Workshop and office furniture, typewrites, calculating machines, trucks and cars				120,-	215,-	335,-
	Weak - current system				95,-	25,-	120,-
	Total				6.502	6080	7110

Table 6 - 3

ESTIMATE OF INVESTMENT COST

Civil engineering works

Source : Page VI - 35

No	Item decsription	Quantity	Unit	Unit Cost K	Cost 1000 K		
					Foreign	Local	Total
	<u>Building</u>						
1	Main production building	2880	m^2	220	-	633,6	633,6
2	Stores	1440	m^2	200	-	288,-	288,-
3	Mounting of joints	210	m^2	200	-	42,-	42,-
4	Stores	330	m^2	200	-	66,-	66,-
5	Hot galvanizing shop, heat treatment shop	360	m^2	200	-	72,-	72,-
6	Store of combustibles	108	m^2	200	-	21,6	21,6
7	Compressor house	54	m^2	220	-	11,9	11,9
8	Transformer station	54	m^2	220	-	11,9	11,9
9	Garages	162	m^2	180	-	29,2	29,2
10	Scrap yard	36	m^2	50	-	1,8	1,8
11	Social amenities	432	m^2	300	-	129,6	129,6
12	Administrative building	648	m^2	350	-	226,8	226,8
13	Gate house	32	m^2	250	-	8,-	8,-
	Fence (incl. gate)	780	m	35	-	27,3	27,3
	Roads, sidewalks	6000	m^2	14	-	84,-	84,-
	Water distribution (approx)	1300	m	35	-	45,5	45,5
	Rain-water drainage (approx)	700	m	40	-	28,-	28,-
	Sewerage system (approx)	1300	m	45	-	58,5	58,5
	Compressed air distribution	350	m	18	-	56,3	56,3
	High-tension cables (approx)	200	m	30	-	6,-	6,-
	Low-tension cables (approx)	1000	m	30	-	30,-	30,-
	Outdoor lighting	1500	m	20	-	30,-	30,-
	Earthwork (estimate)	10000	m^3	6	-	60,-	60,-
	Green area	25000	m^2	2	-	50,-	50,-
	Total					1968,-	1968,-

VII. PLANT ORGANIZATION AND OVERHEAD COSTS

PLANT ORGANIZATION AND OVERHEAD COSTS

Summary of shops and sections in the Plant

Building:	Sections of the Plant:	
Main production building	Stores	Castings, steel, subdeliveries, tools
	Main production	Preparation of materials Pressing shop Assembly shop and testing room
	Auxiliary shops	Tool room and maintenance shop Tool sharpening shop
	Store of products	Store of products and completion of supplies
Mounting of joints	Stores of raw materials	Aluminium pipes
	Main production	Mounting of joints
	Store of products	Irrigation suction pipes

Hot galvanizing shop heat treatment shop	Main production	Hot galvanizing shop heat treatment shop and forge shop
Store of combustibles	STore	Paints, thinning agents, oil, petrole
Energetical buildings		Transformer station Compressor station
Garages		Cars and trucks, fire-fighting equipment
Scrap yard	Store	Scrap
Social amenities		Cloakroom, lavatory,WC
Admin. building		Offices of management of plant, development and designing department, production documentation,economic department, commercial department, telephone--exchange, buffet etc.

Overhead costs

Factory overheads

Wages and salaries /including benefits and social security contributions/ of manpower and employees not directly involved in production - are included in Chapter VIII. Auxiliary material, office supplies and utilities /water, electricity, gases etc./ are included and calculated in Chapter IV. Repair and maintenance /contractual/ is given in this chapter.

Administrative overheads

Wages and salaries /including benefits and social contributions/ are included in Chapter VIII.

Office supplies, utilities are included in Chapter IV.

Communications, engineering costs, insurances are given in this chapter.

Depreciation charges - are dealt with separately in Chapter X.

Financial costs - interest on term loans etc. are treated separately in Chapter X.

Organization chart of the Plant

Organization chart of the Plant /see table 7-2/ is elaborated for the full capacity of the Plant with regard to prospective extension of the Plant after the year 1990 /the second stage of construction/.

High ratio of total manpower to supervisory and managerial staff 3,75 : 1 /see Chapter VIII/ is influenced by the fact, that part of technical staff forms designing department of irrigation systems

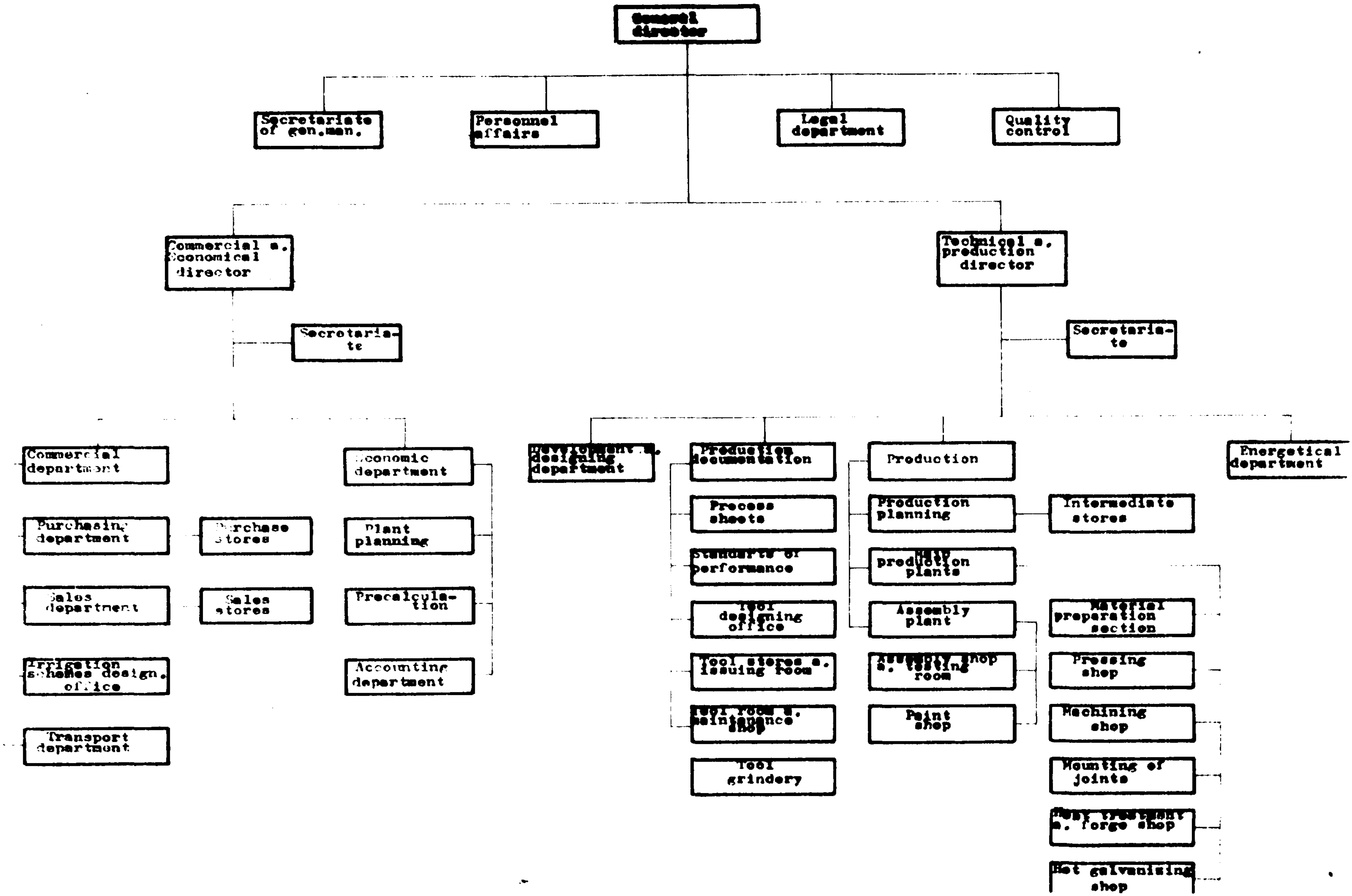
/normally designs of irrigation systems are worked out by special engineering firms and supplied to Irrigation equipment manufacturing plants/.

ESTIMATE OF PRODUCTION COST

Overhead costs

No	Item	Quantity	Unit	Unit Cost K	Cost 1000 K Foreign	Local	Total
1	Wages and salaries /incl. benefits and social security contributions/ of manpower and employees not directly involved in production - included in Chapter VIII.						
2	Auxiliary material, office supplies, utilities (water, electricity, gas-included in Chapter IV.						
3	Repair and maintenance - equipment and civil engineering				30	150	180
4	Communications - telephone, telex, postage, transport cost, trips				-	160	160
5	Replacement of special tools				380	20	400
6	Insurance				-	110	110
7	Taxes, rents, unforessen costs					200	200
	Total				410	640	1050

ORGANIZATION CHART OF THE PLANT



VIII. MANPOWER

MANPOWER

The determination of labour inputs for the Plant is based on the following working regime:

Number of working hours per day in one shift	9
Number of shifts per day	1
Number of working days per week	5
Number of working hours per week	45

Calculation of effective working days per year

Number of days per year	365
Deduct Saturdays and Sundays	- 104
	261

Deduct paid unproductive working days:

Official and religions holidays	11,	paid 7
Leave		paid 18
Sickness	8,	paid 6
Total paid unproductive days		31

Paid working days: 261 - 4 days holidays - 2 days sickness = 255 days

Effective working days 255 - 31 = 224 days

Paid working hours 255 x 9 = 2295 hours

Effective working hours of labour
224 x 9 = 2016 hours

Effective working hours of machines
2016 - 5 % for repairs = 2016 - 101 = 1916 hours

Note: Effective working days and hours are used for capacity calculation, paid working days and hours for calculation purposes of costs.

Workers

Total number of workers in main production and in auxiliary shops	190
from this - general workers /without qualification/	30
- grade I and II /trained/	70
- grade III and IV /qualified/	90

For information there are given the basic professions of workers for main production and auxiliary shops:

Machine operators trades

Turners, lathe operators
Capstan lathe operators
Drillers, drilling operators
Millers, milling operators
Grinders, grinding operators
Press operators
Sharpeners of tools /tool sharpener/

Hand workers /manual trades/

Welders-electric /electr. are welding operators/
Welders - flame /flame welding machine operators/
Tool makers
Mechanical fitters
Assembly fitters
Electrician - fitters
Lay-out men /markers/
Hardener
Painters

The number and qualifications of workers needed for the Plant stem from the individual working processes which will have to be carried out to obtain the required finished products of the Plant and to provide for its uninterrupted operation. It should be kept in mind that the mastering of the manufacture of irrigation equipment puts high requirements on the workers' qualifications.

The number of workers has been determined on the basis of the working regime indicated above.

Irrigation equipment manufacturing plant should be built in the area, where manpower and occupational skills is available. It is presupposed that many workers will be trained in the Plant in the pre-production phase, to achieve within the shortest time the highest skillness /see Chapter IX/.

Supervisory and managerial staff

The determination of supervisory and managerial staff is based on the working regime given above and on the organization chart, given in Chapter VII.

Total number of supervisory and managerial staff is	69
from this engineers and technicians, including foremen and store keepers	49
administrative staff - clerks, book-keepers, secretaries and typists	20

It is presupposed that in the first period of start-up 5 - 6 foreign experts will be employed in the Plant - see estimate of production costs.

Some members of supervisory and managerial staff should be trained for short period abroad in the plant, collaborating with the new Irrigation equipment manufacturing plant in Zambia /granting licences, know-how etc./.

Staff

General director	1
Technical adn production director	1
Commercial and economical director	1
Production director	1
Managers - commercial department economic department, development and design department, production, production documentation, production, irrigation schemes designing office	6
Lawyer	1
Chiefs of department - secretariate of gen. director, personnel affairs, quality control, accounting department, chief of production	7
Technicians - designers of irrigation equipment, tools etc., efficiency standards, sales, purchase, transport department, energet. department, process sheets, production planning	22
Foremen	11
Store keepers	4

Administrative clerks, tool-keepers etc.	5
Secretary	5
Typists	4
T o t a l	69

Ratio: total manpower: staff	3,75 : 1
workers:staff	2,75 : 1

Both ratios are influenced by the fact, that the organization chart of the Plant is elaborated with regard to the extension of the Plant after the year 1990 /the second stage of construction/ - and that the Plant has its own designing department of irrigation systems - /see Chapter VII/.

Designing department of irrigation systems is of vital importance for Zambian economy.

ESTIMATE OF PRODUCTION COST

Wages

No	Item	Quantity	Unit	Unit cost K	Cost 1000 K Foreign	Local	Total
	General workers : 30 x 2295	68850	hour	0,5	-	34,4	34,4
	Operator - grade I.:30x2295	68850	"	0,7	-	48,2	48,2
	- grade II:40x2295	91800	"	0,8	-	73,4	73,4
	-grade III:50x2295	114750	"	1,-	-	114,8	114,8
	- grade IV:40x2295	91800	"	1,2	-	110,2	110,2
	Bonuses - average 15K(month) worker	2280	month	15,-		34,2	34,2
						415,2	415,2
	Overhead : Lodging, voluntary extra pay for food in canteen, Zambia National Provident Fund, overtime, Workers Compulsion fund etc.					145,8	125,8
	Total					561,0	561,0

Table 8 - 2/1

ESTIMATE OF PRODUCTION COST

Salaries

No	Item	Quantity	Unit	Unit Cost K	Cost 1000 K		
					Foreign	Local	Total
	General director	1	year	16000	-	16	16
	Technical and production director	1	year	15000	-	15	15
	Commercial and economical director	1	year	14000	-	14	14
	Production director	1	year	20000	20	-	20
	Managers - commercial department, economic department development and design depart. production, production documentation production irrigation schemes	6	year	local 12000 foreign 17000	34	48	82
	designing office Langer	1	year	12000	-	12	12
	Chiefs of department (secretariate of gen. man., personnel affairs, quality control accounting department, tool designing dept., chiefs of production	~~8~~ 7	year	foreign 16000 local 11000	16	66	82
	Technicians - designers of irrigation equipment tools etc, efficiency standards sales, purchase, transport depart, energet. depart., process sheets, production planning	22	year	9500	-	209	209
	Foremen	11	year	7000	12	70	82
	Storekeepees	4	year	6000	-	24	24

No	Item	Quantity	Unit	Unit Cost K	Cost 1000 K Foreign	Local	Total
	Administrative clerks bookkeepers etc	5	year	6000	-	30	30
	Secretary	5	year	5000	-	25	25
	Typists	4	year	4000	-	16	16
	Subtotal				82	545	627
	Bonuses, increments, notches				26	163	189
	Overhead : Personal levy, lodging, Zambia National Provident Fund, overtime, selective tex, voluntary extra pay for food in canteen etc.				41	303	344
	Total				149	1011	1160

IX. IMPLEMENTATION SCHEDULING

IMPLEMENTATION SCHEDULING

The project implementation the construction period coveres the period f[illegible] the decision to invest, includes a number of activities [illegible] the start of commercial production.

The attached time schedule stipulates 2 years 6 months for construction period. After this period there is start-up period, lasting 4,5 years.

In the 8th year /i.e. after 5,5 years of production/ the Plant will reach its full capacity.

All details are given in time schedule and estimate of investment costs - project implementation.

TIME TABLE

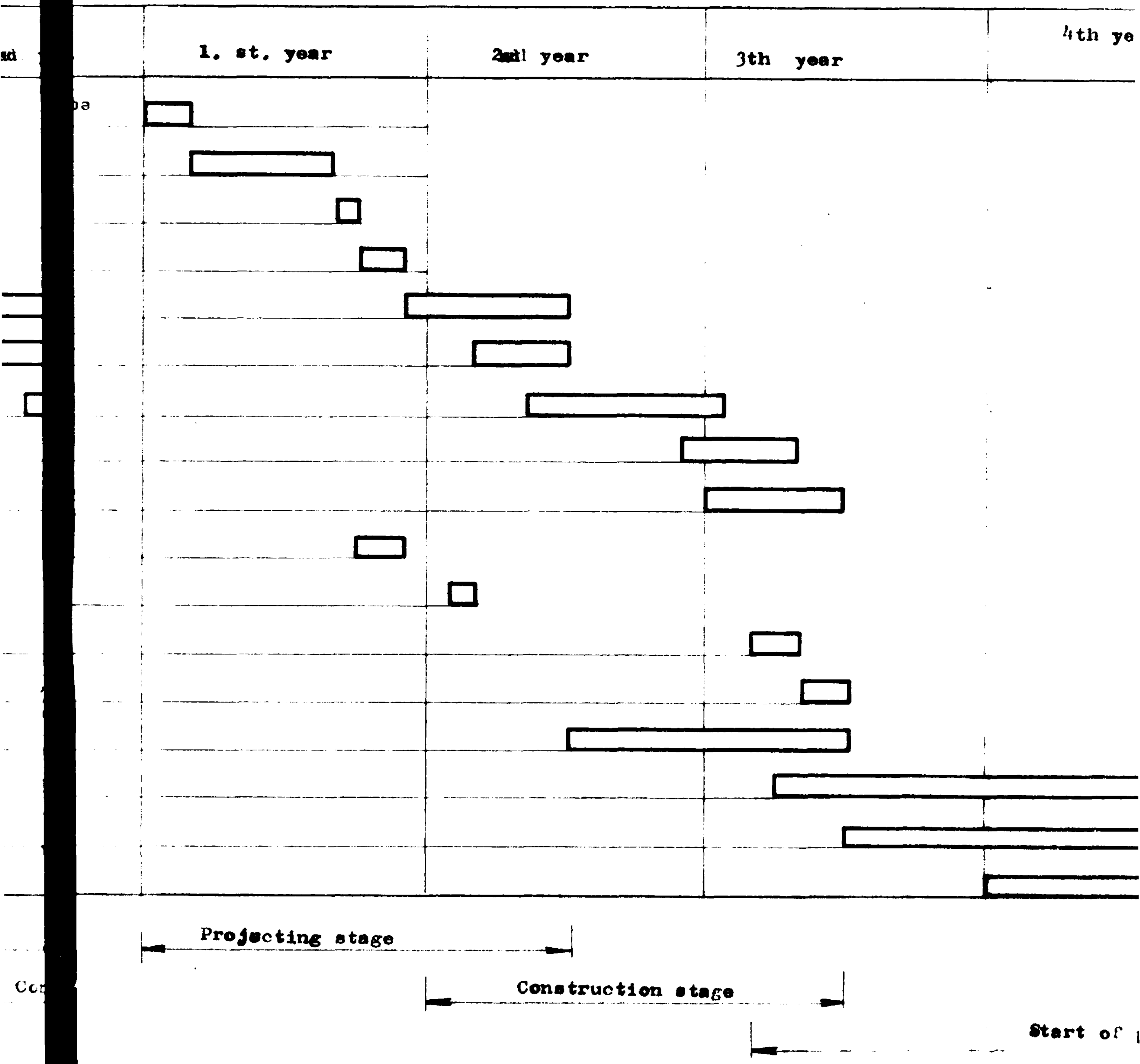
ACTIVITY	1. st. year	2nd
Selection of site, survey of site, data for D.P.R. (collecting of background documents needed for the elaboration of D.P.R.		
Detailed Project Report		
Approval of Detailed Project Report		
Tender invitation and contracting		
Working drawings		
Earth works and service net work system		
Construction of buildings		
Supplies of technological machinery a. equipment		
Erection of machinery and equipment		
Contract for licence, know-how, design a. technological documentation		
Contract for supplies of tools		
Supplies of design and technological documentation		
Supplies of tools and gauges		
Training of staff and man power		
Supplies of raw materials for production		
Start of production		
Production of Plant		

Projecting stage

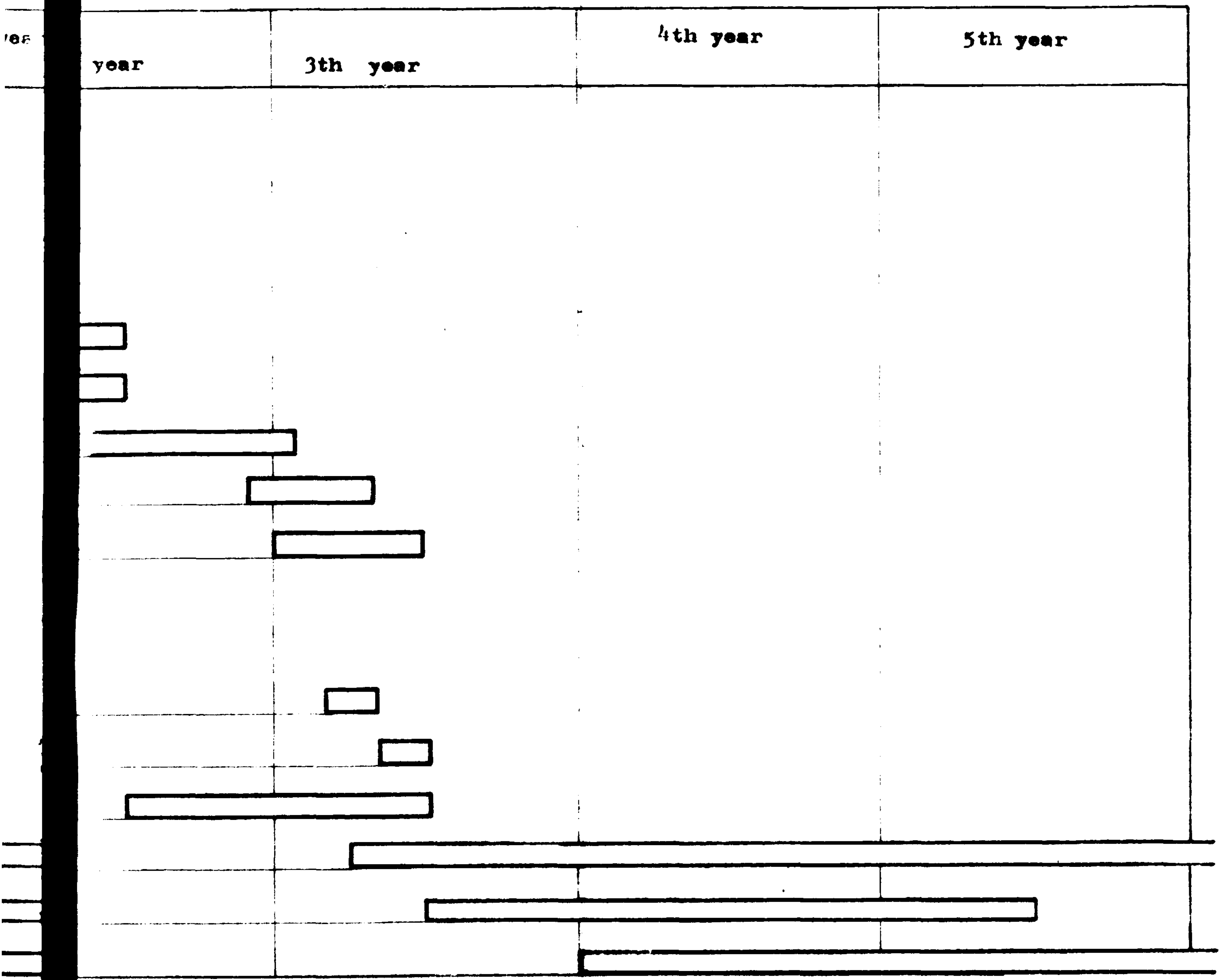
C

SECTION 1

Table - 1



SECTION 2



SECTION 3

onstruction stage

pr

Start of production

Production

Table 9 - 2

ESTIMATE OF INVESTMENT COST

Project implementation

No	Item desription	Quantity	Unit	Unit cost K	Cost 1000 K Foreign	Local	Total
1	Management of project implementation						
	general director	2,5	year	22000	-	55	55
	technicians	5,-	year	13000	-	65	65
	administrative clerks	5,-	year	8000	-	40	40
	secretary	2,5	year	6000	-	15	15
	typist	2,0	y[illegible]	5500	-	11	11
	store keeper	1,5	[illegible]	8000	-	12	12
						198	198
2	Detailed project report				440	-	440
	Working drawings, tendering				200	55	255
					640	55	695
3	Supervision, co-ordination, test - run and take over of civil works and plant				40	40	80
4	Build - up of administration recruitment and training of staff and labour	55	year	7000	-	375	375
5	Arrangements for supplies				-	20	20
6	Arrangements for marketing				-	30	30
7	Build - up connections with authorities				-	20	20
8	Preliminary and capitalisme expenses				-	60	60
9	Financial cost during construction				-	142	142
	Total				680	940	1620

X. FINANCIAL AND ECONOMIC EVALUATION

FINANCIAL AND ECONOMIC EVALUATION

Total investment costs

All investment components are given in tables 10 - 1/1, 10 - 1/2, 10 - 2/1, 10 - 2/2, 10 - 3/2 and summarized in table 10 - 6/1. The annual investment expenditures are projected in table 10-6/2.

Total investment costs are	14 120 000 K
from this:	
- initial fixed investment costs	9 200 000 K
- preproduction capital expenditures	1 630 000 K
- working capital at full capacity	4 290 000 K

Total production costs

All cost items given in chapters III - IX are summarized in table 10 - 12. Total production costs are 18 668 000 Kwacha/year at full capacity.

Average unit costs /in tons/ 5 077 Kwacha/ton

Project financing

As the project promoter is not known, it was not possible to discuss assumed project financing. Sources of financing given in table 10 - 8/1 are mentioned for guidance of the future project promoter only.

It is expected that in the future there will be a project promoter /Zambian organization/ and a foreign collaborator /or collaborators/ who will supply machinery and equipment /main supplier/, know-how, components etc.

