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Ad Hoc Meeting of Intergovernmental Experts
on African Regional Centre for Industrial
Design and Manufacturing

Addis Ababa, 30 October to 2 November 1978

Report of the Preparatory Mission for the Establishment of the Centre

(May-September 1978)

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PREFACE AND ACKNOWLEDGEMENTS

The focus of the project document which spells out the original ideas for the Regional Centre discussed in this report was on the design and construction of machine parts, components, tools and entire machines. The intention expressed in the document relates to the conceptual and functional design of such products. Within industry, this type of activity is described as 'Engineering Design'. In industry, the usage of the phrase 'Industrial Design' has emerged as denoting the determination of the aesthetic and sometimes the ergonomic aspects of the design of a machine or product, and hence refers to a facet only of the total design process of such a machine or product.

In modern industry, machinery and equipment are usually designed first to answer to the requirements of function and operation. This basic design is then revised to suit market requirements for form and appearance. The total process is more accurately described as the 'Engineering Design' of the product.

The French version of the title of the project uses the words 'conception industrielle' and is more accurate in reflecting the intention of the project. The English version of the title uses the phrase 'industrial design' which, as already explained, covers only a part of the total design process. The Preparatory Mission Team recommend the substitution of the phrase 'engineering design' for 'industrial design'. This would change the title for future reference to the project to: African Regional Centre for Engineering Design and Manufacturing.

The report has been arranged into nine chapters. The first chapter is an introduction which deals with the origins of the project and the related series of decisions at the level of the African Ministers of Industry and other instances. The chapter also describes briefly the composition of the Preparatory Mission Team and the organization of its work.

The next three chapters deal with the technical subject matter of the project and describe briefly the nature of the engineering activities which will take place within the proposed Regional Centre. The Centre will be designed around the concepts enunciated in these chapters.

Chapter 5 is a summary of the findings and conclusions reached by the Team during its visits to the selected African countries. A country report was prepared for the field visit to every country and this chapter is a brief summary of the prevailing situation with regard to engineering design and manufacturing activities prepared on the basis of the country reports. It provides what the Team hopes is a representative cross-section of the situation in these fields within the region as a whole.

Chapter 6 contains the proposals put forward by the Team for the role to be played by the Centre which should guide the development of its activities and especially its relation to African member States and other institutions outside the region. A brief statement is also included to show the complementarity of the Centre to the two other regional centres which have been proposed within the framework of the deliberations of the Conference of the African Ministers of Industry.

In Chapter 7, the proposals for the basic design of the organization and the physical structure of the Centre are spelt out. It is clear that the nature of the Centre envisaged is similar to a medium-sized manufacturing establishment with

its own design, manufacturing and prototype development facilities. The concepts around which the structure and organization of the Centre have been built are those expressed in Chapters 2, 3 and 4. This chapter also contains proposals on the staffing and estimates of the operating budget and the capital costs of building and equipping the Centre.

The capital cost estimates will vary somewhat from country to country, but are reasonably close to an average of what will be needed. Operating budget estimates, on the other hand, can only be very rough until a more precise determination of the circumstances of operation of the Centre can be made after a decision has been taken on the location.

Chapter 8 contains the recommended Work Programme of the Centre during the first five years. The proposals made here are based on the priorities observed during the field mission and the needs expressed during discussions held in the countries visited.

In Chapter 9, the Team presents proposals for the establishment of the Centre which cover essentially the initial 5 years of build-up. This is presented in the form of an action programme listing the major tasks to be undertaken during each year of this build-up period.

Three Annexes are attached to the report. Annex I contains a draft Constitution for consideration by the member States who intend to support the creation of the Centre. It is important to bear in mind, during the discussions that will take place on this draft Constitution that the Centre is an operating entity, expected to function, in many respects, in the mode of a typical industrial enterprise. The mode of control and the authority relationships within such an organization are different from those typically encountered in the administrative type facilities usually created by international organizations. It is essential that the Director-General of the Centre is given adequate powers to function as an effective Chief Executive of an industrial enterprise. If the necessary regime of authority and delegation of responsibilities required for such an organization to function properly is absent, the Centre will have been still-born.

Annex II presents a number of criteria to assist in the selection of the location of the Centre. The Preparatory Mission Team strongly recommends that the considerations included in this Annex be given due weight in the choice of the location of the Centre to enable the project to take off properly and the Centre to function effectively.

Before closing this preface, it is necessary to say a few words on the selection of the main sectors of priority for the design activities of the Centre. These are agricultural working and processing machinery, vehicles and transportation equipment, construction and materials handling machinery. In the first place these sectors comprise the largest group of machinery and equipment currently imported from foreign countries into the African countries. These sectors would also account for the largest share of expenditure of foreign exchange on importation of machinery. There is, however, another factor, a technological factor which has been borne in mind by the Team in making the selection. Provided that it is clearly understood that in dealing with any of these sectors, the Centre will not enter into the design of prize movers incorporated into such equipment, the design problems of all equipment in the chosen sectors lie basically in the selection of materials, mechanism and system. In this way, the Centre will not,

at least during the initial stages, require to get involved in multi-technology design problems for which its physical establishment would need to be considerably expanded.