The equity capital will total	7 000 000 K
and will be shared by project	
promoter	4 400 000 K
foreign collaborator/s/	2 600 000 K

Deferred credits for supply fo equipment and know-how will be 4 500 000 K

Total foreign supplies of equipment and know-how will be 7 300 000 K /table 10 - 6/2/. Approx. 2 800 000 K /38,3 %/ are expected to be paid in advance in the first up to the third year of construction, the remaining 4 500 00 K will be collaborators' deferred credits paid in five annual instalmen. .f 900 000 K each, the first instalement being paid at the end of the 4th year /1,5 years after the last delivery/.

The maximum of loans, suppliers' credits and current liabilities will be reached at the end of the third year - 5 375 000 K, i. e. 76,8 % of equity capital.

In the third year, total assets equal

	12 375 000 K	/tab.10-7/2/
- repayments of loans	40 000 K	/tab.10-8/3/
- equity	7 000 000 K	
	5 375 000 K	

Comments on tables

Depreciation /tables 10 - 3/1, 10 - 12/

Calculation of depreciation in Kwacha:

	Investmet costs	Percentage	Depre- ciation
Lump-sum payments	120 000	10 %	12 000
Site preparation and development	110 000	2,5 %	2 750
Structures and civil works	1 858 000	2 %	37 200
Plant and machinery:			
Machines, equipment	5 725 000	10 %	572 500
Special and general utility tools, trucks and cars	1 385 000	20 %	277 000
Preproduction capital expenditures	1 628 000	10 %	162 800
T o ta l	10 826 000	9,8 %	1 064 250

Corporate tax /tables 10 - 8/3, 10 - 9, 10 - 14/

Though the team has been unofficially imformed, that there will be tax holidays since 1981, corporate tax was calculated from the very beginning, i. e. from the first year of production /the third year in the time table/.

The calculation of corporate tax is based on the following:

Distributed profits /dividends	48 %	from gross or taxable profit
Undistributed profits	35 %	see table 10 - 9

Dividends /tables 10 - 8/3, 10 - 9/

Dividends are calculated 8 % net per annum on the equity capital /7 000 000 K/, i. e. 560 000 k p. a.

Life of the project

The life of the project is 15 years of production.

Salvage value /tables 10 - 8/3, 10 - 14/

The salvage value after 15 years of production /life of the project/ is given below:

Structures and civil works	1 300 000 K
Site preparation	70 000 K
Working capital	4 285 000 K
T o t a l	5 655 000 K

Licence and related know-how

It is presupposed that the licence and related know-how will be paid for as follows:

Lump-sum 120 000 K.

Licences - 2 % p. a. from sales revenue for a 10 year period of production /i. e. up to the 13th year of time schedule/.

FINANCIAL EVALUATION

Net present value /NPV/

The net present value of the project is defined as the value obtained by discounting, separately for each year, the difference of all cash outflows and inflows accruing throughout the life of the project at the fixed, pre-determined interest rate. This difference is discounted to the point at which the implementation of the project is supposed to start /year 0/.

The discounted rate for this project is 15 %, the discounting period is 15 years /equal to life time of the Project/.

The NPV of the project can be determined from table 10 - 14:

NPV for the 10th year /7,5 years of production/	+ 4 060 000 K
NPV for the 17,5th year /15 years of production/:	
the 10th year /7,5 years of production	+4 060 000 K
plus from the 10th up to the 17,5th year/15 years of production/	+ 7 120 000 K
plus present salvage value in the last year	+ 490 000 K
minus present value of replaced assets /trucks, ears etc./ aprox.	- 640 000 K
NPV of the project	+11 030 000 K

NPV of the equity capital	5 060 000 K
Present value of the investment /PVI/	5 700 000 K

The ratio of the NPV and the present value of the investment /PVI/ required is called the net present value ratio /NPVR/

$$NPVR = \frac{NPV}{PVI} = \frac{11\ 030\ 000}{5\ 700\ 000} = 1{,}935$$

Pay-back period

The pay-back period is defined as the period required to recuperate the original investment outlay through the profits earned by the project.
From tables 10 - 3/1 and 10 - 9 /in 1000 K/:

Item	Year 3	4	5	6	7
Net profit	65	860	2400	3970	4470
Interests	480	460	425	265	120
Depreciation	530	1060	1060	1060	1060
Profit	1075	2380	3885	5295	8730

Total investment costs /table 10 - 6/2/: 15 115 000 K.

The calculation indicates that the original investment costs will be recovered after 6 years and 3,4 months including the construction period, or 3 years and 9,4 months of start-up production.
The pay-back period is very short.

Simple rate of return

Simple rate of return is defined as the ratio of the profit in a normal year of full production to the original investment outlay.

The simple rate of return on total investment costs - R

$$R = \frac{NP}{K} \times 100$$

The simple rate of return on equity capital Re

$$Re = \frac{NP}{Q} \times 100$$

where

NP - net profit /after depreciation, interest charges and taxes/

K - total investment costs /fixed assets, pre-production capital costs and working capital/

Q - equity capital

Simple rate of return in 1000 K for the 9th year:

$$R = \frac{NP}{K} \times 100 \qquad \frac{4\ 466}{15\ 115} \times 100 = 29{,}5\ \%$$

$$Re = \frac{NP}{Q} \times 100 \qquad \frac{4\ 466}{7\ 000} \times 100 = 63{,}8\ \%$$

The simple rate of return on equity capital Re = 63,8% and rate of return on total investment costs R = 29.5 % are very good.

Financial evaluation under uncertainty

Break-even point BEP

Break-even point is the point at which sales revenues equal production costs.

Algebraic determination of the BEP:

$$x = \frac{f}{p - v}$$

f fixed costs = 5 010 000 K /see table 10 - 11/

p unit sales price = 27 400 000 : 3676,9 = 7450 K/ton

v variable unit costs = 13 660 000 : 3676,9 = 3715 K/ton

$$x = \frac{5\ 010\ 000}{7450 - 3715} = 1\ 341{,}4 \text{ tones/year}$$

i. e. BEP would be reached at a capacity utilization equalling of 36,4 %.

BEP is low - this is very good for the Plant and its viability under conditions of inadequate market.

National economic evaluation

Project exchange rate at full capacity is the rate of $\frac{\text{production costs foreign currency}}{\text{sales revenue}}$

Sales revenue at full capacity	27 400 000 K
Production costs, foreign currency at full capacity	12 560 000 K

Project exchange rate $\frac{12\ 560\ 000}{27\ 400\ 000} = 45{,}8\ \%$

Savings of foreign currency at full capacity:

27 400 000 - 12 560 000 = 14 840 000 K/year

Both indicators - project exchange rate and savings of foreign currency are very good.

Table 10 - 1/1

INITIAL FIXED INVESTMENT COSTS

Item	Investment category	Foreign currency	Local currency	Total cost
		1000 Kwacha		
1.	Technology costs - lump-sum payments	120	-	120
2.	Plant machinery and equipment	6502	608	7110
3.	Site preparation and developmnet	-	110	110
4.	Structures and civil works	-	1858	1858
Total		6622	2576	9198

[illegible]

[illegible]	1			
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]
[illegible]	-	-	-	-
[illegible]	-	-	-	-
3. [illegible]	-	-	-	[illegible]
[illegible]	-	-	-	[illegible]

	6			
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-
[illegible]	-		-	-
[illegible]	-	-	-	-
[illegible]	-	-	-	-
[illegible]	-	-		-

COSTS (000K)

		Start - up years								
2		3			4			5		
LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	
[illegible]	2740	5590	870	6460	-	-	-	-	-	
110	[illegible]	-	-	-	-	-	-	-	-	
1500	1500	-	360	360	-	-	-	-	-	-
-	30	90	-	90	-	-	-	-	-	-
100	1100	[illegible]	510	6010	-	-	-	-	-	-

		Full capacity years								
7		8			9			Total		
LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
-	-	-	-	-	-	-	-	6620	2580	9200
-	-	-	-	-	-	-	-	-	110	110
-	-	-	-	-	-	-	-	-	1860	1860
-	-	-	-	-	-	-	-	120	-	[illegible]
-	-	-	-	-	-	-	-	5500	610	[illegible]

Table 10 - 2/1

PREPRODUCTION CAPITAL EXPENDITURES, BY CATEGORY

Item	Category	Foreign currency	Local currency 1000 Kwacha	Total
1.	Pre-investment studies	-	8	8
2.	Management of project implementation	-	198	198
3.	Detailed project report, working drawings, tendering	640	55	695
4.	Supervision, co-ordination, test-run and take over of civil works and equipment	40	40	80
5.	Built-up of administration recruitment and training of staff and labour	-	375	375
6.	Arrangements for supplies and marketing	-	50	50
7.	Built-up of connections	-	20	20
8.	Preliminary and capital issue expenditures	-	202	202
	Total	680	948	1628

PREPRODUCTION CAPITAL EXPENDITURE, BY YEAR (1000 K)

Period	Construction period					
Year	1			2		
Currency	FC	LC	Tt	FC	LC	Tt
Preproduction capital expenditure	440	128	568	220	455	675

Table 10 - 2/2

3						Total		
FC	LC	Tt				FC	LC	Tt
20	365	385				680	948	1628

Table 10 - 2/2

ANNUAL PRODUCTION - COST ESTIMATE (1000K)

Period	Construction		Start - up					Full capacity
Year	1	2	3	4	5	6	7	8
Production programme	0	0	20 %	40 %	60 %	80 %	90 %	100 %
Costs :								
Raw materials - local	-	-	493,6	901,3	1287,6	1716,8	1931,4	2146,-
- imported	-	-	2664,5	4865,6	6950,8	9267,8	10426,2	11584,7
Utilities	-	-	19,7	35,4	50,4	62,9	70,8	78,7
Salaries	-	-	464,-	870,-	986,-	1044,-	1102,-	1160,-
Wages	-	-	280,5	392,7	476,8	504,9	532,9	561,-
Licence (2 %)	-	-	109,6	219,2	328,7	438,3	493,1	547,9
Special and common utility tools	-	-	40,-	160,-	240,-	320,-	360,-	400,-
Annual payments for land	-	-	9,-	9,-	9,-	9,-	9,-	9,-
Sales and distribution costs	-	-	180,-	280,-	360,-	380,-	400,-	425,-
Maintenance	-	-	10,-	20,-	70,-	120,-	150,-	180,-
Overhead costs	-	-	94,-	188,-	282,-	396,-	423,-	470,-
Operating costs	-	-	4364,9	7941,2	11041,3	14259,7	15898,4	17562,3
Financial costs (interests)			481,-	463,-	425,-	265,-	124,-	43,-
Depreciation			532,1	1064,2	1064,2	1064,2	1064,2	1064,2
Total production costs			5378,-	9468,4	12530,5	15588,9	17086,6	18663,5

WORKING [illegible]AL REQ[illegible]

		Cost. of	
I. Current [illegible]			
A. [illegible]	30	[illegible]	363,7[illegible]
B. Inven[illegible]	30	[illegible]	41,[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	24	[illegible]
[illegible]	[illegible]	16	[illegible]
C. [illegible]			6[illegible]
D. Cur[illegible]			158[illegible],
II. Current [illegible]			
A. Accou[illegible] payab[illegible]	30	12	-264,8[illegible]
III. Work[illegible]			
A. Net work[illegible]			1321,6[illegible]
B. Increase [illegible] capital			

The cash bal[illegible] based on the following calcu[illegible]

IV. Total [illegible]			537[illegible]
less : [illegible]			31[illegible]
[illegible]			1[illegible]
Dep[illegible]			5[illegible]
	[illegible]	[illegible]	1[illegible]
V. Required [illegible]			60,[illegible]

REMENTS

Requirements				
Start - up ...				Full capacity
4	5	6	7	8
65[illegible],4	[illegible]	[illegible]	1324,8	1463,[illegible]
7[illegible]	[illegible]	[illegible]	160,9	178,8
81[illegible]	[illegible]	[illegible]	1737,7	1930,8
3[illegible]	[illegible]	[illegible]	622,4	731,8
[illegible]	[illegible]	7[illegible]	883,[illegible]	975,7
[illegible],2	[illegible]	[illegible]	149,8	158,2
2405,9	[illegible]	4407,2	4878,8	5438,8
-483,[illegible]	-690,7	-92[illegible],6	-1035,7	-1150,7
1[illegible]	1700,8	3486,[illegible]	3843,1	4288,1
680,[illegible]	778,4	78[illegible],8	356,5	445,-
94[illegible]	[illegible]	15[illegible]	17087	18670
57[illegible]	[illegible]	[illegible]	12357,6	13730,7
[illegible]	[illegible]	[illegible]	70,8	78,7
[illegible]	[illegible]	[illegible]	1064,2	1064,2
[illegible]	[illegible]	[illegible]	3594,4	3796,4
[illegible]	[illegible]	[illegible]	149,8	158,2

TOTAL INITIAL INVESTMENT COSTS

Item	Investment category	Foreign currency	Local currency	Total
		1000 Kwacha		
1.	Initial fixed investment cost /schedule 10-1/1/	6620	2580	9200
2.	Pre-production capital expenditures /from schedule 10-2/1/	680	950	1630
3.	Working capital /at full capacity/ from schedule 10-3/2/	-	4290	4290
Total		7300	7820	15120

TOTAL INVESTMENT COSTS (1000K)

Period	Construction						Start - up period								
Year	1			2			3			4			5		
Currency	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
1. Fixed investment costs	-	-	-	1030	1710	2740	5590	870	6460	-	-	-	-	-	-
2. Pre-production capital expenditures	440	130	570	220	455	675	20	365	385	-	-	-	-	-	-
3. Working capital	-	-	-	-	-	-	445	875	1320	[illegible]	235	600	345	435	780
Total investment costs	440	130	570	1250	2165	3415	6055	2110	8165	[illegible]	235	600	345	435	780

Period							Full capacity								
Year	6			7			8			9			Total		
Currency	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
1. Fixed investment costs	-	-	-	-	-	-	-	-	-	-	-	-	6620	2580	9200
2. Pre-production capital expenditures	-	-	-	-	-	-	-	-	-	-	-	-	680	950	1630
3. Working capital	[illegible]	400	[illegible]	[illegible]	[illegible]	[illegible]						-	1930	2355	4285
Total investment costs		400	[illegible]		[illegible]	[illegible]					-	-	9230	5885	15115

Table 10 - 7/1

TOTAL INITIAL ASSETS /1000 K/

Item	Investment category	Foreign currency	Local currency	Total
1.	Initial fixed investment costs	6620	2580	9200
2.	Pre-production capital expenditure	680	950	1630
3.	Current assets /at full capacity/	1930	3510	5440
	T o t a l	9230	7040	16270

TOTAL ASSETS (1000 K)

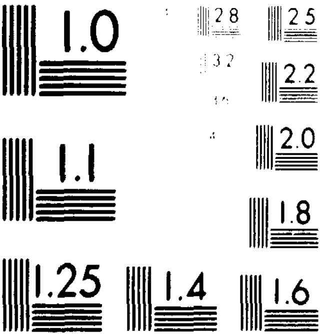
Period	Construction						Start – up								
Year	1			2			3			4			5		
Currency	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
Initial fixed investment cost	–	–	–	1030	1710	2740	5590	870	6460	–	–	–	–	–	–
Pre-production capital expenditures	440	130	570	220	455	675	20	365	385	–	–	–	–	–	–
Current assets increase	–	–	–	–	–	–	445	1140	1585	365	455	820	345	640	985
Total assets	440	130	570	1250	2165	3415	6055	2375	8430	365	455	820	345	640	985

	6			7			8			9			Total		
	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
Initial fixed investment cost	–	–	–	–	–	–	–	–	–	–	–	–	6620	2580	[illegible]
Pre-production capital expenditures	–	–	–	–	–	–	–	–	–	–	–	–	680	[illegible]	[illegible]
Current assets increase	365	650	1015	195	280	475	195	365	560	–	–	–	1930	[illegible]	[illegible]
Total assets	365	650	1015	195	280	475	195	365	560	–	–	–	9230	704[illegible]	[illegible]

Table 10 - 8/1

SOURCES OF FINANCE

		1000 K		
Item	Sources of finance	Local currency	Foreign currency	Total
1.	Promoters			
	a. Equity	4400	-	4400
	b. Preference capital	-	-	-
	c. Loans	-	-	-
	d. Other forms such as deferred credits	-	-	-
	for supply of assets	-	-	-
	Total	4400	-	4400
2.	Collaborators			
	a. Equity	-	2600	2600
	b. Preference capital	-	-	-
	c. Loans	-	-	-
	d. Other forms such as deferred credits for supply of equipment and know-how	-	4500	4500
	Total	-	7100	7100
3.	Financial institutions or development agencies			
	a. Equity	-	-	-
	b. Preference capital	-	-	-
	c. Loans	1490	2130	3620
	d. Other forms	-	-	-
	Total	1490	2130	3620
4.	Government			
	a. Loans	-	-	-
	b. Subsidy	-	-	-
5.	Commercial banks	-	-	-
6.	Public subscriptions	-	-	-
7.	Suppliers' credits			
8.	Current liabilities	1150	-	1150
	Total - all items	7040	9230	16270


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

SOURCES OF INITIAL FUNDS (1 000 K)

Period	[illegible]						Start - up								
Year	[illegible]			2			3			4			5		
Currency	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
Equity capital	[illegible]	130	570	1250	2165	3415	910	2105	3015	-	-	-	-	-	-
Collaborators deferred credits	-	-	-	-	-	-	4500	-	4500	-	-	-	-	-	-
Loans	-	-	-	-	-	-	645	5	650	365	235	600	345	435	780
Current liabilities	-	-	-	-	-	-	-	265	265	-	220	220	-	205	205
	440	130	570	1250	2165	3415	6055	2375	8430	365	455	820	345	640	985

Period							Full capacity								
Year	6			7			8			9			Total		
Currency	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
Equity capital	-	-	-	-	-	-	-	-	-	-	-	-	2600	4400	7000
Collaborators credits	-	-	-	-	-	-	-	-	-	-	-	-	4500	-	4500
Loans	[illegible]	400	[illegible]	[illegible]	165	360	[illegible]	[illegible]	[illegible]	-	-	-	2130	1490	3620
Current liabilities	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	475	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	7040	[illegible]

Table [illegible] - 3/2

CASH [illegible] TABLE FOR [illegible] PLANNING (1 000 K)

Period	[illegible]								Full capacity		Salvage value in last year	Total
Year	[illegible]	2	3	4	5	6	7	8	9	10		
Production programme	0	0	20	40	60	80	90	100	100	100		
Co[illegible]												
A. Cash [illegible]	570	3415	13910	11780	17425	22935	25125	27960	27400	27400		177930
1. Financial resources	570	3415	8430	820	985	1015	475	560	-	-		16270
2. Sales revenue	-	-	5480	10960	16440	21920	24650	27400	27400	27400		161660
B. [illegible]	-[illegible]	-3415	-13910	-11780	-17425	-20585	-[illegible]	-[illegible]	-21320			-15[illegible]
1. [illegible]	-[illegible]	-3415	-8[illegible]	-820	-985	-1015	-4[illegible]	-560	-	-		-1[illegible]
2. [illegible]	-	-	-4560	-7[illegible]	-11040	-14[illegible]	-[illegible]	-17[illegible]	-17560	-17560		-1[illegible]
3. [illegible]	-	-	-5[illegible]	-1830	-3[illegible]	-[illegible]	-14[illegible]	-1560	-	-		-[illegible]
a) [illegible]												
[illegible]	-	-	-105	-32[illegible]	-[illegible]	-1[illegible]2	-[illegible]	-	-	-		-121[illegible]
[illegible]	-	-	-52	-96	-185	-62	[illegible]	-50	-	-		-334
[illegible]	-	-	-23	-[illegible]	-62	-41	-[illegible]	-[illegible]	-	-		-[illegible]
b) [illegible]												
[illegible]	-	-	-	-[illegible]00	-[illegible]00	-900	-[illegible]	-[illegible]00	-	-		-4[illegible]
[illegible]	-	-	-[illegible]	-[illegible]	-1520	-7[illegible]	-[illegible]	-[illegible]	-	-		-3[illegible]
[illegible] holder	-	-	-	[illegible]	-480	-[illegible]	-[illegible]	-[illegible]	-	-		-[illegible]
4. [illegible]	-	-	-[illegible]	-[illegible]	-[illegible]	-[illegible]	[illegible]	-[illegible]	-3100	-3100		-[illegible]
5. [illegible]	-	-	-[illegible]	-[illegible]	-[illegible]	[illegible]	[illegible]	[illegible]	-5[illegible]	-5[illegible]		-[illegible]
C. [illegible]	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	6020		
D. Cumulative [illegible]	-	-	-	-	-	[illegible]	[illegible]	[illegible]	20[illegible]5	21995		[illegible]

NET INCOME STATEME

Period	Construction		St
Year	1	2	3
Production programme	-	-	20
Costs			
1. Sales	-	-	5480
2. Production costs	-	-	-5380
3. Gross or taxable profit	-	-	100
4. Tax	-	-	- 35
5. [illegible]	-	-	65
6. [illegible] (8 % on equity)	-	-	-560
7. Undistributed profits	-	-	-495
8. Accumulated undistributed profits	-	-	-495
Ratios :			
Gross profit : sales %			1,8
Net profit : sales %			1,2
Net profit : equity %			0,9

NT (1000 K)

art - up				Full capacity		
4	5	6	7	8	9	10
40	60	80	90	100	100	100
10960	16440	21920	[illegible]	27400	27400	27400
-9470	-12530	-15590	[illegible]	-18670	-18670	-18670
1490	3910	6330	7560	8730	8730	8730
-630	-1510	-2360	-2700	-3200	-3200	[illegible]
860	2400	[illegible]	[illegible]	5530	5530	5530
-560	-560	-560	[illegible]	-560	-560	[illegible]
300	1640	3410	3910	4970	4970	4970
-195	1645	[illegible]	8965	13935	18905	23875
13,6	23,6	[illegible]	30,6	31,8	31,8	31,8
7,8	14,5	[illegible]	18,1	20,2	20,2	20,2
12,2	34,3	[illegible]	[illegible]	79	79	79

Table 10 - 11

TOTAL PRODUCTION COSTS AT FULL CAPACITY

Item	Costs	Foreign currency	Local currency	Total
			1000 Kwacha	
1.	Direct materials and inputs	11330	1830	13160
2.	Direct manpower : labour and staff	10	490	500
3.	Factory overhead costs			
3.1	Manpower costs	-	200	200
3.2	Overhead materials	245	375	620
3.3	Other factory overheads	-	580	580
	Factory costs	11585	3475	15060
4.	Administrative overhead costs			
4.1	Manpower costs	140	860	1000
4.2	Overhead materials	10	20	30
4.3	Other administrative overheads			
5.	Sales and distribution costs	-	425	425
5.1	Manpower costs	-	20	20
5.2	Others	825	200	1025
	Operating costs	12560	5000	17560
6.	Financial overhead costs : interests	-	45	45
7.	Depreciation	-	1065	1065
	Total production or manufacturing costs	12560	6110	18670

[illegible] ON - COST

Period	Start - up						
Year							
Production programme	[illegible]			[illegible]			
Currency (1000 [illegible])	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1. Materials	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Utilities	-	[illegible]	20	-	35	55	-
3. Salaries	[illegible]	[illegible]	464	100	[illegible]	870	[illegible]
4. Wages	-		[illegible]	-	[illegible]	[illegible]	-
5. Spec[illegible]		-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6. Licen[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	[illegible]
7. Annual [illegible] for l[illegible]	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-
8. Sales [illegible] distribution costs	-	[illegible]	130	-	[illegible]	[illegible]	..
9. Maintenance	-	10	10	-	[illegible]	[illegible]	-
10. Overhead costs	-	94	[illegible]	-	[illegible]	[illegible]	-
Operating costs	[illegible]	1470	4364	[illegible]	[illegible]	7939	[illegible]
Financial costs (interests)	[illegible]	75	481	[illegible]	[illegible]	[illegible]	243
Depreciation	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-
Total production costs	[illegible]	[illegible]	5377	[illegible]	[illegible]	[illegible]	[illegible]

SCHEDULE - (1000 K)

								[illegible]		
[illegible]		[illegible]			[illegible]			8		
60		80			[illegible]			100		
LC	Tt	FC	LC	Tt	FC	LC	Tt	FC	LC	Tt
[illegible]	[illegible]	9268	1717	[illegible]	[illegible]	[illegible]	12357	11584	2146	[illegible]
50	50	-	[illegible]	[illegible]	-	71	71	-	[illegible]	79
866	986	130	914	1044	140	[illegible]	1102	149	[illegible]	1160
[illegible]	476	-	[illegible]	[illegible]	-	[illegible]	532	-	[illegible]	561
[illegible]	[illegible]	290	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-	328	138	-	[illegible]	[illegible]	-	493	547	-	[illegible]
[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	9	-	9	[illegible]
[illegible]	360	-	[illegible]	[illegible]	-	400	400	-	425	425
70	70	-	[illegible]	[illegible]	-	150	150	-	180	180
[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	423	-	470	470
3430	1038	1011	[illegible]	[illegible]	11359	4538	15589	12560	5001	17561
[illegible]	425	162	[illegible]	[illegible]	[illegible]	43	124	-	43	43
[illegible]	1064	--	[illegible]	[illegible]	-	[illegible]	1064	-	1064	1064
[illegible]	[illegible]	[illegible]				[illegible]		12560		[illegible]
			[illegible]		[illegible]		[illegible]		[illegible]	

CASH-FLOW TAB[illegible] AND [illegible]LCULATION OF PRESENT VALUE FOR A PRO[illegible] FINANCING (1000 K)

Period	[illegible]tion		Start - up				Pr[illegible]				Sal[illegible]	
Year	1	[illegible]	3	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]ge value in last	
Production [illegible]	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]%	100%	year	Total
Values (1[illegible]												
A. Cash in[illegible]	–	–	5[illegible]	10[illegible]	[illegible]	21[illegible]	[illegible]	[illegible]	[illegible]400	27400		161650
1. Sale[illegible]	–	–	[illegible]	10960	16440	21[illegible]	[illegible]	[illegible]	[illegible]	27400		161650
B. Cash out[illegible]	–57[illegible]	–3[illegible]15	–7[illegible]	–[illegible]400	–15880	–19010	–2[illegible]	–2[illegible]	–20760	–[illegible]760		141175
1. Total [illegible] costs	–57[illegible]	–[illegible]15	–3535	–[illegible]	–3330	–2[illegible]	–2[illegible]5	–1[illegible]	–	–		–18065
(Fixed [illegible]												
[illegible]	–[illegible]	–[illegible]15	–[illegible]	–	–	–	–	–	–	–		–7000
[illegible]	–	–	–	–[illegible]00	–[illegible]00	–[illegible]	–[illegible]	–[illegible]	–	–		–4[illegible]
c) [illegible]	–	–	–4[illegible]	–[illegible]	–[illegible]20	–[illegible]	–[illegible]	–[illegible]	–	–		–362[illegible]
d) Re[illegible] liti[illegible]s	–	–	–	–	–480	–4[illegible]	–[illegible]	–[illegible]	–	–		–1[illegible]
e) Inte[illegible] defe[illegible]	–	–	–[illegible]5	–3[illegible]	–340	–[illegible]	–[illegible]	–	–	–		–1[illegible]
f) [illegible]	–	–	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–	–		–[illegible]
g) [illegible] [illegible]lities	–	–	–2[illegible]	–14	–[illegible]	–41	–1[illegible]	–[illegible]	–	–		–[illegible]
2. Oper[illegible]	–	–	–4365	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]560	–175[illegible]	–17560		–10612[illegible]
3. Corp[illegible]	–	–	–3[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–[illegible]	–3200		–16925
C. Net cash [illegible]	–57[illegible]	–3415	–24[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6640		20475
D. Present [illegible]	–[illegible]	–[illegible]50	–1[illegible]	3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1640		4060

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(2 of 2)

FINAL REPORT

FEASIBILITY STUDY ON PRODUCTION OF IRRIGATION EQUIPMENT

Project No. DP/Zam/78/008

VOLUME II - ANNEX

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PRAGUE - CZECHOSLOVAKIA

June 1981

C O N T E N T S

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Layouts of irrigation systems and maps of Zambia — 8 pages

Annex B -

Industrial establishments in Zambia that can cooperate with the irrigation equipment manufacturing plant — B 1 - B 23

A. IRRIGATION SYSTEMS IN ZAMBIA

I. BASIC INFORMATION ON ZAMBIA

Area: 752 478 km2

Agricultural lands: 142 000 km2 (1972 census)

% of agricultural lands of total area of the country: 18.9

Area under cultivation: 20 776 km2 (1970 census)

% of area under cultivation of the total of agricultural lands 14.6

Number of inhabitants (in millions)

1973	1975	1977
4.68	4.98	5.30

Number of inhabitants in towns (in millions)

1973	1975	1977
1.60	1.81	2.03

Rural population figures (in millions)

1973	1975	1977
3.08	3.17	3.27

Density of population 7 inhabitants/km2

II. CLIMATIC CONDITIONS

1. Rainfall

The average amount of annual rainfall ranges from 700 mm (southern part of Zambia) to 1500 mm (northern and north-eastern part of Zambia). There is a clearly noticeable a pronounced and even increase of the amount of average annual rainfall in the direction from the south of the country to the north. See map No.1. The whole amount of atmospheric rainfall descends in the rainy season which in Zambia lasts from November to June. Both the onset and the end of the rainy season depends, first of all, on geographic latitude. In the northernmost part of Zambia (at about 8.5^{0} of southern latitude the onset of the rainy season takes place, on the average, in the first decade of the month of November and the rainy season comes to an end, on the average, in the third decade of June. For the southernmost part of Zambia (about 18^{0}of southern latitude) the average start of the rainy season corresponds to the third decade of November and the rainy season ends, as a rule, in the second decade of May. In connection with the time schedule of annual rainfall there are important the terms of "the length of vegetation season for rain-fed agricultural produce" and "period of irrigation of the dry season". The first term is defined in respect of its length by the dates of the beginning and the end of the rainy season. The length of the second term is defined by the difference between the total number of days in a year and the "length of vegetation season for rain-fed agricultural produce" less 30 days as a minimum period required for preparation of soil at the beginning of the season and for harvest at the end of the season.

In the following table are listed the basic data of rainfall measurement obtained from a number of observation posts in various parts of Zambia; they serve as a representative information about the country's rainfall conditions.

TABLE No.1

Station	latitude ° s.l.	longitude ° e.l.	altitude m	annual rainf. mm	Irrigation season beginning	end	length days
MBALA	8.9	31.3	1673	1230	1/7	19/10	111
KASAMA	16.2	31.0	1384	1280	17/6	19/10	125
LIVINGSTONE	17.8	25.8	986	726	19/5	1/11	165
SESHEKE	17.6	24.3	951	713	26/5	2/11	160
KABWE	14.5	28.8	1207	967	4/6	27/10	145
PETAUKE	14.3	31.3	1036	968	15/6	2/11	140
KABOMPO	13.6	24.2	1075	1065	18/6	19/10	123
CHIPATA	13.6	32.6	1032	1015	7/6	25/10	140
ZAMBEZI	13.5	23.0	1078	1004	4/6	18/10	136
KASAMPO	13.6	25.9	1234	1149	7/6	19/10	134
SERENZE	13.2	30.2	1384	1156	9/6	20/10	138
NDOLA	13.0	28.7	1270	1210	8/6	19/10	138
LUNDAZI	12.3	33.2	1143	891	9/6	9/11	153
SOLWEZI	12.2	26.4	1333	1347	25/6	10/10	107
MPIKA	11.9	31.4	1402	1064	12/6	29/10	139
MWINILUNGA	11.8	24.4	1363	1375	1/7	25/9	86
SAMFYA	11.4	29.5	1172	1384	17/6	22/10	127
MANSA	11.0	28.9	1259	1211	18/6	19/10	123
KAWAMBWA	9/8	29.1	1324	1293	12/7	5/10	85
LUSAKA	15.4	28.3	1280	801	18/5	31/10	166
CHOMA	16.9	27.1	1210	825	24/5	26/10	155
KAFUE PODLER	15.8	x27.9	987	783	17/5	2/11	169
MONGU	15.3	23.2	1053	1020	5/6	22/10	139
KAOMA	14.8	24.8	1152	939	8/6	23/10	137

2. Temperature

TABLE No.2 shows temperatures during the rainy season:

Length of season	Daily temperature	Average temperat.	Minimum temperat.	Maximum temperat.
240 days	23.2°C	20.5°C	14.9°C	25.8°C
225	23.6	20.9	15.2	26.3
205	24.2	21.5	15.7	27.0
185	24.9	22.0	16.2	27.7
175	25.2	22.3	16.4	28.1

Table No.3 shows temperatures in dry season of irrigation:

Length of season	Daily temper.	Average temper.	Minimum temper.	Maximum temper.
97 days	22.2°C	18.3°C	10.5°C	26.1°C
125	23.3	19.2	11.0	27.4
138	23.5	19.4	11.0	27.6
153	23.8	19.6	11.2	27.9
167	24.0	19.8	11.3	28.2

Table No.4 shows temperatures in the coldest month of July:

97 days	21.1°C	16.8°C	8.2°C	25.3°C
125	21.0	17.0	9.0	25.0
138	21.0	16.8	8.3	25.2
153	19.5	14.9	5.6	24.0
167	20.1	16.1	8.1	24.0

From the point of view of geographic latitude it can be noted that the areas situated nearer the equator are characterized by less pronounced differences between the respective temperatures of the dry and the rainy season than the areas situated on parallels of higher geographic latitudes.

The altitude above sea level is reflected in average daily temperatures by a temperature drop of 0.7°C or 0.5°C per 100 m of altitude during the rainy or the dry season respectively.

From the point of view of annual seasons it is evident that during the rainy season there are less pronounced differences between the day and the night temperature than during the season without rainfall.

III. CONDITIONS OF THE SOIL

For economic reasons it is necessary that the development of new irrigation systems should be focussed primarily on the zones with favourable soil conditions that will warrant a prompt return of the capital investments to be made. From the results of earlier pedological investigations and from analyses of soil conditions in Zambia it can be deducted that in the western part of Zambian territory there largely prevail less fertile sandy soils, whereas in the central and eastern part of the country there exist for the most part more fertile soils. These can be roughly divided into three main categories, i.e.:

a) less intensely coloured sandy soils of the central plateau, particularly in the basins of the Chambeshi river and the Bangvaulu lake,

b) red clayey to sandy-clayey soils that cover the major part of the uplands,

c) lighter-colour soils of the eastern plains.

In areas with average amount of annual rainfall in excess of 1000-1100 mm there are frequently found less fertile soils impoverished by rain.

In earlier days it was generally assumed that the yields of agricultural produce were, as a result of the prevailing soil conditions, higher in the south of Zambia than in the north. It has, however, been proved by test recently conducted that satisfactory results can be obtained even in the northern regions by means of correct methods of cultivation and fertilization. Evaluation of the contents of different chemical elements in the soils of Zambia will depend on detailed local analyses conducted with the kind of produce envisaged to be cultivated duly taken into account.

IV. SELECTION OF PRODUCE ELIGIBLE FOR IRRIGATION

From the angle of natural, climatic, soil and phenologic conditions, earlier teams of experts in the line of irrigation-based agriculture conducted a systematic and detailed investigation of the eligibility of individual kinds of agricultural produce for the conditions of irrigation-based cultivation in Zambia. With all the factors referred to above duly taken into account, and under consideration of the potential economic assets there were selected from the ample assortment of the kinds of produce suitable from the agronomic point of view the following most important kinds of produce to be cultivated on irrigated terrains: wheat, barley, sugar cane, coffee, tea, vegetables, fruit, fodders and rice.

Wheat is the most significant produce of the future irrigation-based agriculture in the country. It can help to solve the present-day problems of providing food for the population and substantially reduce the costs of import of the basic foodstuffs. At present it is cultivated under systems of irrigation practically only by farms of commercial orientation. Irrigation of wheat is mostly practised by sprinkling, with the only exception of the experimental fields of the Mpongwe Pilot Project where experiments are in progress with surface-type irrigation. Recently experiments have been conducted with cultivation of wheat during the rainy season without irrigation. The results cannot yet be qualified as conclusive and definite ones, but partial results have shown that the yields of this method of wheat cultivation are substantially inferior to those obtained from irrigated lands.

Barley has agronomic conditions similar to those of wheat. The importance of barley from the nourishment point of view is not so great and, besides, the development of cultivation of this kind of agricultural produce depends on the construction of a new malt plant in the country.
Sugar cane is at present cultivated to an extent of about 95% of total production in the Nakambala region. Full utilization of irrigation equipment and of the sugar factory capacity will make it possible to meet the demands of national market in approximately the next 8 years. Additional demand of the market and of export can be complied with by extension of the area under cultivation and of the necessary irrigating installations. The most eligible location of new sugar cane cultivation areas appears to be the terrains situated adjacent to the existing Nakambala plantations.

In respect of coffee production, optimal perspectives of production increase for meeting the demands of both national markets and the demands of export axist in the Northern Province, provided a supplementary irrigation system has been installed for the purpose and correct methods of agricultural production control have been adopted.

Production of tea has optimal conditions, from agronomic point of view, in the Northern and the Luapula provinces. With the aid of a supplementary irrigation system it will be possible.in the newly established plantations, to attain such yields per hectare as will meet the required demand.

Vegetables and fruit are extremely demanding in respect of the difficulty and intensity of agricultural labour. In spite of this fact, substantial proportion of these agricultural products is still being provided by small- and medium--scale farmers, and it will be necessary to concentrate the prospectively enlarged areas of vegetable and fruit cultivation under irrigation systems into larger complexes.
In this way the necessary prerequisites will be afforded

of more rational arrangements of transport of the products from production sites to centres of consumption.

The plants used as fodders must play an important part in making it possible for Zambia to produce a surplus of milk and beef for export instead of having to import these foodstuffs, as it is the case at present.

V. WATER RESOURCES

1. Surface-Type Sources of Water

From the power engineering point of view, the main interest in drawing on water reserves for irrigation is focussed on water sources available on the surface. In this particular instance that part of energy can be saved which is otherwise necessary for conveyance of water by pumps from ground water table to ground surface, as it is the case with underground water sources. The water resources available in Zambia are extremely rich, as compared to most of the other African countries. The whole country is traversed by prolifically branched-out network of rivers which offer great potentialities for development of irrigation systems. The flow rate regime in the network of rivers corresponds to annual distribution of rainfall and to its respective amounts.

From hydrological point of view the whole territory of Zambia can be divided into four principal basins or catchment areas:

Tab.5

B a s i n	extension (km2)	annual volume of rainfall (10^6 m3)
1. Luapula river and Tanganyika lake	194 000	214 132
2. Luangwa river	147 472	122 312
3. Kafue river	155 000	149 720
4. Zambezi river	256 006	228 688

The average annual runoff in the different basins is specified in Tab.6:

B a s i n	November-May (10^6 m3)	June-October (10^6 m3)
1. Luapula river and Tanganyika lake	21 150	7 400
2. Luangwa river	17 600	1 250
3. Kafue river	5 250	3 550
4. Zambezi river	36 800	12 400

The runoff coefficients in the different basins and for the different seasons are specified in Tab.7:

B a s i n	Rainy season	Dry season
1. Luapula river and Tanganyika lake	0.099	0.035
2. Luangwa river	0.144	0.010
3. Kafue river	0.035	0.024
4. Zambezi river	0.161	0.054

The runoff per basin unit for the different seasons is specified in Tab.8:

B a s i n	Rainy season (10^3 m3/km2)	Dry season	Total
1. Luapula river and Tanganyika lake	109	38	147
2. Luangwa river	119	8	127
3. Kafue river	34	23	57
4. Zambezi river	144	48	192

From the above tables it is evident that by far the worst ratio of runoffs during the rainy season to those of the dry season exists in the Luangwa river catchment area. In the publication entitled "The Water Resources Inventory of Zambia", Volume 1 - The Luangwa River Basin, there was examined the capacity of this particular water source for irrigation and other applications. The coefficient of utilization of the water source is defined as the consumption demand ratio to the effective flow rate. This ratio represents the degree of potential utilization of a water source. Where the coefficient is less than 1, the water source can be regarded as capable of meeting the given demands. For the fifteen reviewed points of observation in the Luangwa river basin the ascertained coefficients of water source utilization ranged from 0.48 to 0.10, that is, all of them inferior to 1, whereby the realistic perspective of drawing on this water source and its capacity of meeting the demands of an irrigation system has been sufficiently evidenced. In the remaining basins under consideration the situation should be even more favourable in view of the more advantageous ratio of flow rates during the rainy season to those existing during the dry season. In a detailed dislocation of the irrigation localities it should, however, be borne in mind that small water courses have permanent annual flow rates only in the northern part of Zambia. For minor constructions of irrigation systems drawing on water of smaller rivers in the central and southern part of the country it should be reckoned with construction of artificial water storage reservoirs.

The problems associated with competitive interests in water consumption from the Kafue river, as existing between the power engineering and the agricultural sector, have already been solved in part, according to information obtained from the Ministry of Agriculture, in favour of preferential availability of water to be drawn for irrigation purposes.

2. Subsoil Water Resources

In the 1978 year there was completed a study on "Ground Water Resources Inventory of Zambia". According to this investigation, the ground water resources existing in the main river basins of Zambia are those specified in Tab.9:

B a s i n	Ground water resources in 10^6 m3	ground water level under 5 m	5-10 m	above 10m
1.Luapula river and Tanganyika lake	37741	30%	50%	20%
2.Luangwa river	242760		70%	30%
Kafue river	252057	35%	50%	15%
4.Zambezi river	867821	43%	50%	7%

It was found out that, provided that the attainable resources of ground water are rationally utilized, a rapid upsurge of agriculture and industry throughout the country of Zambia could take place. At present, the available resources of ground water are being utilized to less than 0.05%. With an increase of their utilization to only 1% there is every reason to expect a radical change of the country's entire economic system. In other words, the ground water resources available in Zambia have not yet been practically put to work at all. In spite of the fact that nearly 50 per cent of the samples drawn from the wells under review have been qualified as unsatisfactory in respect of their hygienic properties as set down in the respective standard specifications for drinking water, it is gratifying to state that for irrigation purposes most of the Zambian ground water sources have been found satisfactory. Drawing of ground waters for irrigation purposes is reckoned with to a major extent in a number of projects where accumulation of surface waters in the dry season is found to be less economical. This applies, first of all, to the Mpongwe project where a detailed hydrogeological survey has already been conducted, the same as to Chisamka--West, Monze, Mumbwa, the territory situated to the west of Lusaka and others.

The main significance of ground waters as a source of water drawn for irrigation purposes in the coming 10 years or so consists in safeguarding water supply to small-scale farmers for their irrigation systems. It is assumed that for these applications water can be obtained with the aid of all available pumping installations, including hand-operated pumps for surface irrigation.

VI. IRRIGATION SYSTEMS EXISTING IN ZAMBIA AT PRESENT

In earlier studies dealing with irrigation systems in Zambia a number of attempts were made to present an outline of the conditions of irrigation systems in Zambia. None of these reports, however, presumes to have worked out a perfect and complete review of the existing systems of irrigation. Because of the organizational fractionalization and the frequent reorganizations that took place in both the central and the provincial organs and institutions of the agricultural sector in the course of the past years, it is probably not possible at all to exactly define the authentic present-day state of the irrigation systems up to any specific date. The study that reflects the present-day situation with the maximum possible exactitude, and thus invites a maximum of interest, is the report completed in November 1979 by C.A.LEVY under the title "Preliminary Inventory of Irrigation Development in Zambia. Hereinafter reference is made to the results of this report and of thoseworked out in this connection by a joint German-Dutch working team of experts in 1978 and by experts of the Ministry of Agriculture in Lusaka in the 1975 year. Unfortunately not even the data furnished by C.A.Levy can be regarded as a completely up-to-date information by this time. The team of experts engaged in elaboration of this Feasibility Study had the possibility, during a sojourn in Zambia in the months of October and November 1980, to visit a total of 19 farms, agricultural establishments, enterprises and organizations where irrigation systems are installed. Of this total of 19 irrigation systems installed at present, 15 are not included in the list worked out by C.A.Levy. It can, however, not be asserted that among these 15 irrigation systems which the author failed to indicate in his list there is any one of quite recent construction, i.e. one that originates from the period between the completion of the inventory and the month of November 1980. Moreover, after inspection of the existing irrigation systems, and with a view to a substantial increase of spare part and new irrigation system prices, it can be assumed that not all of the said irrigation systems are in working order. From these aspects the following reviews should be considered and evaluated.

1. REVIEW OF IRRIGATION SYSTEMS IN ZAMBIA according to C.A.Levy:

A) SETTLEMENT SCHEMES, COOPERATIVES AND PARASTATAL UNITS

PROVINCE	NAME	HAS	CONTROLLING AGENCY
NORTHERN	LUBU	187.50	SETTLEMENT SCHEME
	KAPATU	375	-"-
	LUKUPA	53	- " -
	MALOLE	4	- " -
	CHAMFUBU	187.50	- " -
	NGOLI	48	PARASTATAL
	MALASHI	40	SETTLEMENT SCHEME
	CHAIWE	130	- " -
	CHINTU	90	- " -
	MBALA	230	- " -
	IKUMBI	48	COOPERATIVE
TOTAL FOR NORTHERN PROVINCE		1-393.00	
NORTH WESTERN	MWINILUNGA	18	PARASTATAL
LUAPULA	CHIBALASHI	2.2	COOPERATIVE
	TWESHE	2	- " -
	KABENDE	1	- " -
	KASONGO	2	- " -
	PAMBASHE	2	- " -
	KASESE	2	- " -
	ILAMBE	2	- " -
	KAPULAND	3	- " -
	CHISHALA	3	COOPERATIVE
	MALITATI	5	- " -
	SALAMA	2	- " -
	LOSHI	2	- " -
	FIKO	3	- " -
	KANSHIMBA	3	- " -
	KAMPEMBA	2	- " -

	TUSHA	1	COOPERATIVE
	MUNUNSHI	86	PARASTATAL
	KAWAMBWA	264	- " -
TOTAL FOR LUAPULA PROVINCE		387.20	
COPPERBELT	MPONGWE	200	SETTLEMENT SCHEME
	MUNKUMPU	20	- " -
	CHAPULA	125	- " -
	IPAFU	120	- " -
	KAFULAFUTA	2	COOPERATIVE
	KAFUBU	30	- " -
	MUTUNDU	3	- " -
	KAFUE	10	- " -
TOTAL FOR COPPERBELT		510.00	
LUSAKA	CHONGWE	11	SETTLEMENT SCHEME
	CHIAWA	25	PARASTATAL
	LUSAKA WEST FARM	30	- " -
	HARTLEY FARM	10	- " -
	HOLDING FARM	10	- " -
LUSAKA	TUBALANGE	4	COOPERATIVE
	BUHUAGWA	10	- " -
	ANTI POVERTY	38	- " -
TOTAL FOR LUSAKA PROVINCE		138.00	
EASTERN	VUU	8	SETTLEMENT SCHEME
	MWASE	6	- " -
	EMUSA	0.5	- " -
	LUNDAZI	6	- " -
	KATAPOLA	6.25	- " -
	RUKUZYE	2	- " -
	JIMOLI	1.6	- " -
	MAKUNGWA	6	- " -
	MPHANGWE	3	- " -

TOTAL FOR EASTERN PROVINCE		43.35	
CENTRAL	CHIPWEPWE	34.5	SETTLEMENT SCHEME
	BALO	10	- " -
TOTAL FOR CENTRAL PROVINCE		44.50	
SOUTHERN	BULEYA	61	SETTLEMENT SCHEME
	CHIRUNDU	80	- " -
	LUSITU	20	- " -
	SIATWINDA	118	- " -
	NKANDAMBWE	8.8	- " -
	NAKAMBALA	9500	PARASTATAL
	MAZABUKA FARMS	102	- " -
TOTAL FOR SOUTHERN PROVINCE		9889.80	
GRAND TOTAL		12 423.85	

B/ COMMERCIAL FARMS

NAME	HAS
J.G. BENDER	100
BONDALE HOLDINGS LTD.	120
CANTLEY BRO'S	2
B.J. COXE	8
CHANYANYA RANCHING LTD.	60
JOEL CHITAFU	39
R.L.DEAN	100
B.G.EVANS	5
A.C. FISHER LTD.	20
H. GIBBONS, WAKEFIEKD FARM LTD.	3
GREEN BRO'S /F.A.GREEN/	12
BONANZA FARM	10
K.T. MALINKI MBAULA INVESTMENT LTD.	5
A.S. MARSHALL	220
R.R. MOORE	20
SAN ISADORE EST	25
R.J. SHENTON	15

W.B. THOMSON SUNNYRIDGE FARM	2
P.C.F. VAN WIJK	20
F.R. ARNOLD	15
H.G. CURTIS	86
P. GOSAI	70
R. LEGGOTT	5
W. PIETERSE	80
T. VLANDKEN	2
TOTAL FOR COMMERCIAL FARMS	1044

RECAPITULATION :

A/ SETTLEMENTS SCHEMES, COOPERATIVES AND PARASTATAL UNITS	12 423.85	HAS
B/ COMMERCIAL FARMS	1 044.00	HAS
TOTAL	13 467.85	HAS

2. **REVIEW OF IRRIGATION SYSTEMS IN ZAMBIA according to categories for preparation of the THIRD NATIONAL DEVELOPMENT PLAN - Ministry of Agriculture**

A) Large-area irrigation systems

Name, province	has	Number of schemes
Nakambala	7 500	1

B) Medium- and small-area irrigation systems (large schemes)

Name of controlling office, province	has	Number of schemes
Projects Division	283.04	7
Land Use Services Branch	146.60	8
Private growers:		
- Southern Prov.	191.80	6
- Northern Prov.	20.00	1
- Copperbelt Prov.	2.50	1
- Central Prov.	279.00	8
- Luapula Prov.	138.24	23
- Eastern Prov.	33.00	15
Total for medium and small schemes	1 094.18	

<u>Recapitulation:</u>

A) Large schemes	7 500.00 has
B) Medium and small schemes	1 094.18 has
T o t a l	8 594.18 has

3. REVIEW OF IRRIGATION SYSTEMS IN ZAMBIA according to JOINT FAO GERMAN/DUTCH MISSION

In the report of the Joint German/Dutch Mission from the 1978 year there are indicated a total of 17 irrigation localities on a total extension of 816.80 ha. The sizes of individual localities range from 0.4 to 240 ha.

The principal reason that accounts for the relatively great differences among the results obtained by the different missions is the way in which the largest large-scale irrigation system in Zambia has been taken into account in the calculation, i.e. the Nakambala Sugar Estate Irrigation System. Its proportion in the summary of individual results amounts to 9500 ha, 7500 ha or 0 ha. This irrigation system construction scheme, for which there is envisaged an extension from 9500 ha to 10200 ha in the near future, is situated with its extension, outfit and the way of control of its operation outside the regular yardsticks of the remaining irrigation systems existing to date in Zambia and, in view of this, it is not considered in the subsequent reviews of the sizes of average irrigation units. For illustration only of the methods adopted in irrigation under this scheme: 90% of the total surface are irrigated by surface-type arrangements (canals) and only on 10% of the surface overhead irrigation is used.

4. Evaluation of Existing Irrigation Systems

According to size categories, the existing irrigation systems can be roghly subdivided as follows:

under	1 ha	10 %
1 -	5 ha	25 %
5 -	10 ha	15 %
10 -	20 ha	10 %
20 -	50 ha	15 %
50 -	100 ha	15 %
100 -	200 ha	5 %
above	200 ha	5 %

The surface water sources (rivers, lakes, artificial basins) are used for irrigation to 85 % of extension and to 75 % of the different irrigation schemes. Ground water (wells, drilled holes, karst waters) are utilized for irrigation to 15 % of surface extension and to 25 % of individual irrigation schemes.