In carrying out their task, the Preparatory Mission Team have received considerable co-operation and assistance from many sources. The Team was particularly impressed and at times even inspired by the great enthusiasm shown by the officers and staff of many of the engineering institutions and firms visited in the individual countries. The number of such people who have in many cases contributed ideas that have been useful to the Team in preparing this report is too large for individual mention. However, a list of principal executives of Government departments and private companies who received the Team in different countries has been prepared. The Team would also like to mention the considerable support and assistance received from the staff of the Joint ECA/UNIDO Industry Division and from many other officers in other Divisions of the ECA secretariat who have demonstrated a great deal of enthusiasm for this project. One of such officers has been Mr. G.E.A. Lardner whose ideas and counsel have been invaluable. The Team would like to take this opportunity to express their appreciation to these staff members of the ECA for their assistance and collaboration.

CHAPTER 1

INTRODUCTION

Origin of the project

1. In application of resolutions 3201(S-VI) and 3202(S-VI) of May 1974 adopted by the General Assembly on the subject of the establishment of a new international economic order, the need for the industrialization of the developing countries remains until now a common point of agreement between the developed countries and the developing countries. It is now generally accepted that the process of industrialization is a priority and an instrument of growth which is indispensable for the accelerated economic and social development of the developing countries.

2. The realization of this priority was expressed in definite terms by the provisions of the declaration of Lima of March 1975 (ID/B/155 and ID/B/155/Add.1) concerning the objectives of industrialization in Africa, in the sectors of basic and strategic industries as well as in small-scale industries within the rural sector. On the subject of the practical measures to be taken to implement industrialization at national level, the Lima Declaration recommends to the developing countries to adopt policies for industrialization based on several elements, in particular, the establishment of facilities for production through the creation of integrated industries such as those in mechanical and electrical engineering.

3. According to the Lima Declaration, the application of such a policy of industrialization will enable the developing countries to increase their industrial production to a maximum and to raise their contribution to world industrial production to at least 25 per cent of the total, between now and the year 2000.

4. In order to attain this objective, the revised plan for the establishment of the new international economic order in Africa (E/CN.14/ECO/90/Rev.3) gives a special importance to the development of industries which by virtue of their potential forward and backward linkages could contribute considerably to the growth of other industries, for example those which produce agricultural tools, implements and machines, etc. This implies the development of industries producing capital goods.

5. At the Conference of African Ministers of Industry (E/CN.14/649 and E/CN.14/INR/215) held at Nairobi in December 1975, the subject of creating capital goods industries was discussed. One of the major constraints to the development of such industries recognized at the meeting was the absence of engineering design capabilities in most African countries for the conception and design of machinery. At this Conference, the idea of creating a regional institution to promote the development of machine design capabilities within the African countries was first discussed.

6. During its deliberations on the implementation of the Lima Declaration, especially on the question of creating facilities for production covering all the industrial branches necessary to satisfy the needs of international markets, the fourth meeting of the Conference of African Ministers of the United Nations Economic Commission for Africa (E/CN.14/682/Rev.1 and E/CN.14/ECO/116/Rev.1) held at Kinshasa in February 1977 confirmed the determination to seek for the ways and means to establish mechanical engineering manufacturing industries. In similar fashion, the

Fourth Conference of African Ministers of Industry held at Kaduna in Nigeria, in November 1977 (E/CN.14/689 and E/CN.14/INR/221) in its resolution 1 (IV) reaffirmed the decision to create a regional centre for engineering design and manufacturing.

7. It is, of course, true that in Africa there exist a number of workshops whose principal activity is to undertake the manufacture of simple spare parts and the repair of equipment. Some of these workshops possess equipment similar to those installed in the factories of industrialized countries and a few of such workshops possess considerable facilities for mechanical engineering production. Many of these workshops are oriented towards the production of agricultural implements and the fabrication of spare parts for vehicles and transportation equipment generally. Equipment can be found in many African countries for metal forging and foundry work. Many machine tools for metalworking are available in several African countries where they are utilized primarily for the maintenance of machinery in industrial firms producing consumer goods. The capacities of such equipment are never fully utilized because of the absence of machine design capabilities in the firms or organizations operating the workshops.

8. This is why a Regional Centre for Engineering Design and Manufacturing which has been the subject of several resolutions of the Conferences of African Ministers of Industry has as its main intention to support directly or through appropriate African national institutions, the creation of suitable facilities to undertake the engineering design and manufacture of spare parts, components and simple machine tools.