By the end of the 1979 year there had been issued 118 legal permits for drawing on surface water courses for water to be used in irrigation systems. According to the different provinces these claims in connection with the use of water resources are divided as follows:

Copperbelt	-	24
Central	-	12
Eastern	-	2
North-Western	-	1
Luapula	-	11
Lusaka	-	24
Northern	-	29
Southern	-	15

According to the way in which irrigation is arranged, the irrigation systems are divided with relative uniformity into three basic categories - overhead irrigation, furrow irrigation and surface flooding. In terms of irrigated areas, overhead irrigation systems account for 55 %, furrow irrigation for 35 % and surface flooding for 10 %.

VII. BRIEF DESCRIPTION OF IRRIGATING INSTALLATIONS INSPECTED

1. NDOLA CITY COUNCIL FARM - COPPERBELT PROVINCE

Total acreage of the farm 350 acres. Production is aimed at cultivation of vegetables and maize, as well as at breeding sheep and poultry.

5 acres of vegetable cultures are served by overhead irrigation. The irrigation water source is a well that obtains water by seepage from a permanent water course situated nearby. A centrifugal pump driven by a Diesel engine supplies pressure water to the main delivery pipeline laid through the centre of the irrigated area. The pipeline is made of steel, galvanized and laid at a shallow depth under the ground surface. To the main pipeline hydrants are connected portable aluminium branch pipelines with small sprinklers on the riser pipes. Maximum number of sprinklers operating at a time is 15.

The installations of the surface distribution system and the sprinklers have been made in Israel. The irrigation system is operated under extremely primitive conditions and the irrigation equipment makes the same impression.

2. CHERRY´S FARM - COPPERBELT PROVINCE

Approximate acreage of the farm is 1000 acres. The irrigating installation has been built for 120 acres. Of this total, 100 acres are planted with orange trees and the remaining acreage features other species of trees, vegetables and there are pasture lands, too. The irrigation water source is an artifical basin situated near the farm from which water is brought to the pumping stations through open admission canals. Originally the fam was equipped with 3 pumping sets. At present there is in operation only one pumping station with a centrifugal pump and an electric motor. There is a 6" suction and a 4" delivery branch fitted to the pump. The farm owner had to build a connection line to the main HV line, including a 50 kVA transformer station at his own expense in the 1973 year. Although a relatively high investment was involved (about 5000 kW), it was found to be an economical one when potential dispensing with pump drive by Diesel engines was contemplated. The main distributing irrigation pipeline dimensioned to 4" - 6" is laid along the edge of the longer side of the irrigated plot.It has been laid immediately below the ground surface. In detailed distribution through the area under review there are used 3" - 4" portable aluminium pipes. This is a pipeline the individual pipes of which are joined to one another by means of lever-type couplers; it dates from a relatively early time (year of manufacture 1971). During the initial stage of operation of the irrigation system the entire area was served by overhead sprinkler system. At present water is being distributed in some parts of the orange orchard through a surface pipeline between the rows of trees and used for surface flooding.

The lady owner of the farm exercised harsh critisism of inadequate distribution of pesticide spray agents and protective chemicals used to prevent orange tree diseases and, in particular, she criticized the unacceptably high prices of new irrigation installations. She would welcome the production of this kind of equipment in Zambia, provided it would be supplied to users at lower prices.

3. BORDER FARM - COPPERBELT PROVINCE

The farm uses overhead irrigation on about 30 acres of vegetable cultures. The plots are operated by a few small--scale farmers after the original owner went abroad. The source of water for irrigation is a permanent water course situated near the farm. Throughout the area there is built an underground distribution system made up of PVC pipes and to 17 surface-type hydrants there can be connected a portable aluminium pipeline. Two portable pipelines with four small sprinklers can operate at a time on each line. The irrigation cycle takes 3 days. Doses of water for irrigation are assessed by farmers on hand of experience made before. The irrigation equipment is a very simple one, but those who operate it are fully satisfied with it. In our opinion, an improvement of the results of operation of the system is jeopardized by fractionalization of the element shapes and by non-uniform and erratic arrangement of individual plots that make up the farm.

4. MPONGWE PILOT FARM

This irrigation scheme was inaugurated in 1977. Its principal objective in its present-day stage consists in acquiring experience in cultivation of wheat on large-sized plots under application of an irrigation system. It is very important because it can practically confirm the assumptions formulated in the project, and also call attention to not yet solved problems involved in the introduction of irrigation systems into wholesale agricultural production in its agronomic and technical aspects, as well as to problems associated with the control organs.

The terrains under review of the Mpongwe scheme are situated about 60 km to southwest of the town of Luanshya. At present , from the envisaged final extension of about

22 000 ha there are served by an irrigation system about 240 ha of which 130 ha are served by overhead irrigation and 110 ha by surface irrigation. In the 1981 year there is envisaged to be in operation an irrigation system serving an area of 550 ha and in the few subsequent years the irrigated area is scheduled to increase to 5000 ha.

The principal kind of produce to be irrigated will be wheat. To a lesser extent irrigation will also serve maize used as fodder and vegetables. The crop envisaged for cultivation after wheat in the rainy season will be soya beans. On limited acreage there will also be cultivated maize for grain outside the irrigation season.

The source of water for irrigation is at this time natural springing-up of ground water that accumulates in rock formations at a distance of approximately 1 km from the terrains under review. With the present-day maximum drawing on the source to the amount of 2 million gallons a day (i.e. about 105 l/sec) the source always appears to be able to meet the demand. However, for prospective enlargement of the area to be served it will be necessary to supplement and expand this source. In the adjacent hydrogeological zonethere was already conducted a hydrogeological survey in 1979 which dealt with this problem. Under the programme there have been made a total of 37 probing drilled holes and it has been ascertained that two hydrogeological units are suitable for water intake purposes as water sources for irrigation. In respect of quality the examined water is found suitable for irrigation purposes. In the course of pumping experiments there were ascertained in the different drilled wells capacities ranging from 0.7 to 10.5 l/s, static level of ground water was found to be situated between 4 and 29 m below the ground level and the ground water level drop during experimental pumping amounted to 0.2 - 23.4 m. The hydrogeological survey resulted in a statement according to which for irrigation purposes it can be reckoned with a permissible drop of water level in the aquifer by an average of 10 m when pumping is carried out during 150 days in a year on the average. One water drawing zone has an output of 75 l/ and the other one 45 l/s per drilled well. The wells of this type should be arranged in "batteries" with 2 to 4 wells in each one, and each water intake zone is envisaged to contain 4 "batteries". The design of production drilled wells determines that the well diameter will be formed, depending on concrete local conditions, by a combination of 14", 12", 10" and 8" profiles.

As far as the soil conditions are concerned, on the definitearea under review there is represented to 70 % red--coloured soil of the best quality, some 15 % of the area features soil of second-grade quality and the remaining 15 % are soils that are inadequate for intensified agricultural production of wholesale type. In addition to overhead irrigation, experiments are conducted on the Mpongwe terrains with several types of surface irrigation; there is tested primarily their convenience and the economical aspects of their construction and operation under the local conditions. The methods under test are the following ones: NARROW STRIP IRRIGATION, CORRUGATION IRRIGATION AND BORDER STRIP IRRIGATION.

According to the results obtains up to the present, the most eligible one appears to be the first one of the alternatives referred to above; it is regarded as its principal advantage that after the irrigated produce has been harvested , it is possible, with the aid of disc ploughs, to liquidate the low ridgesof individual "strips" and the field can then be immediately used for sowing the subsequently cultivated non-irrigated kind of produce. What, however, still remains problematic, is the overhead irrigation to surface irrigation ratio. From the angle of economy of irrigation water and its distribution over the area served by the system, the same as from the point of view of the demands for extension and quality of soil processing prior to application of irrigation, the authors of the present study regard overhead irrigation as more advantageous. One indispensable prerequisite, however, is a cost reduction of the irrigation equipment, adequate supply of spare parts and flexible organization of servicing attendance. The resultant yields from experimental fields, irrigated by different techniques of irrigation, also speak in favour of overhead irrigation (in the Mpongwe scheme the wheat treated by overhead irrigation showed in 1979 yields 23 per cent higher than the wheat to which surface irrigation had been applied.)

In its technical aspects, the part of an overhead irrigation system operated in 1980 is arranged as follows: on the lake that serves as water source there is mounted on pontoons a pumping set that consists of a KSB-Johanesburg pump and a Detroit Diesel engine. Impulsion of water from the lake to a storage reservoir situated at the highest point of the irrigated area is arranged through an underground 12" asbestos-cement pipeline. Both the pumping set and a part of the main delivery line are doubled up in order to remain operative in case of a breakdown. The storage reservoir is made of earthwork, without consolidation of the bottom and the inclined walls, with 60 x 60 m ground plan dimensions of the bottom. The inclination of the reservoir sides is 1 : 3. Maximum depth of water in the reservoir is 3.0 m, the safety superelevation margin of the dikes is 0.50 m. Evacuation into a system of open canals of the surface irrigation system and the safety overflow are designed in a common structure. Approximate column of the reservoir is 14 300 m3. On the south-western border of the storage reservoir there is installed a pumping station for overhead irrigation. It consists of a HDM-II-12 pump of American manufacture with an output of Q = 4280 USgall/min, H = 130 PSI, the associated engine is a 6-cylinder Diesel Caterpillar. The underground distribution system of pressure water over the area of irrigation is made of asbestos-cement pipelines. The hydrants are spaced at 100 m intervals. Portable pipelines with sprinkling heads spaced at 8 m intervals on a branch line and with the branch lines spaced at 18 m intervals are used in a maximum length of 120 m. The sprinkling heads are of Israeli manufacture, they bear the RAVIT 254 NAAN trade mark and the nozzles have 4 mm in diameter. In respect of operation it was found out that when larger systems of irrigation are operated, it is antieconomical to use small sprinkling heads.

Consequently, in the next programme there is contemplated the introduction of larger sprinkling heads, with the result that a substantial part of the already laid AC pipelines will have to be replaced by those of a larger diameter. For irrigation of wheat there is applied an irrigation cycle 15 - 20 days long in which in the course of 8 hours of irrigation there are supplied 70 - 80 mm of water.

As has been stated above, it is assumed that after completion of the irrigating installation to what is called a Pilot Project that will remain reserved for experimental work and for cultivation of seeds, the remaining area of 5000 ha will be divided into separately irrigable units in an extension of 50 ha each. Once the construction of the irrigation equipment has been completed, these plots will be leased out to independent farmers. Even these relatively small units are expected to evidence that under application of intensified operation of irrigation equipment it is possible to attain commercial production standards, with very favourable economic results.

5. TWIN RIVERS FARM

A farm with 460 ha of lands, engaged primarily in production of milk, beef, vegetables and fruit. From the way in which the farm is exploited and from the results obtained it is evident that operational control has attained very high standards and that most up-to-date method, including control by a computer, has been adopted.

A total of about 350 ha of lands are irrigated, most of which are pastures and grounds from which fodder plants for cattle are harvested. In the course of these last two years irrigation has also been extended to vegetables and there has been started cultivation of apples and peaches, also under irrigation. Overhead irrigation prevails; it uses portable aluminium branch lines connected to hydrants of an underground network of pipes. For irrigation of pasture lands are designed the DOLPHIN irrigation machines with a trailed hose and a sprinkling head with a wide radius of action and a high output. These heavy-duty machines are, however, not yet applied on a large scale.

There are two available sources of water for irrigation. For irrigation of pastures and fields of fodder cultures there are used water effluents from copper mines that are settled in a sedimentation tank. Production of effluents is a relatively high one and would permit a substantial expansion of irrigation to an adjacent zone. The quality of water is appropriate for irrigation of pasture lands. With the pH factor equivalent to 7.5 it aids to improve the acid soils of the farm. Dispersed sludges also contribute towards increase of fertility. For irrigation of vegetables and fruit river water is made use of. Both systems have separate delivery pipelines - 15" or 8" - steel. The pumping stations are equipped with pumps driven by electric motors.

The general outfit of both the pumping stations and the rest of the irrigation equipment is a very good one.

6. IPAPU SCHEME

Information on this irrigation scheme substantially differs from one document to the next. Hereinafter there will be discussed the facts obtained from a technician who right up at the farm controls the work at the irrigation system. The area served by the system consists of 44 plots owned by independent farmers; each one of them has the extension of 2.5 ha. The total area thus measures 110 ha. The source of water for irrigation are two small rivers and the pumping station is situated at the point of confluence of the two rivers. In view of the inadequate capacity of the source at the time of peak water demand it is not possible to irrigate the whole area. The KSB pump (suction 8", delivery 6") driven by a LISTER Diesel engine (6 cylinders, 1500 r.p.m.) delivers water under pressure through a 6" - - PVC underground pipeline of about 2000 m in length into a reservoir with earth dams situated at the highest point of the farm grounds. The dimensions of the reservoir are 20 x 40 x 3.5 m and its approximate capacity is 2800 m3.

Filling time is 18 hours. From the reservoir water is distributed by gravity through a system of furrows towards the different plots. Withdrawal from the furrows, reinforced by moulded concrete channels, is arranged by siphons. According to the system of orientation of the furrows, groups of plots (there are 6-9 plots in one group) receive water for an interval of 4 hours. Two groups are supplied with water at a time. Under this arrangement each plot takes its turn every 4 days. Dosing of water is carried out according to time and experience. At present the farmers pay for a daily amount of water supplied 2.6 Kw and a slightly higher sum is paid by the state for the same interval of time. The general impression made by the irrigating construction is that it is very primitive and its maintenance is inadequate. The conditions of the plots as also unkempt and there are great differences in this respect from one farmer to the next. The endeavour to teach the farmers to work not only for their own subsistence, but, in addition, to produce surplus crops for the market has so far not recorded any noticeable success.

7. <u>MFUBU RANCH</u>

The size of the arm lands is 10 000 acres, most of which serve as pasture lands for cattle. The farm is equipped with a total of 4 irrigating structures which serve about 100 acres in total. Irrigation is applied to fodder cultures, vegetables, fruit trees and pastures. The water source used is the Kafue river. The pumping station which supplies water to 22 acres has a KSB ETA 65 pump with a 25 kW electric motor. The switchboard with a starter is of national manufacture by the ALLENWEST company. For the underground pressurized distribution network the ranch owner uses a 6" PVC pipeline the acquisition cost of which is, as a matter of fact, higher than that of an asbestos-cement pipeline, but in case of a breakdown it can be more easily repaired by the user. The portable pipeline is made of aluminium to 3" and 4" diameters and to a maximum length of 120 m; it is of English manufacture. The sprinklers are small throughout and require a spacing of 12 x 12 m. The irrigation dose of 2.4" is supplied in a six-day cycle.

From his point of view of an experienced farmer, the owner recommends to local operators of small farms to start with irrigation on plots of 10 - 20 acres as a maximum. He places great emphasis on electrification that can help to ensure the development of irrigation systems. At the same time, however, he calls attention to the fact that it will be necessary to revise the existing system of payments for new electrical equipment and of the rates charged for electric power consumption. Another factor that is pointed out is the necessity of improving the services of repair of the entire irrigation equipment and the supply of spare parts. The firms that sell irrigation equipment are only interested in selling their products and they do not care for what has become of them thereafter. Under these conditions, a farmer, particularly when he does not live near a larger town, is obliged to resort to makeshift repairs he has to make himself. This state of affairs frequently discourages the farmers from establishing new irrigation facilities.

8. COPPERBELT POWER WORKS LTD.

This large company, organized and controlled on modern lines, engaged primarily in transformation and distribution of electric power, has also its associated multi-purpose agricultural establishments. Fish are bred in 14 ponds to which water is supplied from an earthwork reservoir the approximate area of which is 1.5 ha. The reservoir also serves as a source of water for irrigation of about 2 ha of vegetables and citric fruits. The general disposition can be regarded as an example of how also an organization of production orientation different from agricultural pursuits can contribute towards providing nourishment for the population. Under these conditions, the economic effect of these subsidiary activities is by no means a negligible one.

9. YORK FARM

A farm in the vicinity of Lusaka which for commercial purposes cultivates wheat, vegtables, maize and alfalfa. A total of 200 ha are served by irrigation with prevailing crops of wheat, onions, alfalfa and maize harvesgted as fodder. Throughout the irrigated zone there has been laid an underground network of AC pipes with diameters ranging from 8" to 10". The spacing of pipeline network branch lines is approximately one of 250 m.

Ground water is used as source of water for irrigation. Five MONOMEESTER MONO PUMPS LTA spindle pumps with 30 kW electric motors pump water into a common delivery line through which w_ter is conveyed into an earthwork reservoir situated at the distance of about 1 km. The extension of the reservoir is about 0.8 ha, maximum water depth is 6 m at the centre and 3 m near the banks. Two pumping stations have been built adjacent to the reservoir. Both of them are equipped with KSB centrifugal pumps. The first pumping station has one pump of KSB VIOSE 150-50 type and a 132-kW electric motor, and supplies pressure water to the marginal zone of the irrigated area. The major part of the area is served by a second pumping station that is fitted with two pumps with 90 or 70 kW motors.

In the proximity of the drilled wells there is constructed a circular concrete reservoir of 20 m in diameter and 2.0 m water depth. It serves as storage reservoir of water for irrigation of the adjacent vegetable cultures. This irrigation unit has a self-contained pump, a surface delivery line and a 6" portable pipeline. On the rest of the cultivation area there is mostly used a portable aluminium pipeline of 3" and 4" of English, Israeli and South African manufacture, together with small sprinklers. For irrigation of green maize there are well suited large sprinklers with nozzle size of 20/8 mm. The spacing of the large sprinklers is 45 x 45 m. Two sprinklers are in operation at a time. The irrigating equipment installed at the YORK FARM is well maintained and serviced, the irrigation is utilized economically and yields good results.

On the 3" surface line there is always in operation one sprinkler of this kind which within 4 hours of operation supplies 2" of water. This dose is applied every week.

10. ELLENSDALE FARM

Another good example of commercial cultivation of wheat under conditions of irrigation . In the 1980 year irrigation was applied to 322 acres of wheat. The whole plot was divided into 13 fractional plots the size of which ranged from 2 to 50 acres. The source of water for irrigation is a basin on a small river course. To underground asbestos-cement network of pipes of 6"water is supplied by 3 pumping stations. To all pumping stations electric power is supplied. To the hydrants are connected portable branch lines made of aluminium and steel . The sprinklers are of a small type, with short radium and low output. There are 10 000 sprinklers in total installed on the farm grounds; these are of US manufacture. Next there are 5000 sprinklers made in England and 1000 made in Israel. Apart from the conventional portable irrigation detail with small sprinklers there is in preparation the introduction of strip-type WRIGHT RAIN TOURAINE irrigation unitsFor larger farming establishments with sufficient experience in operation of irrigating installations, with efficient organization and control of labour, these irrigating machines of a higher generation substantially increase the productivity and improve the working conditions. The introduction of this higher level of technical equipment, however, contrasts with the attitude of the farm owner according to which the principal aim in view in respect of any agricultural installation or equipment to be put to work in Zambian working conditions should be its simplicity and the longest possible working life span.

During the visit to this farm the experience made earlier was confirmed again, i.e. that the present-day price level of irrigation equipment in Zambia is a prohibitively high one and stand in the way towards further development of irrigation systems. Another factor that inhibits the development trend is the want of more efficient repair services that is experienced by all those who run irrigation systems.

11. BENDER FARM

The owner of this farm has prolific experience to his credit in respect of operation of irrigation systems because he figures among the first promoters and users of irrigation systems in Zambia. At his farm a total of 280 acres are being served by irrigation by this time; 250 acres of this total are sown with wheat and 30 acres with maize harvested for green fodder. The irrigated surface is divided into three autonomous parts, each of them with its own pumping station. All distribution lines throughout the irrigated area consist of steel surface pipelines of 4" - - 6", most of them made by the WRIGHT RAIN and PERROT companies.

The pumping stations are made up of centrifugal pumps driven by 30 - 110 kW electric motors. The HV connections of 11 kVfrom the trunk power line to transformer stations associated to pumping stations, including the equipment of the former, were provided by the farm owner at his own expense. The switchboard and the starters are made by the ALLENWEST company.

Under the conditions of undulating ground surface and fractionalized configuration of the plots run by the farm, the owner does not recommend the use of strip-type irrigation units. Moreover, he anticipates potential damage that might be caused by larger sprinklers used with the strop--type irrigation units to wheat cultures.

For further development of irrigation in Zambia the farm owner deems it necessary to count with all kinds of assistance of the state, primarily in financing of new schemes of this sort.

12. MURRAY EVANS FARM

The farm on the bank of the Zambezi river irrigates a limited extension of farmland with the aid of a small pump with electric motor. More detailed information on the irrigated area extension, on the irrigation system etc., was impossible to obtain because at the time of the visit neither the owner nor any other informed worker were present.

13. VINCENT EVANS' FARM

With the aid of a KIRLOSKAR pump with parameters Q = 34 l/s, H =75 m, 100 kW, 1450 r.p.m. and two Chinese pumps ABA-6 with parameters Q = 115 m3/h, H = 81 m, 55 kW, 2900 r.p.m., water from the river is pumped into an asbestos--cement pipeline that distributes it over the area served by the system. There can be irrigated about 300 acres, mostly of wheat cultures which prosper relatively well in heavier soils. When the work is efficiently organized, it is possible to attain yields of up to 5.4 t/ha. In the course of the irrigation period there are supplied, on the average, 600 mm of irrigating water. In the irrigation system detail are used aluminium pipes of Israeli and English manufacture. The sprinklers are largely of the NAAN 354 trade mark, 5 mm dia, from Israel. At this farm it was evident, too, that the present-day high prices of irrigation equipment are the principal handicap that hampers further expansion of areas under irrigation.

14. PATELS' FARM

A farm with modest extension of irrigated vegetable cultures. Water is drawn from a river by a small pump into an underground distribution system laid at a shallow depth. For detailed distribution of water over the area are used portable aluminium pipes and small sprinklers. The irrigation equipment is not in good condition and it is evident thatthe operation of the system does probably not receive sufficient attention.

15. KAYUMBAS' FARM

There is irrigated approximately 1 ha of vegetable cultures by means of portable aluminium pipeline and slow-acting sprinklers. The water source used is a permanent water course from which water is pumped by a pump with a Diesel engine. At the time of our visit no one was present at the farm who could provide more detailed information about the operation of this irrigation system.

16. GRABBS' FARM

On the grounds of this farm of 107 acres there are cultivated vegetables only. The irrigating installation makes it possible to irrigate a total of 60 acres of which 25 acres can be irrigated simulteneously. Water for irrigation is pumped from a permanent water course by two pumps with outputs of 15000 gal/h and 18000 gal/h and it is distributed over the irrigated area through a system of surface channels. The irrigation proper is accomplished by surface-flooding.

This farm is a very good example of operation of an irrigation system and of the owner's endeavour to utilize the available water source for increase of production of vegetables for commercial purposes. In near future it is envisaged to expand the capacity of the existing irrigation system by drilling a new well for ground water intake.

17. STRYDOMS' AND BASSONS' FARM

The farm specializes, first of all, in production of milk. Its total extension is 180 acres. Irrigation caters to 30 acres, primarily for cultivation of fodder - lucerne. On the bank of a small river there is built in a sunk concrete reservoir of 4 x 4 m a pumping station with two pumps (STEWARDS LLOYDS VEG 100 and INGERSOLL-RAND COMPANY 65-250 MC). The pumps deliver water into a common steel delivery pipeline. Water is distributed over the irrigated fields through a surface-laid pipeline of 6" in diameter (main valve and 4" (lines with sprinklers). On each one of the four lines there can operate 10 sprinklers at a time. The doses of irrigation are determined by experience. During the dry season the irrigation system operates for 8 hours a day. In the cool monthsthe irrigation is reduced to 4 hours a day.

The fact that a variety of portable pipeline and sprinkler types is used is justified because it is not possible to adhere to one specific trade mark only, but instead it is imperative to purchase what is available in the market at the time of necessity and when acquisition is possible.

18. J. LOWE FARM

The farm is essentially of the same extension and production orientation as the preceding one. Likewise, the same applies to the irrigation equipment as has been said about that of the BASSONS´FARM.

19. COMBRINKS´FARM

None of the employees who were present at the time of the visit could furnish any information about orientation of production and extension of the irrigation system. The farms´ owner was absent. From an inspection of the equipment stored there it is evident that preparations are under way of an expansion or modernization of the irrigation equipment. This is indicated by stored supplies of asbestos-cement pipes of diameters ranging up to 600 mm. For utilization in operation of the irrigation system there has also been prepared a HEINZMAN TRAVELER 6645 irrigating machine with a trailed hose and a sprinkler. of NELSON type, and nozzle diameter of 28 - 32 mm.

The source of water for irrigation is a pond situated adjacent to the farm.

VIII. LIMITING FACTORS OF THE DEVELOPMENT OF IRRIGATION SYSTEMS IN ZAMBIA

Notwithstanding the fact that Zambia is a country with tremendous potential of prospective agricultural production, it is evident from official statistics reflecting the state of affairs in recent years that the country must make available high sums of money for purchase and import of the basic agricultural products in order to safeguard the nourishment of the population.

Irrigation systems are one of the means to be adopted in order that the country may be able to export the surplus of the products for the production of which favourable conditions exist in respect of the local climate. The principal advantages of irrigation systems are a stabilization of yields of the cultivated produce and their becoming independent from the climatic agents, increase of yields to a maximum and, finally, the possibility of harvesting the crops twice a year. The basic prerequisites of profitable cultivation of agricultural produce under irrigation by farming establishment, i.e. ample reserves of suitable soils and of water for irrigation, can be reckoned with in Zambia.

There exists, however, a number of factors that might make impossible, or at least substantially difficult, the cultivation on irrigated landsto an extent that is necessary to ensure self-supporting production of foodstuffs and to attain a standard where Zambia might also become an exporter of agricultural products.

A substantial part of these factors are of economic nature and the possibility of influencing them rests, in view of the regime in Zambia, with the Zambian government. It is thus a matter to be dealt with by government organs of the Zambian Republic, and it is up to them what an attitude they are going to adopt towards the problem of further development of irrigation systems. According to the documents entitled THIRD NATIONAL DEVELOPMENT PLAN and OPERATION OF FOOD PRODUCTION the government is interested in an expansion of irrigation systems in Zambia. Hereinafter there are outlined the different factors that can influence this sphere of national economy and their significance is pointed out.

1) Most of the small-scale agricultural producers will have radically to change the existing system of agricultural practice. By this time their endeavours are largely aimed at providing subsistence and nourishment of their own families alone. This is also reflected inthe extension and intensity of their labour input. It will be necessary to have this large percentage of farmers interested also in production envisaged for marketing. With this the nationwide agricultural production will be substantially increased.

2) Through an appropriate policy of prices in the sphere of agricultural production it will be necessary to pro-

mote the interest of small farmers in higher production. At a certain stage this will already be possible only when irrigation systems are used for some kinds of agricultural produce. With this there is also associated the establishment of appropriate conditions for export at the moment when the local markets have already been adequately supplied with the produce of the farms.

3) The irrigating structures are associated with high costs of acquisition and most of the investors will not be able to start such constructions, even those of small-scale type, without financial assistence afforded by the state. The forms of this government coparticipation may be different, but on no account they should become a financial burden to the user of an irrigation systemduring the period before positive results of the irrigating installation that has been built have manifested themselves in concrete figures.

4) The construction of an irrigation system and its operation without a parallel outfit of the agricultural establishment in question with process equipment of non-irrigating nature (agrotechnical implements, machines, storage facilities, transport equipment etc) and with fertilizers results in deterioration and devaluation of the investment made. It is consequently necessary in the state budget, the same as in the provincial and district budgets, to reckon with appropriations for acquisition of this kind of equipment with the due anticipation.

5) The present-day prices of all kinds of imported irrigation equipment are so high that they have become the cause of certain stagnation in irrigation activities. One potential alternative of approach is a reduction of the prices of this imported equipment and the other alternative is the construction of a manufacturing establishment in Zambia that would be capable of supplying local users with basic irrigation equipment (pumps, surface-type pipelines including pipe fittings, adapters and sprinklers) in good quality and at acceptable prices.

6) In view of the mounting world-wide energetic crisis it can be assumed that the oil prices will continually increase. Consequently, it will become increasingly advantageous to operate machines that are driven by electric motors. Zambia has a sufficient amount of electric power resources. There are, however difficulties in power distribution to the points of consumption if such sites are remote from industrial or commercial centres or from the high voltage transmission trunk lines. For further development it will be indispensable to bring to the sites where pumping stations of individual systems are going to be situated, high voltage transmission lines and to make arrangements for its transformation to voltage appropriate for drive of the pump motors. This condition is a very important one because with the existing network of roads in the country it is found extremely difficult to uphold continuous supply of fuels even to smaller Diesel-electric sets used in irrigation systems.

7) The principal centres of the prospective development of irrigation facilities must be able to rely on adequate communication routes available to them so as to eliminate the problems involved in transport of manufactured products to points of consumption or of further processing. Through a good network of hard-surfaced roads there will also improve the conditions necessary for carrying out repairs of irrigation equipment and for its maintenance during the season when the equipment does not operate, which is precisely the time when earth roads are next to impassable due to heavy rains.

8) In spite of the fact that in Zambia there is available enough of convenient soil for agricultural use, there begins to make itself felt by this time already a shortage of plots that should be readily available for potential users who wish to establish new farms on them. The tracts of land have not yet been surveyed and the basic pedological survey of these lands has not been carried out.

9) There is not much experience available with irrigation systems in Zambia. For most of the workers engaged in farming

activities agriculture under conditions of irrigation will be a novelty. It will be a new experience to them not only to master the technique of irrigation itself, but also to solve the agronomic problems associated with soil preparation prior to irrigation and while the same is in progress, the same as appropriate fertilization, protective sprinkling and harvesting practice and technology. Likewise, the assortment of varieties of irrigated produce will be different from that envisaged for farming without irrigation. From this point of view it will be found advantageous to distribute the construction of initial irrigation equipment of the new irrigation structures and facilites so as to build in each district and to put into operation one structure that will then serve as a model for demonstration of farming with the use of an irrig tion system to ample circles of farmers and farming personnel. Here it will be possible to acquire the basic experience and skill for subsequent irrigation schemes.

10) With the subject of the preceding paragraph there is closely associated also the factor of qualified control of irrigation systems. It is in particular in the case of larger systems which, for instance, utilize a common water source for irrigation, where coordination and methodical control of operation are imperative. In view of the existing shortage of qualified personnel graduated from high schhols in the discipline of irrigation systems, it will be necessary, even in the structure of the educational system, to make certain interventions that will be aimed at staffing the control functions with qualified experts. There should also be considered the possibility of setting up a specialized department in the Ministry of Agriculture that would take charge of centralized direction and control of irrigation system in the country in the aspects of investments and operation. As the number of trained experts will increase, such departments could then be set up also in provincial and district centres.

11) Much criticism on the part of those who by this time review the irrigation systems is inspired by the fact that there does not exist any organization that would be systematically engaged in routine repairs and maintenance of the irrigation equipment. It is next to impossible for the farmers themselves to make arrangements for the necessary repairs at their own expense and on hand of the available experience. If an irrigation equipment manufacturing enterprise came into existence in Zambia, it might be possible within such a factory to set up a department engaged in providing this kind of services to the farmers.

IX. IRRIGATION SYSTEMS PLANNED IN ZAMBIA

In the course of our investigations of the irrigation equipment market in Zambia we discovered a number of studies and reports the subject of which was a plan of irrigation system constructions in that country for the next few years. As work of this kind had been carried out by different teams of experts, at different times and from different angles of interest, it appears advisable to us to review their respective results and thus confront them with one another.

1) Report of the Committee for Irrigations - worked out as part of preparatory work for the THIRD NATIONAL DEVELOPMENT PLAN - 1975.

The statement was made in this report that in the period of the Third Five-Year Plan a total of 61 150 ha of agricultural lands will be exploited with the aid of irrigation systems. Of this total, 8 594.18 ha were envisaged to be served by the already existing irrigation systems and 52 555.82 ha by newly built ones. In the report of the said Committee there are indicated both the territories of potential development of irrigation systems and those on which attention should be primarily focussed in the course of the 3rd Five-Year Plan.

A general review of irrigation potential in Zambia is divided into areas with surface water sources and those of ground water.

Surface Waters:

ZAMBEZI NORTH/KAFUE WEST Catchment Area:

KENYAUNA	184 ha
MPUNGU	59 ha
LOBUFU	215 ha
KAMATETE	53 ha
DONGWE	182 ha

The Committee voiced their conviction that in the NORTH-WESTERN province there exists an ample potential for medium-sized and small-scale irrigation structures.

ZAMBEZI WEST AND SOUTH Catchment Area:

CHAVUMA	1000 ha
KAMBANGA	200 ha
SINAMALIMA	3000 ha
CHIAWA	4000 ha

KAFUE Catchment Area:

MIDDLE KAFUE REGION	34 000 ha
LUKANGA BIG CONCESSION	12 000 ha
UPLAND FRINGES OF KAFUE FLATS	26 500 ha
KAFUE FLATS	56 500 ha

In respect of this particular catchment area, the Committee calls attention to the fact that utilization of water for irrigation depends on how much water it will be possible to obtain from the Kafue river at the expense of the power plant interests that have been a preferential aim up to the present.

LUANGUA Catchment Area:

KAKUMBI AREA	4000 ha
LUPANDE RIVER	(construction of dams necessary)
LUNSEMPFA RIVER	

CHAMBESI Catchment Area:

SOUTH MPIKA	500 ha
LAKE ISHIWA NGANDU	
CHAMBESI RIVER	
WEST OF MBALA	
MOSES	
NSEMBO (BANGWELA NORTH)	10 000 ha

LUAPULA Catchment Area:

MATANDA	2 000 ha
KASOMPE	1 400 ha
CHILONDO	5 000 ha
KASHIBA	6 700 ha
MUSANGA	1 600 ha
KAWAMBWA	9 000 ha
MBERESHI	7 000 ha
KANYAENBO	1 000 ha
CHABILAKILA	2 400 ha

Ground Waters:

WEST LUSAKA	5 000 ha
CHISAMBA WEST	5 000 ha
KABWE SOUTH	2 000 ha
MPONGWE	8 000 ha
MONZE-MAZABUKA	
MUMBWA	
CHINGOLA	
KASEMPA	
SOLWEZI	
MWINILUNGA	

The area size,as indicated in the preceding list, totals 208 493 ha (less the areas the sizes of which are not specified). The areas that should receive particular attention in the development of irrigation systems during the 3rd Five-Year Plan are the following ones:

NORTH-WESTERN PROVINCE:

CHAWUMA
KABANGA

SOUTHERN PROVINCE:

SINAMALIMA
SOUTH OF KAFUE RIVER
KAFUE

CENTRAL PROVINCE:

KAFUE FLATS
CHIAWA

COPPERBELT PROVINCE:

MUNKUMPU
MPONGWE

EASTERN PROVINCE:

KAKUMBI

NORTHERN PROVINCE:

SOUTH OF MPIKA
BANGWELU SWAMPS

LUAPULA PROVINCE:

MATANDA
KAWAMBWA

2) Report by the FAO Joint Commission (West Germany/Holland) - worked out in the study on irrigation potential in Zambia - 1978.

The objective of the report worked out by the above joint team of experts consisted, apart from an evaluation of the irrigation potentialities in Zambia from natural and economic points of view, in determination of the necessary extent of irrigation systems with the end in view of attaining self-sufficiency in production of food in the 1990 year.

As a result of this work it was ascertained that in addition to the existing 15935 ha of irrigated lands it is necessary to install irrigation equipment made up of new units on other 62777 ha.

According to the different kinds of produce the distribution of the new irrigation systems is as follows:

wheat	44 500 ha
barley	8 680 ha
sugar	2 800 ha
coffee	804 ha
tea	1 178 ha
vegetables	2 873 ha
fruit	314 ha
fodders	1 628 ha
total	62 777 ha

In respect of situation of the new irrigation systems, in the FAO report are indicated only the following larger irrigation complexes:

MUNKUMPU	20 000 ha
BIG CONCESSION	4 000 ha
LUENA	14 000 ha
MPONGWE	22 000 ha
KAWAMBWA	237 ha
NAKAMBALA	2 430 ha
LUCULU	400 ha

3) THIRD NATIONAL DEVELOPMENT PLAN - 1979

In this basic document for development of national economy in Zambia in the 1979 - 1983 years the following facts are exposed about irrigation systems:

The total of irrigated surface is estimated to amount to 1 - 10 million hectares. At present approximately 10 000 ha are served by irrigation systems. The government's strategy in the course of the Third Five-Year Plan in the sphere of irrigation is the following one:

- through extension of small irrigation systems with simple methods of irrigation to ensure sufficient production of food (primarily of vegetables) for local markets and to acquire fundamental experience in operation of irrigation systems
- to build a medium-sized irrigation system in every district for demonstration of irrigation techniques

- by means of large-scale irrigation systems for selected kinds of agricultural produce to ensure a substantial increase of production and to make possible exports thereof.

In the TNDP there are expressly indicated the following areas where either some of the preparatory work for the projects has already been done or where exist realistic perspectives of irrigation system development:

MUNKUMPU	20 000 ha
MPONGWE	22 000 ha
BIG CONCESSION LUENA	30 000 ha
CHAMBESHI	25 000 ha
ZAMBEZI/SESHEKE	30 000 ha
KAFUE FLATS	20 000 ha
LAKE BANGWEULU	

The total extension of the schemes referred to is 147 000 ha.

4) OPERATION FOOD PRODUCTION -1980

The newest document with which the president of the Zambian Republic Dr.K.Kaunda establishes new foundations of a rapid development of agricultural production in the country, places great emphasis on development of irrigation systems. Individual irrigation schemes are not identified expressly by their names. Reference is made, however, to new state farms of which two are scheduled to be set up in each province. The average size of one farm is to be 20 000 ha.

As in the course of our stay in Zambia it was on no account possible to obtain any other information about the state farms, it can only be deducted empirically that on about one-half of the extension of all state farms it will be necessary to build irrigation equipment. To this concept there corresponds the necessary extension of irrigation systems on 180 000 ha of the lands.

5) Conclusions of Planning Department of the Ministry of Agriculture - 1980

(ASSISTANT SECRETARY IN PLANNING - MINISTRY OF AGRICULTURE AND WATER DEVELOPMENT)

According to the data available from the Ministry of Agriculture there is envisaged, for the period up to the 1990 year, the construction of new irrigation systems on an extension of 60 to 100 000 ha. The great difference between the lower and the upper limit of extension of the scheduled new irrigation systems evidences the fact that the central agricultural authority has so far not formulated any concrete and exact concepts as to what should be constructed in the sphere of irrigation systems. This is also documented by the fact that only five concrete schemes have been specified by the ministry with a total extension of 15 200 ha:

MPONGWE	5 000 ha
MGUSHI BLOCK	6 000 ha
KLEYA	1 600 ha
BIG CONCESSION	1 000 ha
MAZABUKA	1 600 ha

Up to an extension of 60 200 ha this list is supplemented with irrigation systems of state farms in an extension of 40 000 ha and by minor irrigation systems to an extent of 5 000 ha without detailed specifications.

6) Proposal of UNIDO Group, Vienna - 1981

During the conclusive negotiations of the market investigation results in the sphere of demands for irrigation systems and equipment that took part on November 26, 1980 con participation of representatives of the Ministry of Agriculture and Water Development and of the Ministry of Commerce and Industry, the group of UNIDO Vienna presented a proposal according to which there should be constructed, up to the end of the 1990 year, new irrigation systems in Zambia on an extension of 130 000 ha. This determination of systems extension resulted from the survey of lands that had been conducted, from discussions with irrigation engineers and technicians engaged in all branches of Zambian agriculture, from opinions voiced by Ministry executives, by representatives of provincial and district organs and authorities, but, first of all, from all available studies and research reports that had been worked out in the sphere of development of irrigation systems in Zambia. It is the opinion of the team members that without a radical and prompt development of irrigation systems it is not possible to safeguard the supply of local markets with food without fluctuations of supply caused by climatic agents. Without such a development it will not be possible either to furnish agricultural produce for export that is reckoned with in the most up-to-date plans and perspectives.

From a comparison of the data indicated in paragraphs 1) to 4) of this chapter it is evident that the value of 130 000 ha surpasses only the value that is specified by the German Dutch FAO joint committee for the 1990 year. In this instance, however, it should be pointed out that the FAO report was aimed only at attaining a self-supporting standard in food production, without taking into account potential exports. This fact was, however, pointed out with due emphasis in the document entitled OPERATION OF FOOD PRODUCTION by the president Dr.K.Kaunda, and it would be actually an economic hazard not to reckon with potential exports of food from a country in which favourable conditions exist for its production, to countries where natural conditions make agricultural production entirely impossible or at least make it prohibitively expensive. As regards the report worked out by the team for preparation of the TNDP, it should be taken into consideration 52 555 82 hawere contemplated only for the Third Five-Year Plan.)The suggested value of 130 000 ha to be served by new irrigation systems by the 1990 year did not meet with approval of the Ministry of Agriculture representatives. In the subsequent negotiations they stipulated values of 60 - 100 000 ha, as referred to in detail in paragraph 5). As the final decision on the extent of construction of the irrigation systems in the country will restwith an organ of the Zambian Republic government, that is, with the Ministry of Agriculture, the team of experts made a concession and revised the value of 130 000 ha down to the required 100 000 ha. The upper limit of the given range was upheld in view of the importance attached to agriculture practised under conditions of irrigation for attaining the target figures in the sphere of nourishment of the population of Zambia and for potential exports of agricultural produce from Zambia.

X. TECHNICAL ARRANGEMENT OF NEW IRRIGATION SYSTEMS

As a starting value for subsequent considerations there are assumed 100 000 ha of new irrigation systems envisaged to be constructed until the 1990 year.

It is assumed that 25 % of the area under review will be irrigated by surface-type methods (surface flooding, flooding from ditches, furrow irrigation), and 75 % of the area will be served by overhead irrigation. When water is drawn by pumps from drilled holes and wells,it is reckoned with a system in which water for irrigation will be pumped from the sources into surface-type accumulation reservoirs and from these it will be distributed by a pressure-type pumping station into a network of pipes laid on the area served.

Extension for overhead irrigation: 100 000 ha x 0.75 =
= 75 000 ha.

From the extension of the area served by overhead irrigation 20 % are envisaged for irrigation systems with Diesel engine-driven sets.

For the area envisaged to be irrigated by sets with electric motors there remain in total 75 000 ha x 0.8 = 60 000 ha.

It is recommended to design for irrigation a type of sets that will contain an irrigation pumping set, a portable irrigation pipeline (including the fittings) and sprinklers. The size of irrigation sets is designed so as to cater to plots of 6 ha, 12 ha, 24 ha and 48 ha with their operating range and the capacity of the amount of pumped water, with an envisaged average inflow of 1 l/sec/ha. For this it is recommended to manufacture a typified range of pumps with stepped-off deliveries in the following succession: 6 l/sec, 12 l/sec, 24 l/sec and 48 l/sec. Areas of greater extension, up to about 200 ha, can be irrigated by the highest sets of the above range of types arranged in parallel. If necessity should arise of extremely larger irrigation units, the problem will have to be dealt with either by importing larger pumps, or else, in the next stage by construction of a plant for manufacture of irrigation equipment, by adding a pump with approximate output of 66 l/s or by adding a pump of another type.

There is recommended a uniform distribution of the above sizes in the range of types of irrigation sets, that is, 25 per cent of each one of the above sizes. By 1990 there should be in operation according to that schedule a total of 4 690 pieces of irrigation sets, the distribution of the different sizes being then arranged as follows:

6 ha set	-	2 500	pieces
12 ha set	-	1 250	"
24 ha set		625	"
48 ha set		315	"
T o t a l		4 690	pieces of sets

XI. INCREASE OF DEMAND FOR IRRIGATION SYSTEMS FROM ONE YEAR TO THE NEXT

The plant for manufacture of irrigation equipment should begin with the manufacture in the fourth year from the date of conclusion of an agreement on its construction. It is assumed that at present the import of irrigation equipment provides an overall extension that approximately corresponds to 80 sets which are envisaged to be made in the new plant. In order to come near the target figure of 4 690 sets, there is necessary an annual increase of 31 %. An even and balanced keeping of the rate of increase of 31%, in both making arrangements for providing irrigation equipment and in putting new irrigation systems into operation, will make it possible to fulfil the task of establishing 100 000 ha of new irrigation systems by 1990. Until the new plant has started to operate, it will be necessary to fit the new structures with irrigation equipment imported from abroad. Once national manufacture of the equipment has been started, it is assumed that the whole demand will be met by the new plant within the range of its regular production programme.

For the requirements of new irrigation systems, the distribution of the number of irrigation sets in the successive years is indicated in the following Table 10:

Year	Number of required irrigation sets	Note
1980	80	initial conditions
1981	105	
1982	135	
1983	180	
1984	235	start of manufacture
1985	310	
1986	405	
1987	530	
1988	690	
1989	910	
1990	1 190	
Total 1981-1990	4 690	

In the 1990 year the new plant will make 1190 irrigation sets a year. This amount, however, represents only new irrigation systems. From the point of view of making arrangements for replacement of old irrigation equipment, furnishing reserves and utilization of some elements of the irrigation systems (such as pumps) also for other spheres of national economy, it will be necessary to design a higher production capacity of the new plant. The extent of such an increase will differ from one part of an irrigation set to the next and will be laid down in detail in the specification of individual components of the set.

XII. SPECIFICATION OF IRRIGATION SET

1) Pump

a) Set for 6 ha

There is designed a horizontal, centrifugal, single-stage pump of spiral design with the following parameters:

- volume delivered	6 l/sec
- manometric (total) head	52 m
- suction capacity	6.5 m

The driving electric motor, which will not be manufactured in the new plant, must be of a closed, combined foot- and flange-mounted design, with short--circuited armature, three-phase for 380 V, 50c/s, with 7.5 kW horsepower and speed identical with that of the pump, i.e. 2900 r.p.m. The pump-electric motor set will be fitted on a baseplate.

In the 1990 year 635 pieces of these pumps for new irrigation systems will be required. The determination of the number of pumps that will replace the old irrigation pumps is based on a 10-year working life span of the mechanical equipment of irrigation systems. In 1990 it will thus be necessary to replace the existing 80 pumps. Of this total there are 25% of pumps of this size, i.e. 20 pieces.

A reserve margin is assumed to be about 10 %, which means that,because of this, 65 additional pumps will be manufactured in 1990.

In the sphere of utilization of the designed irrigation pumps in other lines of national economy it has been estimated that at present there are required approximately 400 pieces a year. With an annual increase of 8 %, the resultant annual requirement for the 1990 year is 860 irrigation pumps for operation outside the sphere of irrigation (water supply, mines, other branches of industry etc.). The distribution into size categories will be even and regular, at 25% intervals, that is, 215 of the smallest pumps will be required in the 1990 year for applications other than irrigation.

Recapitulation of demand in 1990:

- new irrigation systems	635 pieces
- replacements of old pumps	20 "
- reserve	65 "
- applications other than irrigation	215 "
T o t a l	935 pieces

b) Set for 12 ha

It is suggested to use a pump of the same type as in the sets for 6 ha, with the following parameters:

- volume delivered	12 l/sec
- manometric head	58 m
- suction capacity	6.5 m
- electric motor horsepower	13 kW
- rotational speed of pump and motor	2900 r.p.m.

The demand was determined according to the same principles as for the pump to be used in the 6 ha set.

Recapitulation of demand in 1990:

- new irrigation systems	315 pieces
- replacements for old pumps	20 "
- reserve	30 "
- applications other than irrigation	215
T o t a l	580 pieces

c) Set for 24 ha

It is suggested to use a pump of the same type as in the sets for 6 and 12 ha, with the following parameters:

- volume delivered	24 l/sec
- manometric head	72 m
- suction capacity	4.5 m
- horsepower of electric motor	30 kW
- rotational speeds of pump and motor	2955 r.p.m.

The demand was determined according to the principles indicated above.

Recapitulation of the demand in 1990:

- new irrigation systems	160 pieces
- replacements for old pumps	20 "
- reserve	15
- applications other than irrigation	215
T o t a l	410 pieces

d) Set for 48 ha

A pump of the same type as those of the sets for 6, 12 and 24 ha is suggested, with the following parameters:

- volume delivered	48 l/sec
- manometric head	80 m
- suction capacity	4.5 m
- electrid motor horsepower	55 kW
- speed of pump and motor	2975 r.p.m.

The demand was determined according to the above principles.

Recapitulation of the demand in 1990:

- new irrigation systems	80 pieces
- replacements for old pumps	20 "
- reserve	10 "
- applications other than irrigation	215 "
T o t a l	325 pieces

Review of pump manufacture in the new plant in 1990:

- for 6 ha set	935 pieces
- for 12 ha set	580 "
- for 24 ha set	410 "
for 48 ha set	325 "
T o t a l	2 250 pieces

2) Irrigation Pipeline for Suction Branches of Pumps

For individual pumps it will be necessary to provide suction branches. For the pumps envisaged for 6 and 12 ha the diameter of the suction pipeline will be 100 mm, for the remaining two types the suction pipeline will have a diameter of 150 mm. The pipeline will be made of steel, with flanges, in order to attain maximum tightness in the intake section. As a pipeline of this type is not going to be manufactured in the plant, it will be necessary to make arrangementwith a cooperating factory for its manufacture. For orientation there follow data about the required quantities of the suction pipeline the envisaged length of the pipe being 2 m.

Demand for suction pipelines in 1990:

Js 100 mm : 935 x 4 pcs. + 580 x 4 pcs. = 6060 pcs.(à 2 m)
Js 150 mm : 410 x 4 pcs. + 225 x 4 pcs. = 2540 pcs. (à 2 m)

3) Delivery Irrigation Pipeline

As surface delivery and distributing irrigation pipeline from the pumping set to the sprinklers there is designed an aluminium pipeline in standard lengths of 6 m. The pipes will be fitted with dependable lever-operated couplers that enable easy and quick connection or disconnection. On an uneven terrain these couplers should permit a deviation of the pipeline up to 15^{o}.

For the different sizes of irrigation sets there are designed, with a view to the configuration of the plot to be served and to hydraulic conditions that exist during operation of the irrigation system, pipeline profiles of 80 mm, 100 mm and 120 mm. Diagrammatic views of the irrigation sets are shown in Appendices No.2 - 5. Here a recapitulation is made of the demands for pipelines of different profiles in the different types of irrigation sets:

Extension	Js 80	Js 100	Js 120	Total
6 ha	131 pieces			131 pieces
12 ha	88 pieces	89 pieces		177 pieces
24 ha	80 pieces	88 pieces	72 pieces	240 pieces
48 ha		424 pieces		424 pieces

The common reserve, the replacements for old equipment and the demands for applications of non-irrigating nature are estimated to be 15 % of the total of irrigation pipelines.

a) Js 80:

131 x 635 + 15 % = 83185 + 12478 = 95 663 pcs.
88 x 315 + 15 % = 27720 + 4158 = 31 878 pcs.
80 x 160 + 15 % = 12800 + 1920 = 14 720 pcs.

T o t a l 142 261 pcs.

b) Js 100:

89 x 315 + 15 % = 28035 + 4205 = 32 240 pcs.
88 x 160 + 15 % = 14080 + 2112 = 16 192 pcs.
424 x 80 + 15 % = 33920 + 5088 = 39 008 pcs.

T o t a l 87 440 pcs.

c) Js 120:

72 x 160 + 15 % = 11 520 + 1728 = 13 248 pcs.

Note:

The Js 150 asbestos-cement pipeline that figures in the diagrammatic views of the irrigation sets for 24 ha and 48 ha will not be manufactured in the new plant. In Zambia there does not exist any establishment that would be in a position of supplying AC pipelines in the required quantities for use in irrigation sets.
In the 1990 year the demand for AC pipelines Js 100, Jt 10 (with 5% reserve included, will be as follows:

24 ha : 200 m x 160 + 5% = 32 000 + 1600 = 33 600 m
48 ha: 880 m x 80 + 5% = 70 400 + 3520 = 73 920 m

T o t a l 107 520 m

4) Shaped Elements and Fittings for Suc ion Branch

In the suction branch of the pumping sets it will be necessary to use a flanged steel 90^{o} elbow. This shaped piece wil not be manufactured in the new plant. Orientational demand in 1990 is as follows:

Js 100 mm : 935 x 1 pc + 580 x 1 pc = 1 515 pcs.
Js 150 mm : 410 x 1 pc + 225 x 1 pc = 635 pcs.

For each pumping set there is required a flanged suction strainer that should be manufactured in the new plant. There is suggested a lightweight suction strainer made of aluminium alloy, Js 100 mm for 6 ha and 12 ha sets, and Js 150 mm for 24 ha and 48 ha sets. The demand in 1990 is as follows:

Js 100 mm : 935 x 1 pc + 580 x 1 pc = 1 515 pcs.
Js 150 mm : 410 x 1 pc + 225 x 1 pc = 635 pcs.

5) Shaped Elements and Fittings for Delivery Branch

For the possibility of shutting-off the delivery branch from the pumping set, for connection of the set to the delivery pipeline, for connection of side branches to the main delivery line that is laid through the centre of a plot, for connection of sprinklers to the pipeline and for shutters of pipeline ends there are required in each irrigation set various kinds of shaped elements and fittings. As there exist various possibilites of assembly of an irrigation set by means of shaped elements and fittings, their exact specification can only be made by the operator of the new plant. Hereinafter there is attempted an approximate specification according to one of the systems of set assembly and combination, in order to give an idea of the types and the number of individual specimens. It is assumed that the shaped elements will be made of thin-walled steel pipes protected from corrosion by galvanization. The ends of the shaped pieces will be mostly fitted with lever-operated couplers, such as the irrigation delivery pipeline. Some of the shaped elements will have special-type fittings for connection of branch lines or sprinklers. For calculations it is reckoned with a reserve amounting to about 10 %.

Determination of demand in the 1990 year:

- valve for shutting off the delivery line from the pumping set
  Js 70/80 mm : 635 x 1 + 10 % = 635 + 65 = 700 pcs.
- ditto
  Js 80/100 mm : 315 x 1 + 10 % = 315 + 30 = 345 pcs.
- ditto
  Js 100/120 mm : 160 x 1 + 10 % = 160 + 15 = 175 pcs.
- ditto
  Js 125/150 mm : 80 x 1 + 10 % = 80 + 10 = 90 pcs.
- connecting pipeline from valve to delivery pipeline
  Js 80 mm: quantities identical with those of the valve = 700 pcs.
- ditto, Js 100 mm : -"- = 345 pcs.
- ditto, Js = 120 mm: -"- = 175 pcs.
- ditto, Js 150 mm : -"- = 90 pcs.
- valve for possibility of connection and shut-off of side branch
  Js 80 mm : 635 x 13 + 10 % = 8255 + 825 = 9080 pcs.
  Js 100 mm : 315 x 17 + 10 % = 5355 + 535 = 5890 pcs.
- end piece for blinding the pipeline
  Js 80 mm : 635x5+315x4+160x4+10% =
  = 3175 + 1260 + 640 + 505 = 5580 pcs.
- ditto
  Js 100 mm: 315x1+ 160x1+80x8+10% =
  = 315 + 160 + 640 + 110 = 1225 pcs.
- pipeline coupler for connection of side branches
  Js 80 mm : 635x4 + 315x4 + 10 % =
  = 2540 + 1260 + 380 = 4180 pcs.
- extension pipe 1500 mm long for sprinkler, with tripod
  Js 3/4" : 635x28+315x24+160x44+10% =
  = 17780 + 7560 + 7040 + 3240 = 35620 pcs.
- ditto, Js 2 1/2": 80x16+10%=1280+130 = 1410 pcs.
- reducing piece of pipeline
  Js 120/150 mm : 160x1+10% = 160+15 = 175 pcs.
- ditto
  Js 150/120 mm : 160x1+10% = 160+15 = 175 pcs.
- ditto

Js 102/76 mm : 160x4+10% = 640 + 65 = 705 pcs.

- irrigation system slide valve for the possibility of connection and shut-off of a side branch
  Js 120/102 mm : 160x19+10% = 3040 + 305 = 3345 pcs.
- connecting element for the possibility of connection and shut-off of a side branch
  Js 100 mm : 160x4+10% = 640 + 65 = 75 pcs.
- double breeches pipe for connection of side branches
  Js 100 mm : 80x16+10% = 1280 + 130 = 1410 pcs.
- sprinkler shutter
  Js 102 mm : 80x64+10% = 5120 + 510 = 5630 pcs.

Note:

The shaped elements and fittings for asbestos-cement pipelines in the sets for 24 ha and 48 ha are not included in the review.

6) Sprinklers

For the 6 ha, 12 ha and 24 ha irrigation sets it is recommended to use sprinklers of low intensity that will be found convenient primarily for cultivation of vegetables. For the 48 ha irrigation set are designed medium-intensity sprinklers that will be found suitable for irrigation of grain and fodders that will be largely cultivated on lands of greater extension. The representative of the first (small) type is a sprinkler that will feature parameters in the following range:

- with nozzle diameter of 5 mm, pressure of 0.3 MPa:
  flow rate - 28 l/min
  operating radius - 17 m
  intensity for 18/18 spacing - 5.2 mm/h
- with nozzle diameter of 7 mm, pressure of 0.4 MPa:
  flow rate - 62 l/min
  operating radius - 20.5 m
  intensity for 24/24 spacing - 6.4 mm/h

Changes of parameters will be obtained solely through a change of the sprinkler nozzle size. A representative of the second (medium) type is a sprinkler with the following parameters:

- with nozzle diameter of 16/7 mm, pressure 0.35 MPa:
  flow rate - 350 l/min
  operating range - 33 m
  intensity for 42/42 spacing - 11.9 mm/h.

In the determination of the number of sprinklers it is reckoned with a 10 % reserve.

In the irrigation system for 6 ha there will be in operation 14 small sprinklers at a time and other 14 sprinklers will be kept ready for putting them to work. There will be 28 sprinklers in total.

In the 12 ha irrigation set there will operate 12 small sprinklers at a time, with other 12 sprinklers kept in readiness for operation. There will be 24 sprinklers in total.

In the 24 ha irrigation set there will operate 22 small sprinklers at a time, with other 22 sprinklers kept ready for operation. There will be 44 sprinklers in total.

In the 48 ha irrigation set there will be 8 medium-sized sprinklers in operation at a time, with other 8 sprinklers kept ready for operation. There will be 16 sprinklers in total.

Determination of demand for sprinklers in 1990:

a) small sprinklers:
   635 x 28 + 315 x 24 + 160 x 44 + 10 % =
   = 17780 + 7560 + 7040 + 3240 = 35 620 pcs.

b) medium-sized sprinklers:
   80 x 16 + 10 % = 1280 + 130 = 1 410 pcs.

Total 37 030 pcs.

XIII. PUMPING SET WITH DRIVE BY DIESEL ENGINE

As has been pointed out in the chapter "Technical Arrangement of New Irrigation Systems", it is assumed that in the 1990 year 20 per cent of the area served by overhead irrigation will be irrigated by means of pumps driven by Diesel engines. The extension of this proportion is 15 000 ha.

It is suggested that the pump of a Diesel engine driven set should have an output of 39 l/sec. Under this assumption there are required in total 385 sets for irrigation of 15 000 ha. At the rate of annual increase of 23 % and when it is assumed that about 10 sets of the size indicated above will be needed, the production capacity of the new plant should be one of 85 sets in order that the target demand may be met in the year 1990.

When the reserve sets, the replacements for old sets and the demand of units for purposes other than irrigation are included in the considerations, the annual production in the 1990 year will amount to 100 sets.

Parameters required:

- volume delivered	39 l/sec
- manometric head	73 m
- suction capacity	5.8 m
- pump speed	2925 r.p.m.
- engine horsepower (at 1800 r.p,m.)	80 h.p.

- engine: four-stroke, four-cylinder, water-cooled, with direct fuel injection, electric starting
- connection of pump with Diesel engine through gearbox and clutch
- automatic protection from overload by consumption of larger amount of water, protection from inadequate oil pressure in engine, from overheating of engine, from operation of pump in absence of water
- for evacuation of suction branch utilization of exhaust gas vacuum pump
- suction branch including suction strainer Js 120 mm
- two-wheel undercarriage
- lock-up type cowl

It is assumed that the production of this relatively demanding pumping set will not be initiated until experience in production has been acquired in the new plant, that is, probably not earlier than in the fourth or fifth year of production.

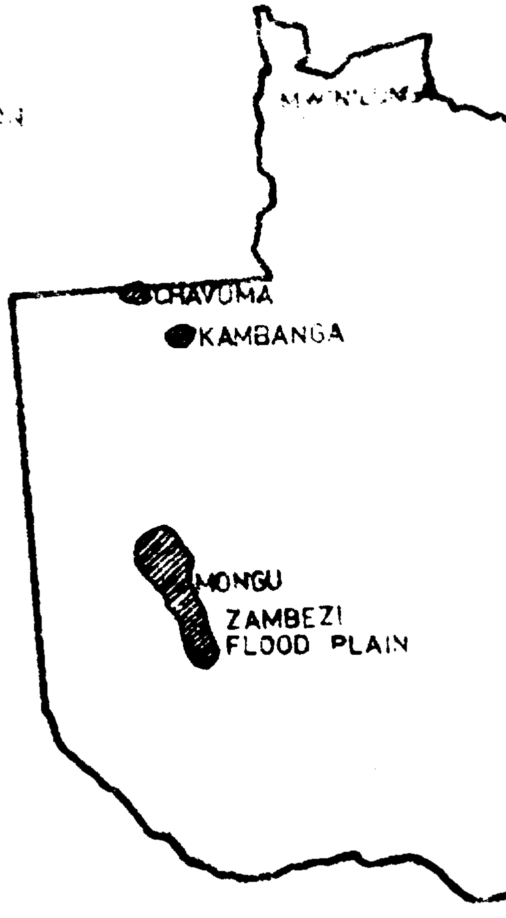
XIV. STRIP-TYPE IRRIGATION UNITS

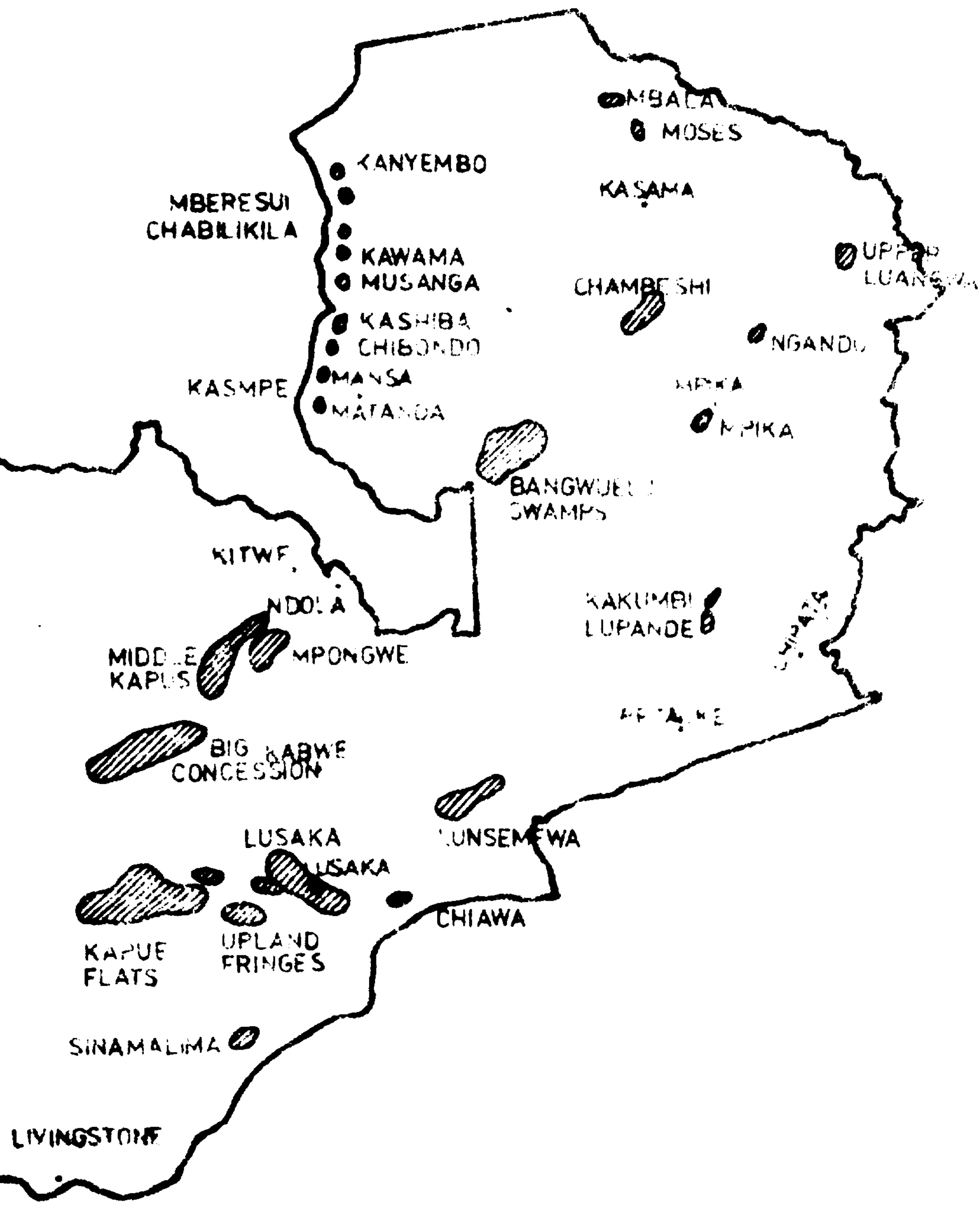
Before the 1990 year there is not envisaged any mass introduction of strip-type irrigation units in the practice of irrigation. Provided that positive experience has been made with these machines in local Zambian conditions in the meantime (on hand of work carried out with imported strip-type irrigation units), their production in the new irrigation equipment manufacturing plant can be planned for the second stage of construction of the said plant.

oooo

1 : 650 000

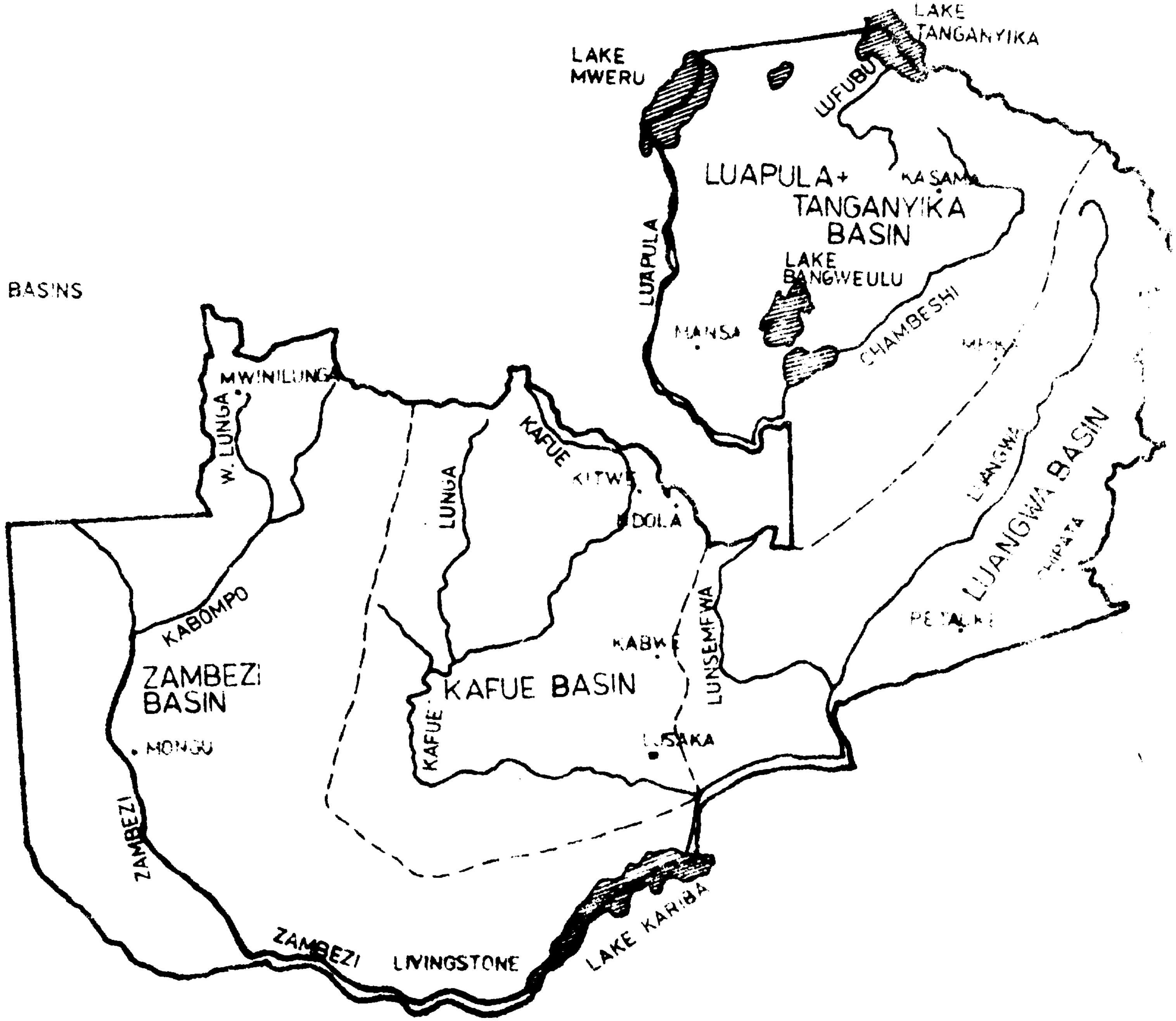
MAP 3 MAIN AREAS OF IRRIGATION
DEVELOPMENT




MOSES
KASAMA
MBERESUI
CHABILIKILA
KAWAMA
MUSANGA
KASHIBA
MANSA
KASMPE
MPIKA
NDOLA
MPONGWE
KAKUMBI
LUPANDE
BIG KABWE
CONCESSION
LUSAKA
CHIAWA
KAPUE
FLATS
UPLAND
FRINGES
SINAMALIMA

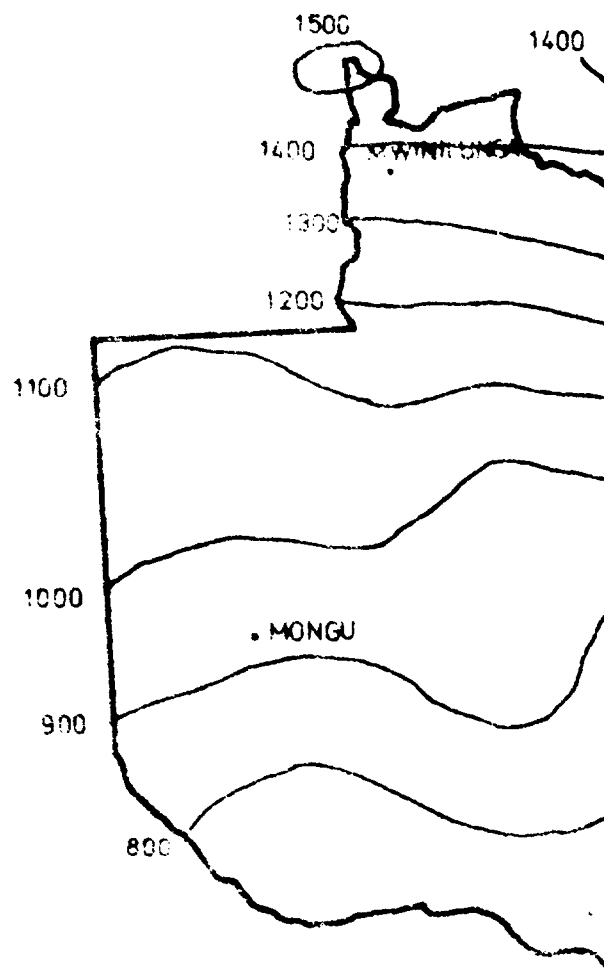
1 : 650 000

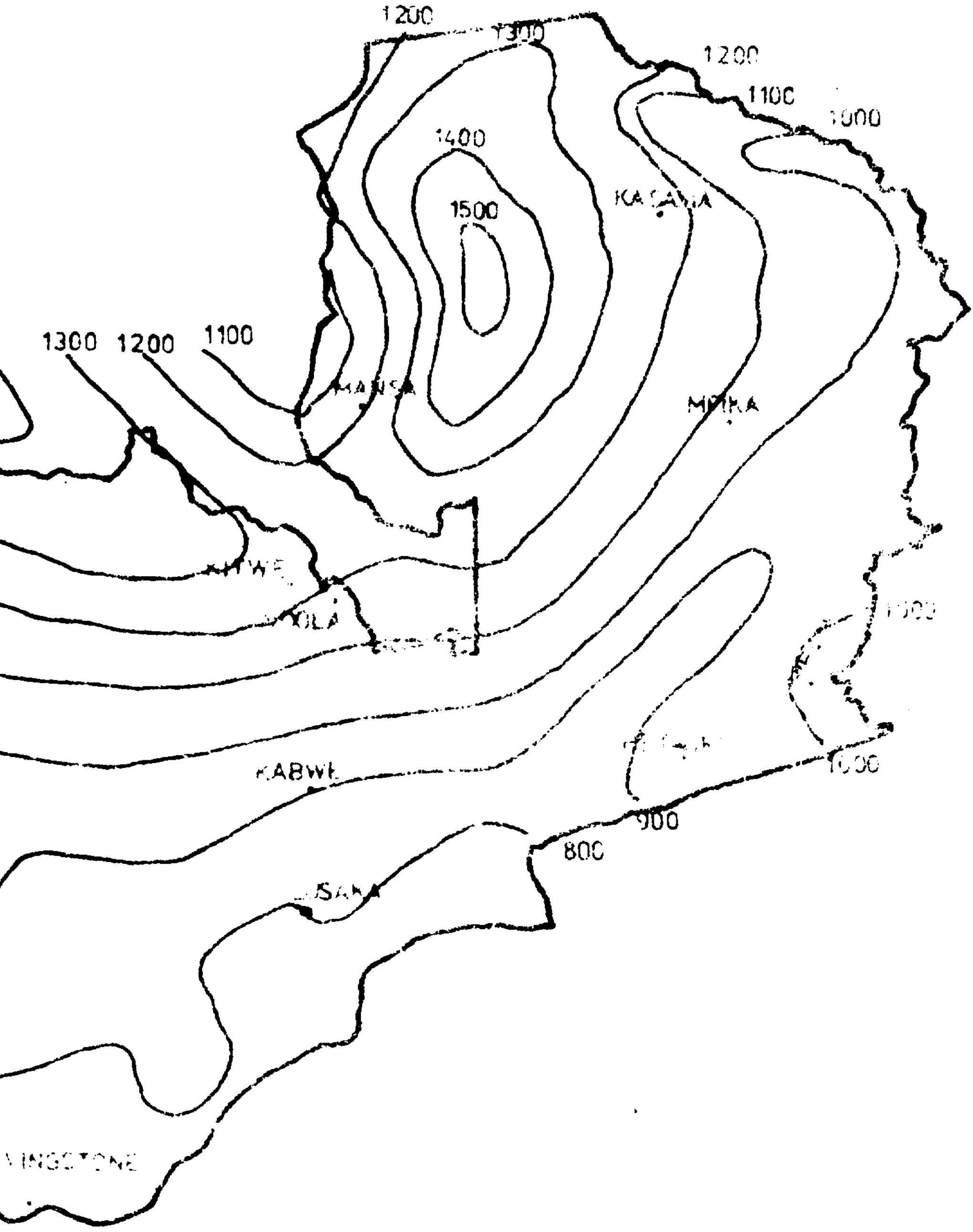
MAP 2 MAIN RIVERS AND RIVER BASINS



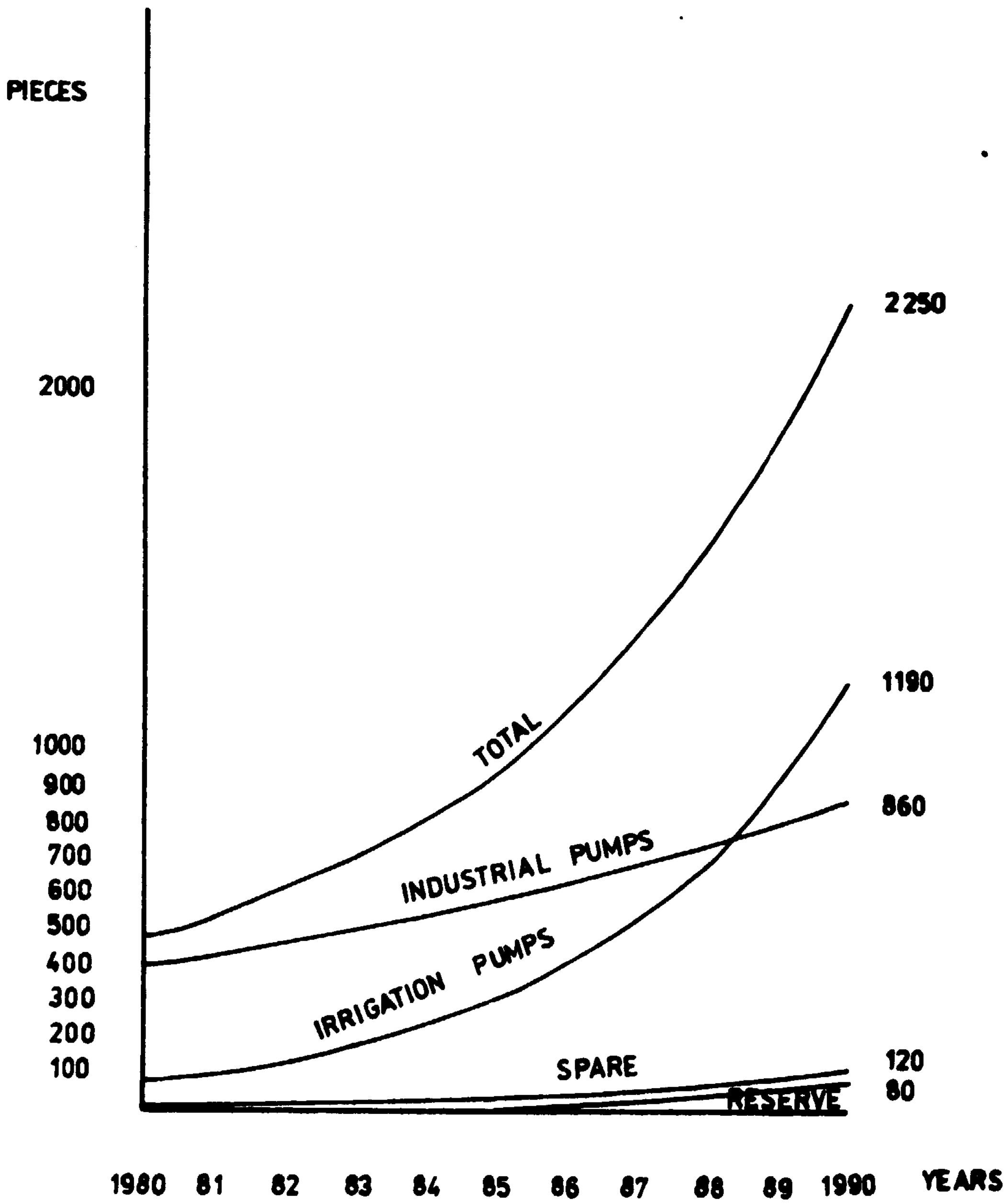
1 : 650 000

MAP 1 MEAN ANNUAL RAINFALL IN mm

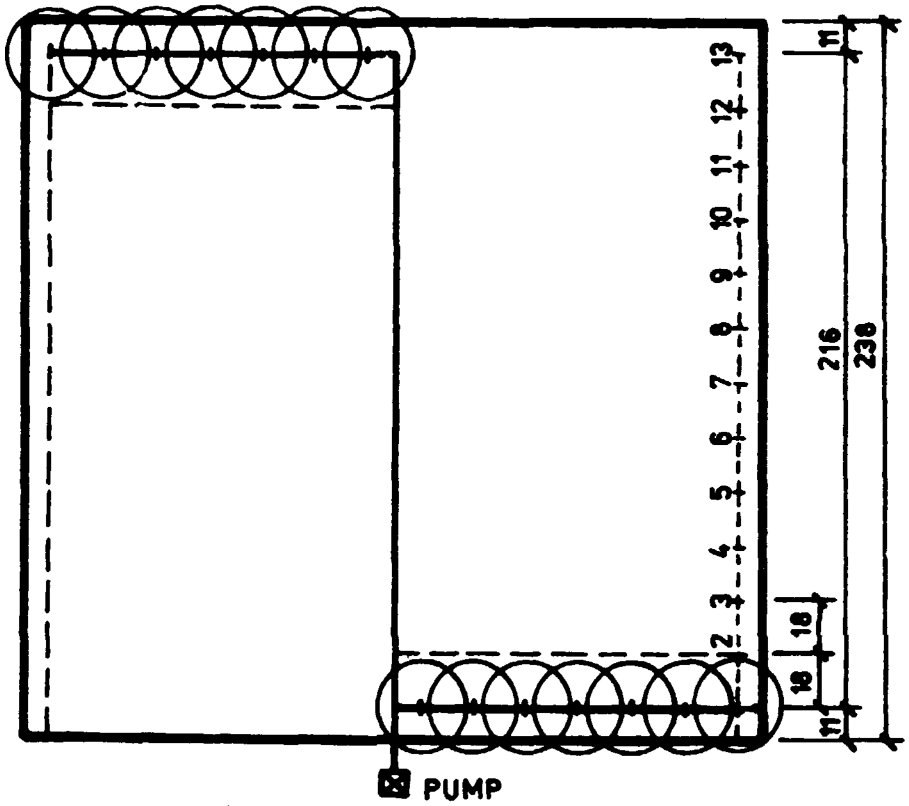


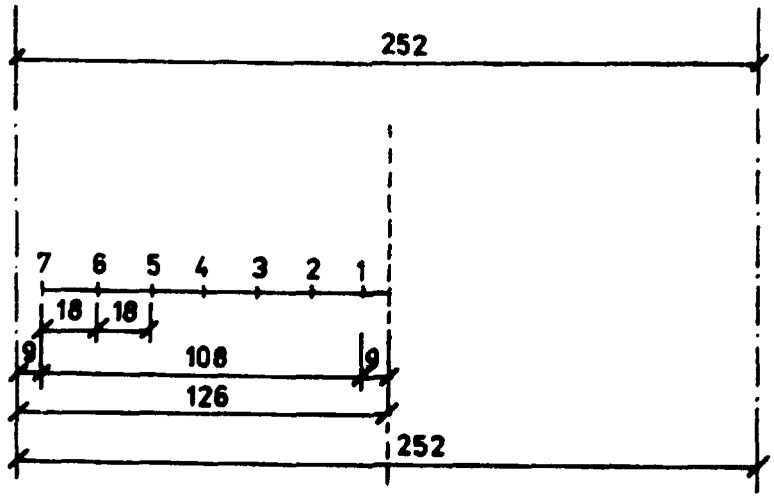

1200
1300
1200
1100
1000
1400
1500
KASAMA
1300 1200 1100
MANSA
MPIKA
KABWE
1000
900
800

INCREASE OF THE DEMAND OF PUMPS

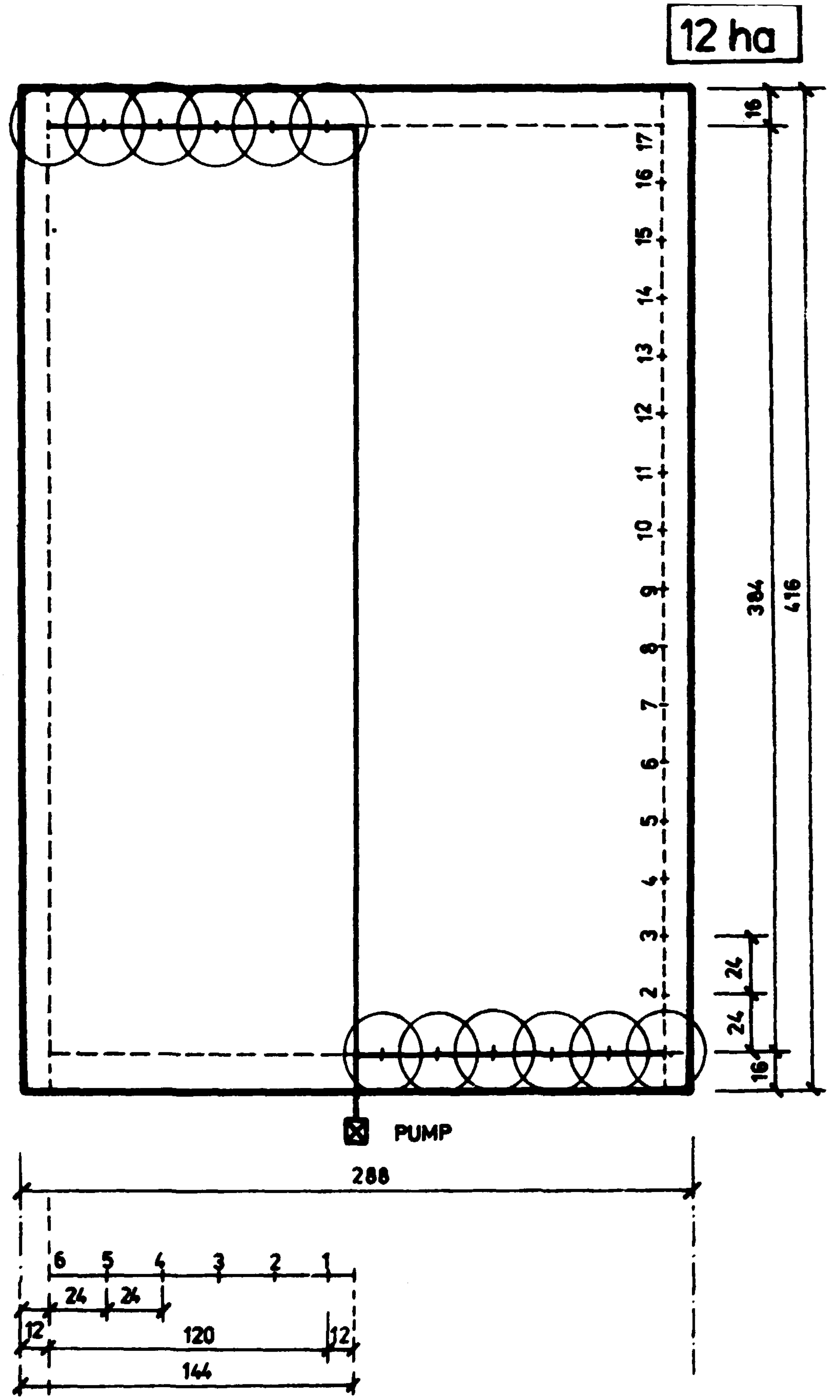


6 ha





⌀ 76	100 m –	RISING MAIN (TO THE FIRST LATERAL BRANCH)
	216 m	MAIN PIPES
	468 m	4×(108+9)-4 LATERAL BRANCHES (2 IN PREPARATORY POSITION)
	784 m : 6 = **131 PIECES**	



ϕ 102 : 150 m – RISING MAIN

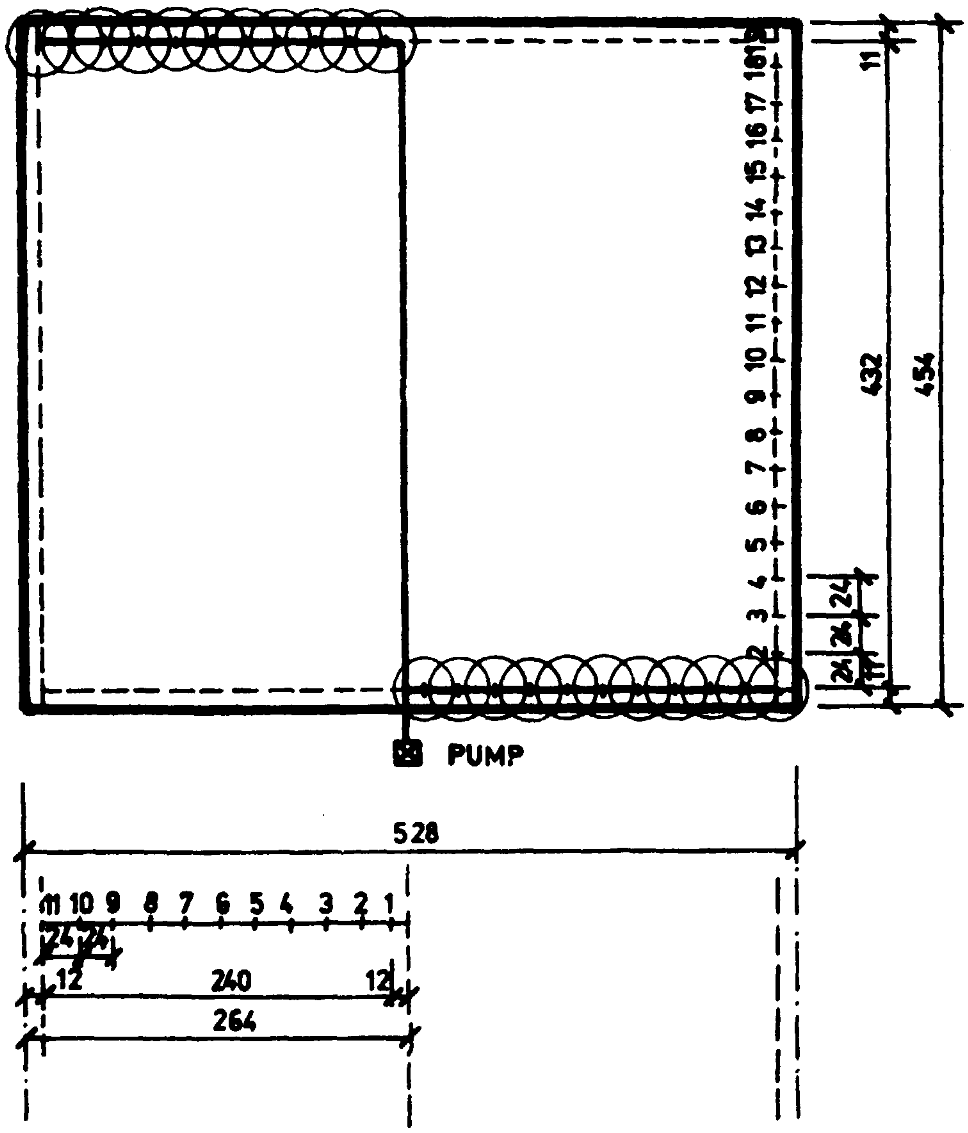
384 m MAIN PIPES

534m : 6 = 89 PIECES

ϕ 76 : 528 m – 4 x (120 + 12)

528 m : 6 = 88 PECES

24 ha



AC ϕ 150 : 200 m RISING MAIN

ϕ 120 : 432 m - MAIN PIPES

432 : 6 = 72 PIECES

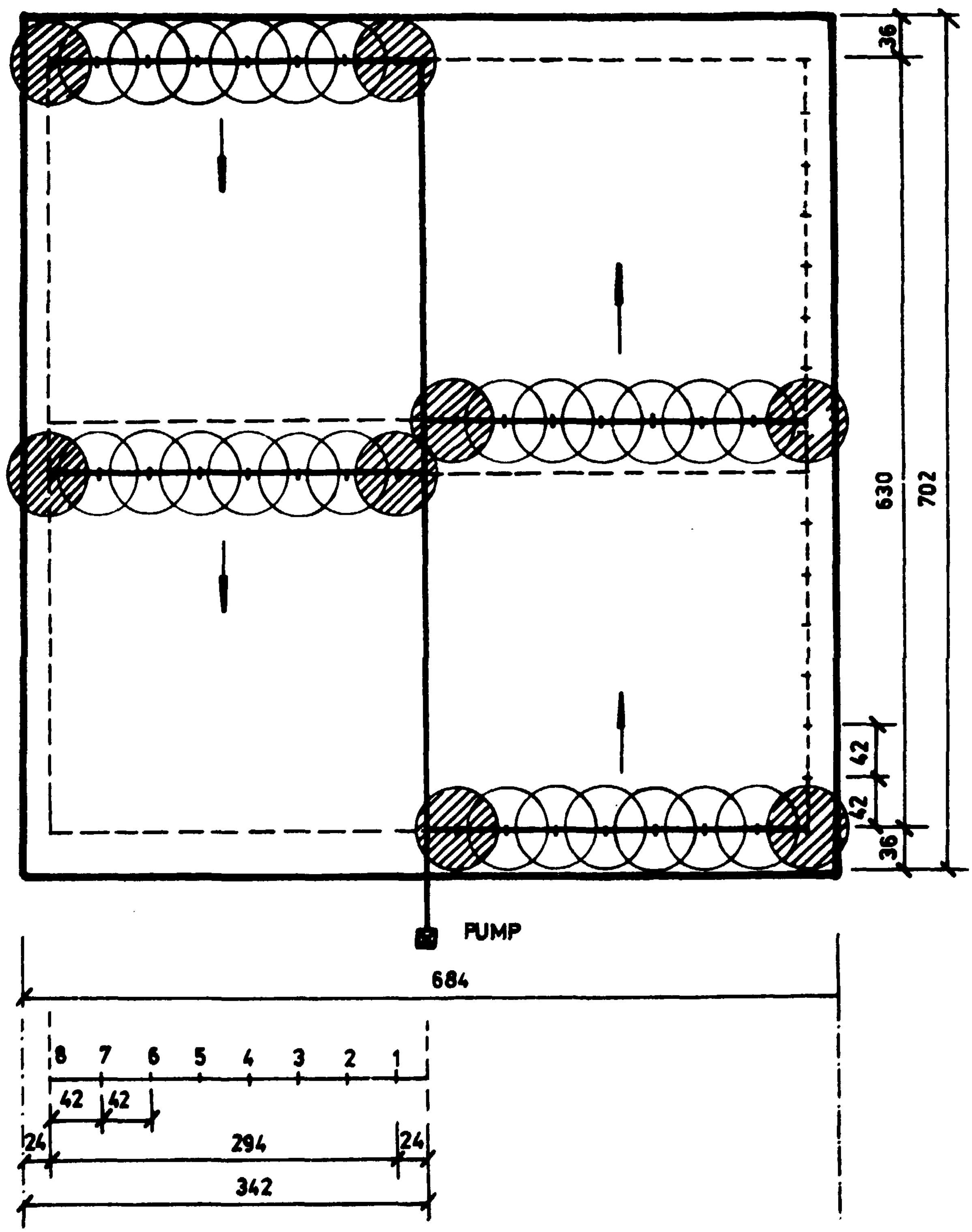
ϕ 102 528 m - 4 × 132 (FOR THE FIRST SIX SPRINKLERS ON THE LATERAL BRANCH)

528 : 6 = 88 PIECES

ϕ 76 : 480 m - 4 × 120 (FOR THE FOLLOWING FIVE SPRINKLERS ON THE LATERAL BRANCH)

480 : 6 = 80 PIECES

48 ha



AC ø 150 : 880 m (250 m RISING MAIN + 630 m CENTRAL MAIN PIPES)

ø 102 : 2544 m - 8 x (294 + 24)

2544 : 6 = 424 PIECES

INDUSTRIAL ESTABLISHMENTS IN ZAMBIA THAT CAN COOPERATE WITH THE IRRIGATION EQUIPMENT MANUFACTURING PLANT

Contents

1. Pipeco Zambia Ltd. Lusaka
2. Plastico Zambia Ltd. Lusaka
3. Robert Hudson (Zambia) Ltd. Ndola
4. Hume Ltd. (Zambia) Luancha
5. TAP (Tube Asbestos Products) Lusaka
6. Concrete Pipes and Products Ltd. Luancha and Ndola
7. Roan Engineering Ltd. Luancha
8. Vulcan Foundry and Iron Works Ltd. Lusaka
9. SCAW Ltd. Kitwe
10. Foundry Engineering Ltd. Luancha
11. Non-Ferrous Metallic Works Ndola
12. Northland Engineering Ltd. Ndola
13. Water Wells Ltd. Lusaka
14. Irrigation Pumps Ltd. Lusaka
15. Monarch Zambia Ltd. Kitwe
16. Lenco Ltd. Lusaka
17. Repair workshops of irrigation equipment
18. The firms that can cooperate with the Irrigation Equipment Manufacturing Plant and which were not visited by the team of experts

PIPECO ZAMBIA LTD. LUSAKA

The plant was built in 1973 and is specialized in manufacture of welded tubes made of steel, of the light and medium class, both black and galvanized ones, from dia.3/8" to 3".

The plant was built for a capacity of 15 000 - 18 000 tons of tubes of dia.3/8" - 3" a year in three-shift operation. In the 1975 year maximum production figure amounted to 4200 t/year (total consumption of tubes of dia.3/8"-3" in Zambia in 1975 was about 6000 - 7000 tons).

As the demand for conventional types of tubes and pipes is inadequate, the firm launched the manufacture of other products - furniture tubing, fencing tubes, Z-purlins, and manufacture will also be started of square and rectangular hollow sections and of steel conduits for electric power distribution lines dia.3/8" - 1 1/4".

At present there are manufacturd only 1000 tons/year of all products in one-shift operation (the plant operates during three months a year). The present-day demand for welded steel tubes in Zambia is estimated at about 4000 tons a year.

It was planned to manufacture 4" - 6" - 8" tubes; there is room enough for expansion of production, but this is not possible for the time being because not enough orders would be received.

Production Programme

Light- and medium-class welded steel tubes from dia.3/8" to 3", black or galvanized, in lengths from 20 to 7.5 m. Tube couplers of 3/8" - 3" are imported, as their production would not be economical.

Fencing tubes outside dia.1.5" to 5" outside dia.1.5" to 5", wall thickness 2 mm, length 7.5 m; Z-purlins (5" x 2" x 3/4" x 14SWG, 6" x 2" x 3/4" x 14SWG and 6.5" x x 2" x 3/4" 14SWG, 3" x 2" x 1/2" x 14SWG.

Description of Equipment

Modern machines in very good condition. Uncoiling mechanism can be swivelled to 180° (one coil is being uncoiled while the other one is being placed in position). Welding up of individual coils is carried out by hand. There follow straightening and forming of the strips, high-frequency welding (450 kC), calibration, cutting up to required lengths with a circular saw and deposition on a mechanical table from which the tubes are withdrawn for removal of burrs at the ends and passed on for pressure test. Tubes are manufactured and tested according to BSS 1387. Mechanical equipment was supplied by Fuji Works.

There follows a process in the galvanizing shop: pickling, hot rinsing, galvanizing in molten zinc.

The last operation is cutting of threads at both ends, fitting-on of a coupler, binding of tubes into bundles, deposition in stands and transport to customers.

The tools used in the manufacture are imported and are of very good quality.

The factory has its own railway siding, the buildings are lightweight structures, with the roof shell made of corrugated asbestos-cement panels, the outside walls made of corrugated metal sheets. The hall is 16 m wide and is equipped with a crane of 2-tons capacity.

Cooperation with the New Irrigation Equipment Manufacturing Plant

This establishment can supply medium-class tubes, primarily those of larger dimensions (2" - 3"). The quality of the tubes is very good and complies with BSS 1387. As has been stated above, the factory has much of unused capacity available and can thus provide the required amount of tubes up to dia. 3" until 1990 and thereafter without having to install any accessory equipment.

PLASTICO ZAMBIA Ltd., LUSAKA

The plant is specialized for manufacture of PVC pipes dia. 1/2" to 12" or 16", installed capacity 4000 tons/year in three-shift operation. The plant was built in 1973.

At present the company turns out 300 - 400 tons/year - it has not enough material and there, too, is lack of orders.

Production Programme

Pressure pipes made of PVC, dia.1/2" - 12", pressure class B, C, D, E according to BSS 3505.

Pressure class	Ft. head	Bars
B	200	6
C	300	9
D	400	12
E	500	15

The E class pipes are made only up to dia.1", the D class pipes from dia.1 1/4" to 12", the C class pipes from dia. 2" to 12", class D from dia.3" to 12". Standard length ~~of~~ of the pipes is 6 m, but they can be supplied in lengths up to 12 m.

Underground Drain/Sewer Pipes

Outside diameter	Class
110 mm	BS, W
160 mm	BS, W

The BS class conforms to BSS 4660, 1973, the W class is equivalent to BSS 3506 1969 Class 00.

Pipes for main sewers from 8" to 12" Imperial Standard class B and O.

Of the assortment of fittings there are made sockets and bends up to dia.6"; other fittings, such as adaptor unions, caps, flange adaptors etc. are imported (their manufacture would make necessary the installation of additional equipment that would not be utilized to the full). All products are of very good quality. Recently the firm launched production of conduits for electric power transmission lines up to dia.1".

Description of Equipment

Chemicals are transported in metallic containers with suspensions for attachment to a crane and with wheels for transport on shop floor to mixing equipment and to extrusion presses. There are two extrusion presses - the smaller one up to 6" dia., the larger one up to 16" dia., both supplied by Cincinnati Co. The larger extrusion press has a capacity of 10 tons/day. After extrusion the pipes are cooled and cut to the required lengths. The cut-up lengths of pipes are automatically deposited on a bed.

At the other end of the hall two machines are installed for shaping sockets for the so-called Z-joints. The tools of very good quality are imported. When running to capacity, the shop would employ 52 workers.

Description of Buildings

Modern workshop bay, steel structure, the roof shell made of asbestos-cement panels, the outer building shell of bricks. Bay width 15 m, the whole bay is served by a crane runway with a crane of 2-tons lifting capacity.

Cooperation with the Irrigation Equipment Manufacturing Works

This firm can supply pressure pipes made of PVC to various diameters up to dia.16", fittings of PVC (sockets and bends) up to dia.16". As has been stated above, the plant has much unused production capacity, and thus it can furnish the required quantity of pipes up to 16" in diameter until the 1990 year and thereafter without any accessory equipment.

ROBERT HUDSON (ZAMBIA) Ltd. NDOLA

This firm specializes in the manufacture of pipes welded long a spiral line, carries out repairs of pumps, imports pumps, particularly those for mines and irrigation systems. It prepares a radical expansion of its production programme.

The line for manufacture of pipes welded along a spiral uses steel strips for manufacture of pipes in 4" - 36" diameter range with wall thicknesses from 1/8" to 1/2". Both the manufacture and the testing are conducted according to BSS (including radiographic examination). The line capacity is 7000 tons/year in two-shift operation, actual production at present is about 2000 tons/year, which means that the equipment is not used to capacity even when one shift a day is worked. Of the pipes there are also made fittings, such as bends, T- and Y-pieces.

The firm bought a line for production of polystyrene pipes dia.1/2" - 2", with a capacity of about 500 tons/year. The equipment has not been installed and is not exploited at all.

The mechanical workshops in which repairs of pumps and other equipment are carried out manufacture special tools for their own use and machine profiled parts; they are well equipped: 10 universal lathes, 1 automatic lathe, 2 turret lathes, 1 shaping machine, 3 universal milling machines, 1 radial drilling machine, 3 frame saws, 2 pipe threading machines, 3 tool sharpening machines.

The firm contemplates construction of their own grey cast iron foundry, a foundry of cast steel and one of non--ferrous metals in 2 - 3 successive stages. First it is scheduled to build a non-ferrous metal foundry, then that of grey cast iron and finally that of cast steel. A site of appropriate size has already been prepared. The capacity of the foundries has not yet been specified in exact figures; they are reckoned with as foundries of medium size with medium degree of mechanization, maximum weight of castings 250 kg. The foundries are scheduled to replace imports of special-type castings of which the firm imported 2 million US $ worth in the 1979 year.

The firm also plans the introduction of production of light class steel pipes with folded seams, dia.2" - 8", capacity 750 tons/year. These pipes are suitable for irrigation, for distribution pipelines leading to sprinklers.

Cooperation with the Irrigation Equipment Manufacturing Plant

The firm can supply pipes welded along a helix and shaped pieces for irrigation systems. The unused capacity is sufficient for the period until 1990 and even beyond that date.

In the newly built workshops there can be made also castings of grey cast iron, cast steel and non-ferrous metals. (The foundries are envisaged to be fitted with equipment for this exacting kind of work). It is also reckoned with manufacture of light class steel pipes with folded seams in the 2" to 8" diameter range that can be used for irrigation purposes.

The firm has a chance to become one of the important suppliers catering to the new plant.

HUME Ltd. (ZAMBIA) - LUANCHA

The firm specializes in the manufacture of large-diameter pipes from 175 mm dia. to 1380 mm, with wall thickness ranging from 4.5 mm to 16 mm.

The pipes are manufactured according to BSS 534, 3601 (1966) from steel sheet grade 43A BSS 4360 by coiling on a power operated cold-coiling machine, with metal sheets [illegible] up to 16 mm thickness. The coiled sheet is then longitudinally welded up by automatic submerged arc process, whereby rings are formed that are subsequently joined by welding into continuous pipes of the desired length (from 2 to 10 m). The final operation is a pressure test according to BSS and surface treatment by asphalt coating with outside protection by means of glass fibres (spun bitumen with fibre glass wrap to BSS 534, Section 5) coal tar epoxy's Mirseol (non-toxic) rubberized paint, zinc chromate, bituminous aluminium, bitumen paints etc.

The pipes are made primarily for use in mines; a small number of them are also exported (Malawi, Kenya, Zaire). The plant's capacity is utilized in part only.

The plant has a well-equipped forging shop with a pneumatic power hammer and a hot coiling machine.

Fittings (elbows, bends, short tees, hydrant tees, crosses, reducers, laterals etc.) are purchased from Zambian firms, flexible couplings are imported.

Another part of the plant is the production department of reinforced concrete pipes dia.6" to 24". The pipes are made by vibration and rotation and cannot be used as pressure pipes. About 6000 tons of them are produced annually.

Cooperation with the Irrigation Equipment Manufacturing Plant

This firm can supply forgings and welded pipes of smaller diameters to the Plant, large-diameter welded pipes and reinforced concrete pipes right up to the irrigation system building site.

TAP (TUBE ASBESTOS PRODUCTS) LUSAKA

The plant came into existence in 1957 through initiative of the Endurite Co. in cooperation with the Turnall Co. At that time this was only a store of imported products. in the 1963 year the TAP firm was established, there was built a production shop hall and in 1965 production was launched of flat and corrugated asbestos-cement panels and also of asbestos-cement pipes with fittings.

Asbestos-cement pipes are manufactured in 50 to 540 mm diameter range, classes A - F. The pipe length is 4 m. The asbestos-cement pipe production equipment´s capacity is one of 14 500 tons/year/1 shift, i.e. with 2, 3 working shifts production amounts to about 30 000 tons/year. Actual production figure is 5000 - 5700 tons/year, which means that the equipment operates to capacity only during a part of the first shift. Small amounts of products are exported to Malawi and Zimbabwe.

From fitting assortment there are manufactured only asbestos-cement bends. The remaining elements, such as short collar detachable joints, riser tees, end caps, reducers, flange adaptors, hydrant tees, equal and unequal tees) are made of cast iron; they are supplied by various foundries in Zambia and, where necessary, the TAP firm assembles them with asbestos-cement products.

Mechanical equipment - semi-automatic production - in very good condition. Asbestos-cement fittings are made by hand.

Cooperation with the Irrigation Equipment Manufacturing Works

According to estimates made by the TAP Co., only 20 per cent of the production volume, i.e. 1000-1100 t/year are supplied for irrigation equipment and installations. The capacity of the existing production line is found sufficient to meet the demand for asbestos-cement pipes even in the 1990 year and thereafter.

CONCRETE PIPES AND PRODUCTS Ltd. LUANCHA AND NDOLA

The firm has two plants - in Luancha and in Ndola.

Both plants were founded in the 1958 year. In Luancha there is a central gravel crushing plant that serves to supply both establishments with material. The plant in Luancha produces moulded bricks, curbstones and reinforced concrete pipes dia.12" - 48".

The plant in Ndola is specialized in the manufacture of reinforced concrete pipes in the 6" - 52" diameter range. Production technology: manufacture of steel reinforcement of steel wires, compaction by rotation and vibration. The pipes belong to X, Y, Z categories, i.e. they are free from pressure. In the 1981 year the plant in Ndola is going to produce pressurized pipes.

In Ndola there are also made moulded bricks for open canals and various other elements for the building industry.

Cooperation with the Refrigeration Equipment Manufacturing Works

The firm Concrete Pipes and Products Ltd. can supply direct to the site where an irrigation system is envisaged to be constructed, reinforced concrete pipes, both pressurized and pressureless, the same as moulded bricks for open canals.

ROAN ENGINEERING Ltd. LUANSHA

This firm specializes in production of flanges and coupling elements for pipes, mainly for welded pipes turned out by HUME Ltd. Next to these, if manufactures beams for accommodation of distribution systems in mines, the same as spare parts for machines and equipment in mines, primarily those made of steel sheets and plates.

Another workshop turns out laminated parts - profiling according to models.

Equipment of the plant: 2 hot coiling machines for flanges, 3 copying units for gas cutting, 1 welding and cutting tractor, 1 vertical boring and turning mill dia.1200 mm, 7 universal and chucking lathes, 3 radial drilling machines, 1 bending machine, several electr. arc welding machines.

Cooperation with the Irrigation Equipment Manufacturing Works

The ROAN ENGINEERING Ltd. LUANSHA can supply flanges for pipelines and, if necessary, laminated guards for mobile pumping sets on an undercarriage,

VULCAN FOUNDRY AND IRON WORKS Ltd. LUSAKA

This is primarily a foundry for production of simple castings made of grey cast iron and poured into sand moulds (green sand casting), as well as of a small amount of non--ferrous metal castings (aluminium or copper alloys). Most of the castings are delivered to the customers without dressing of machining - only part of them are processed into finished products, such as cable shoes, coupling elements for asbestos-cement pipes and spare parts.

The plant turns out, first of all, simple castings used in construction of sewerage systems and made of cast iron (drain grates, stormwater grates, manhole covers and frames, hydrant and meter surface boxes, sluice valves and stop cock boxes), together with machined or unmachined castings of spare parts for agricultural machines, boilers and brick-making machines; for electric power distribution systems it supplies cable joint boxes, meter boxes and the like.

According to classification of castings in respect of their complexity - see the chapter presented in Part I, chapter IV - the castings primarily fall within Class I, with a smaller percentage of them belonging to Class II.

Production capacity of the plant is not yet utilized to the full.

Description of Equipment

In the grey cast iron foundry are installed 2 obsolete cupola furnaces, without preheating of incoming air and without forehearth. The diameter of one cupola furnace is 24" (600 mm), that of the other 42" (1050 mm). The melting capacity of 5 tons/hour is more theoretical and attainable.

In the moulding shop are installed 2 moulding machines, one for mould boxes of 24" x 18", the other one for mould boxes of 42" x 12". Moulds are deposited on simple casting lines (rail-bound trolleys).

For melting non-ferrous metals there has been purchased a new crucible melting furnace of 50 kg.

In the sand preparation shop a simple mixer is installed. In the pattern making and repair shop there are available 4 lighter woodworking machines of older design type. In the dressing shop there is one suspended grinding machine and two light hand grinders. The shop also has one saw for cutting off gates, 2 electrical welding machines and one gas-oxygen welding set.

The best equipped department is the mechanical shop for dressing castings. In this shop are installed 2 centre lathes with maximum swing of 600 mm, a turret lathe with spindle hole dia.60 mm, a radial drilling machine designed for drilling diameters up to 50 mm, 3 round-column drilling machines of different sizes, a shaping machine with stroke of about 600 mm, a milling machine with table of 250 x 1250 mm, 1 frame saw.

The buildings are obsolete, too low headroom for the manufacture in hand (inadequate ventilation facilities).

Cooperation with the new Irrigation Equipment Manufacturing Works

Unless the plant has undertaken to modernize their existing production equipment (there is interest shown in the introduction of production of cast pipes, production of fittings etc.), it can supply only the simplest castings to the new factory (i.e. those of Class I and in part of Class II - certain coupling elements, covers etc.). The castings used in manufacture of pumps, which for the most part fall within Class III and IV, must be made by dry moulding or no--bake moulding method, they must be alloyed etc., and thus they cannot be madeon the existing equipment.

SCAW Ltd. KITWE

The SCAW Ltd. establishment is the largest grey cast iron and cast steel foundry in Zambia.

Castings of grey cast iron and cast steel are made up to maximum weight of 3 tons/piece. in the moulding shops are used green sand moulding, dry sand moulding, CO_2 process moulding and core making. All castings are hand-moulded, small castings on various kinds of moulding machines, grinding balls on an automatic casting machine.

The melting sets are medium-frequency electric furnaces. Cast steel is made in the conventional grade, the same as high-carbon steel, and preparations are in progress of production of alloy steel castings. There are produced high--alloy castings (containing up to 18% of chromium), abrasion--resistant castings etc. The non-ferrous metal castings turned out by the plant are bronze and brass castings, the same as aluminimum ones made for the plant's own use.

The plant's capacity amounts to 30 tons of grey cast iron products per week, 90 tons of cast steel castings per week, 550 tons/day of grinding balls and 1 ton/week of bronze and brass castings.

The principal purchasers of castings are mines - grinding balls, spare parts etc.

After removal from moulds the castings are dressed in the foundry dressing shop and then either dispatched straight away, or else passed on to the rough- and finish-machining shops for the respective machining operations to be performed.

The rough machining and the mechanical shop are equipped with largely modern machines which are continually supplemented by new ones. In the workshops there are in total 9 lathes among which there are those with maximum swing of 900 x 4800 mm, one 4000 x 1350 mm planing machine, two vertical boring and turning mills with maximum swing of 3750 mm, 2 milling machines, 2 radial drilling machines with 63 mm max.drilling dia., 1 horizontal boring machine (with another one in progress of installation), 1 slotting machine with a stroke of 150 mm.

Overhead cranes are installed in both buildings and the plant has its own railway siding. The buildings are modern and efficiently ventilated.

The firm is going to expand its production programme primarily in the cast steel foundry; next to this, they want to establish a modern forging shop and they supplement the machines in the rough and finish machining shops.

Cooperation with the Irrigation Equipment Manufacturing Works

Provided the personnel of the foundry will become acquainted with the problems of production of grey cast iron and non--ferrous metal castings for manufacture of pumps, it is possible at once to supply all castings of grey cast iron or non-ferrous metals for the new Irrigation Equipment Manufacturing Works. It would be advantageous to supplement the existing methods of moulding with the no-bake moulding method.

The SCAW Ltd. Co. could become the largest and most important provider of semi-finished products for the new Irrigation Equipment Manufacturing Works.

FOUNDRY ENGINEERING Ltd. LUANCHA

The firm specializes in manufacture of non-ferrous metal castings, particularly those of bronze, phosphor-bronze, manganese-bronze, phospohor-copper, aluminium and aluminium bronze, up to maximum weight of 500 kg of individual castings (inclinable melting furnace capacity).

At present, the firm is negotiating the acquisition of a furnace with a graphite electrode for melting grey cast iron and cast steel, with 1-ton capacity (installation of the furnace is scheduled for the 1981 year).

Cooperation with the Irrigation Equipment Manufacturing Works

The quality of non-ferrous metal castings is a very good one and, consequently, this firm can supply castings to the new plant. In the future it also could supply grey cast iron and cast steel castings.

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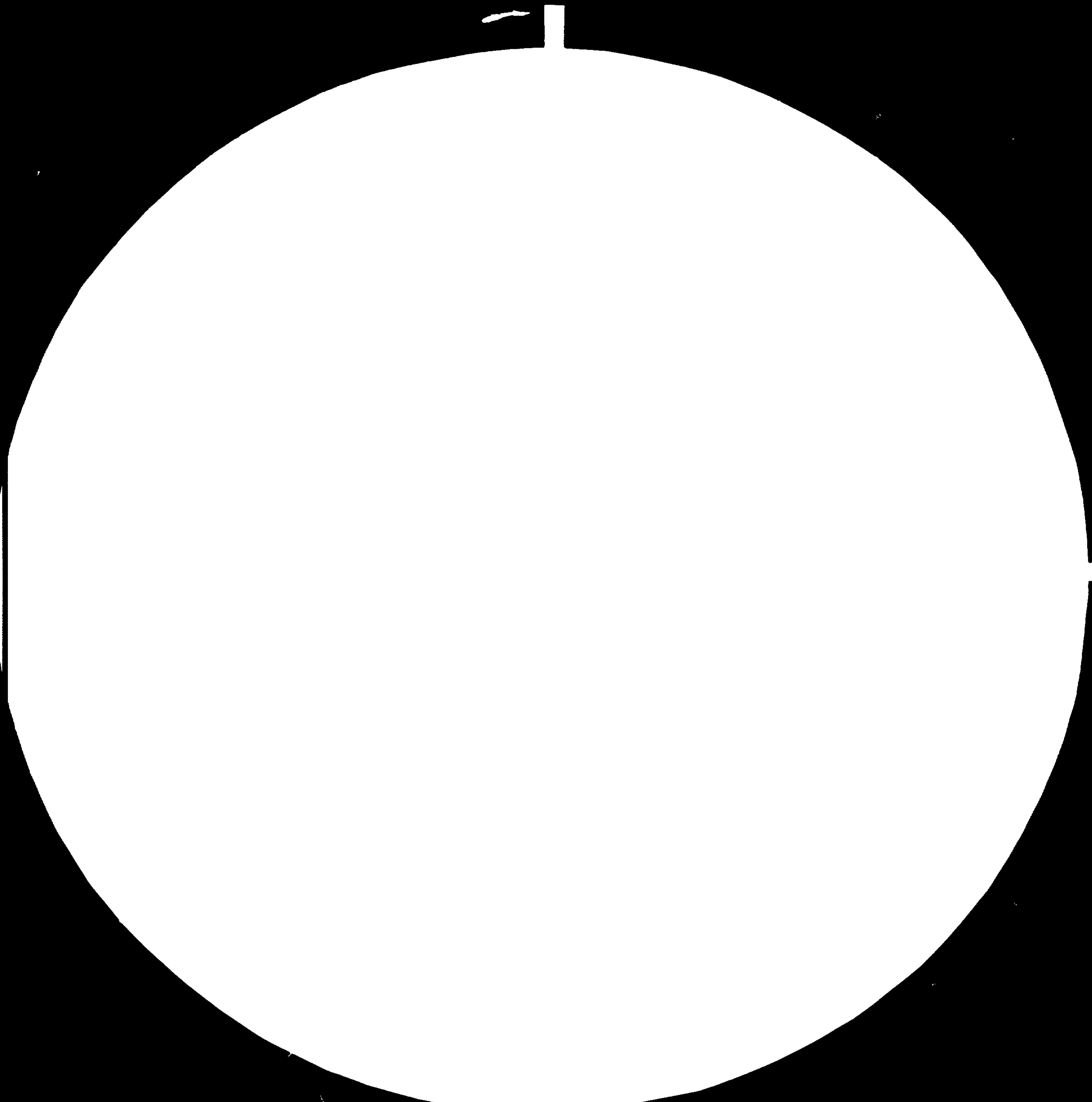

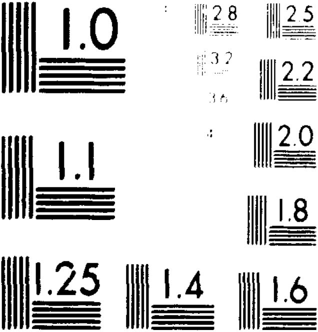

MICROCOPY RESOLUTION TEST CHART

NON-FERROUS METALLIC WORKS NDOLA

A small non-ferrous metal foundry that makes 90 per cent of their castings of bronze and 10 per cent of aluminium and brass. Simple mechanical equipment, with the main building under reconstruction at present.

The installed melting furnace has a capacity of 1000 kg per heat. For 1981 there is scheduled the installation of a new inclinable electric melting furnace with 2000-kg capacity and, prospectively, also pressure die casting machines.

Cooperation with the Irrigation Equipment Manufacturing Works

This firm can supply the new plant with non-ferrous metal casting poured into sand moulds, permanent moulds or made by pressure die casting method.

NORTHLAND ENGINEERING Ltd. NDOLA

This firm specializes in the manufacture of agricultural machines, equipment and implements. There are manufactured primarily single- and double-blade ploughs, maize grinders with silos, hand tools and other items.

Another line of the production programme includes manufacture of pressurized and pressureless reservoirs, pontoons and similar products, undercarriages for Diesel--electric sets etc.

The principal technologies used in the plant are metalforming, welding and in part also machining.

Mechanical equipment: 2 press brakes, 3 eccentric presses of up to 50 tons, 1 hydraulic press for assembly, 1 radial drilling machine, 4 round-column drilling machines, 1 frame saw, 1 milling machine, 1 shaping machine, 2 sheet metal coiling machines processing sheets of thicknesses up to 6 mm, 1 surface grinding machine, 4 universal lathes, one flame cutting set, gas torch welding apparatuses and electric arc welding machines; the forging shop has 3 double hearths and 6 anvils.

The firm has a total of 200 employees, including technical and administration personnel. It has about 50 - 60% of unused capacity.

Cooperation with the Irrigation Equipment Manufacturing Works

This firm could manufacture undercarriages for pumping sets or pontoonsfor installation of pumping sets on water surface etc.

WATER WELLS Ltd. LUSAKA - Borehole Contractors

The principal activity pursued by the company is carrying out of bores and arrangement of supporting structures of bored holes/wells. For the supporting structures of bores it is necessary to make specific arrangements such as to drill or make notches in the steel casing of boreholes, to cut threads in pipes, to weld up a frame envisaged to be placed under a welding set etc.

For this purpose and for repairs of pumps propulsion units (Diesel engines) and of the boring equipment itself the plant has production and maintenance workshops.

Description of Equipment

2 metalcutting frame saws, a hydraulic press for assembly, 1 round-column drilling machine, 1 lathe dia. 630 x 2000 mm, 1 centretype lathe with 6.5" spindle passage, 1 large welding transformer, 2 oxy-acetylene welding sets, 1 hearth and anvil, 2 double-wheel grinding machines, 1 crane trolley - 2 pieces, compressor and minor items of equipment.

Cooperation with the Irrigation Equipment Manufacturing Works

Cooperation with the new plant will be minimal and of passive nature. This firm may possibly purchase certain products of the new plant and fit them in the boreholes that it will make and provide with outfit.

IRRIGATION PUMPS Ltd. LUSAKA

The plant is organizationally and financially associated with the firm of Water Wells Ltd. Lusaka. It specializes in the manufacture of hand-operated stand pumps, provides outfit for pressurized reservoirs for household water supply installations, repairs pumps of various types, particularly those used for irrigation, imports and complements submerged pumps.

The hand-operated stand pumps are of a very simple design, weld-fabricated of pipes (with no use of cast iron at all). The pumps can reportedly be used for depths down to 30 m, pipe dia. 1 1/2" - 2". Pump deliveries range from 60 to 450 gallons/hour (according to well depth and pumping intensity). Annually there are turned out300 pumps; the plant could produce more, when necessary, but there are not enough orders.

The pressure reservoirs for which outfit is provided in the plant are imported from Sweden; their volumes are 250 and 370 litres, 15 atm. The reservoirs are used for household water supply stations.

Repair work is concerned for the most part on routine repairs of irrigation pumps.

Submerged pumps are imported mainly with dia.6", seldom for dia.8", for depths of 30 - 50 m, exceptionally for 80 m.

Plant's outfit: 1 frame saw, 1 universal lathe, 1 drilling machine, 3 tube threading machines up to dia.4", 1 hand-operated tube bending machine, 1 double-wheel grinding machine, 1 gas welding set and 1 compressor.

Cooperation with the new Irrigation Equipment Manufacturing Works

As this plant manufactures particularly hand-operated pumps, cooperation with the new plant will be of passive nature only. This firm will probably further develop the manufacture of hand-operated pumps and repairs of submerged ones. From the new plant it will purchase certain products for complementation.

MONARCH ZAMBIA Ltd. KITWE

One of the largest establishments of engineering industry in Zambia. In large lots it manufactures metallic window and door frames, silos for powder-type materials in bulk (bins), wheel barrows for construction sites, concrete reinforcements and metallic pails.

The firm has 417 employees of which 307 are workmen and 110 technicians and office staff.

The principal technologies used in the factory: cold metalforming, pressing, bending, coiling, edge dressing and gas welding, electric arc welding, carbon dioxide shielded welding, spot welding, butt welding.

The plant is well equipped for series production. It has a well-equipped toolroom in which most of the special tools and fixtures for workshop use are made.

Cooperation with the Irrigation Equipment Manufacturing Works

There will be a minimum, and possibly no cooperation, either passive or active. Inspection of the Monarch Co. premises was included in the programme in order to find out the existing posibilities of introduction of series production envisaged to be carried out largely by Zambian workers, particularly in the ranks of the controlling executives.

LENCO Ltd. LUSAKA

LENCO is a parastatal organization. It is one of the largest establishments of engineering industry in Zambia. The firm has two parts:

1) light engineering industry section - manufactures metallic furniture of sheet steel, tubes and complementary elements made of wood and plastic materials, such as filing cabinets, safes, cupboards, desks, table tennis tables, school furniture, chairs and elements used in the building industry, such as window and door frames, doors etc.

Another department manufactures various sizes of nails (there are in total 9 automatic machines for production of nails), wire mesh for windows etc.

2) Heavy engineering production - chassis for trucks, trailers and semi-trailers, including their repairs; next to this, the plant manufactures small and large cisterns for water and fuel, it assembles FIAT buses for 50 passengers - the annual total is 300 buses and trucks and 50 tankers.

The plant has a well-equipped toolroom (3 universal lathes, one centretype grinding machine, 2 surface grinding machines, 3 milling machines, 3 shaping machines, one frame saw, one drilling machine, one hand-operated press).

In the whole plant are employed in total 400 workers and shop foremen and 100 members of technical and office staff.

Cooperation with the Irrigation Equipment Manufacturing Works

LENCO could manufacture chassis for irrigation sets (pump with Diesel engine), including sheet metal covers, or else chassis for mobile irrigating machines with trailed or coiled-up hoses.

REPAIR SHOPS OF IRRIGATION EQUIPMENT

In Zambia there is a shortage of repair shops for maintenance of irrigation equipment. Local artisans' workshops in the towns are not adequately equipped and do not have enough of qualified personnel.

Some importers of irrigation equipment have smaller or larger repair workshops in which at least in part they deal with the most urgent situations. The best equipped workshops are in possession of

PRAGO Ltd. LUSAKA

This importing firm imports not only irrigation equipment, but also machine tools, tractors, agricultural machines, high-lift trucks and other items.

The repair shop is arranged as a common one for all imported products indicated above.

Outfit of the workshops: 2 universal lathes, 1 universal milling machine, 2 drilling machines, 2 double-wheel grinding machines, one electric arc welding set, one gas torch welding and cutting machine, 1 frame saw, 1 compressor, a paint spraying gun and other items of equipment.

FIRMS THAT CAN COOPERATE WITH THE IRRIGATION EQUIPMENT MANUFACTURING WORKS AND HAVE NOT BEEN VISITED BY THE TEAM OF EXPERTS

ZAMEFA Ltd. KITWE

This firm manufactures electric power supply cables up to 500 V - power supply line from a transformer to the electric motor of a pump. These deliveries do not fall direct within the concept of irrigation equipment and, in view of this, the plant has not been visited.

The products of ZAMEFA Co. are entirely satisfactory and can meet the specific requirements they are the object of. The plant has ample unused capacity.

ALLENWEST Ltd. KITWE

This firm manufactures low-voltage switchboards for pumping sets with electric motors. The basic structure of the switchboard is manufactured in the plant, whereas all instruments are imported. The switchboards have already been installed at various farms and their quality is a good one.