The Preparatory Mission

9. In order to prepare proposals for creating the Centre it was decided to send a Preparatory Mission to a representative selection of African countries to carry out the following tasks:

(a) To collect information on and to assess the current situation within African countries on the following: the facilities for engineering design and design studies, foundries, forges, repair workshops and machine shops producing spare parts. components and accessories.

(b) To make contact with and to discuss with responsible government officers working in these fields or similar experts in ministries of government, and within public and private institutions in relevant sectors of industry.

(c) To prepare, on the basis of the foregoing, proposals for setting up the Centre.

Composition of the Team for the Preparatory Mission

10. The Preparatory Mission Team consisted of the following members:

(i) Dr. Ademola Banjo, Team Leader
(Mechanical and Industrial Engineer)
Senior partner in a firm of consulting engineers in Lagos, Nigeria; Chairman of the Nigerian Standards Council,

Lagos; President of the African Regional Organization for Standardization (ARSO), P.O. Box 2915, Lagos, Nigeria.

(ii) Dr. Yusef K. Mazhar, Mechanical Engineer
Director-General and National Project Manager
Engineering and Industry Design Development Centre
49 Giza Street, Giza, Cairo, Egypt.

(iii) Ing. Mec. J.M. Cabezudo-Sanchez, Mechanical Engineer
Consultant on Foundry Work and Forging
Bairescentro-Consultora
Consulting Engineers
Avenida Avellaneda 1293/1299
7000-Tandil, Argentina

(iv) Mr. K.K. Peki, Industrial Economist
United Nations Economic Commission for Africa
P.O. Box 3005, Addis Ababa, Ethiopia.

11. The following countries were selected for the field visits: Madagascar, Swaziland, Zaire, Uganda, Nigeria, Ghana, Upper Volta, Libya, Mali, Burundi and Togo. Eventually, it was not possible for the Team to visit Libya because of difficulties in obtaining visas.

12. Because of the large number of countries to be visited it was necessary for the Team to divide itself into two groups of two and later into individual missions. However, in order to develop a common methodology, the whole Team visited two countries during the period 7-22 May 1978 (Madagascar and Swaziland). The mission then divided into two teams as follows. Team A consisting of Dr. Banjo and Dr. Mazhar visited Nigeria, Ghana, and Upper Volta during the period 21 May to 23 June 1978; Team B consisting of Mr. Cabezudo-Sanchez and Mr. Peki visited Zaire and Uganda during the period 22 May to 18 June 1978. To cover the visits to the remaining countries within the time available, the following members of the Team undertook individual country missions as follows: Dr. Banjo (Togo), Mr. Cabezudo-Sanchez (Mali) and Mr. Peki (Burundi) at various periods during the second two weeks of July 1978.

13. The preparation of the report of the Preparatory Mission on the Centre was carried out in two stages. In the first stage, individual country reports were prepared on the separate countries visited and these were employed as background material in the second stage for preparing the final report.

CHAPTER 2

ENGINEERING DESIGN OF MACHINERY AND COMPONENTS

The nature of design

14. Design is the activity that formulates and decides the shape and layout of a machine part or structure so as to fulfil the functional requirements for which the final machine is destined. Design is therefore primarily an intellectual activity based very firmly on the theoretical principles of knowledge in the particular field of practice. The practice of design requires a considerable element of individual imagination and and a creative flair which should ideally be innate in the individual, but which can also be developed by training. There is, however, another point of view which maintains that these aptitudes must form a part of the natural endowment of the individual who is selected for training as a design engineer. Consequently, not all formally trained engineers can be good designers.

15. The degree of complexity of modern machines and structures and the mastery of detail which is necessary to evolve a satisfactory design makes it imperative for the design engineer to specialize in a particular field of machinery or equipment after his initial general training in machine design. By and large, an engineering design bureau or office will specialize in a particular class of machinery or equipment, e.g. automotive engines, vehicle bodies, materials handling equipment, machine tools, electrical motors, etc. In general, such a design office would be part of an organization manufacturing the particular class of machinery and would therefore be attached in one form or another to a manufacturing workshop.

The parameters of engineering design

16. The range of parameters that enters into the design of a machine or a piece of equipment is quite wide. The designer has to select the appropriate mechanism of operation and the geometry of the machine: he has to select the material for the various components and decide on the leading dimensions of the individual machine parts. Other factors which must come into consideration in the course of evolving a design include: the environemnt of operation of each machine part (e.g. heat, shock-loads, corrosion from fluids, etc.), the reliability and life expected, the available processes of manufacture, the costs of production and the economics of operation. In many cases, safety of operation and ease of maintenance may also be very important factors. The design engineer must, therefore, be familiar with the conditions of operation of the machine or equipment he is designing; he must be well informed on materials and processes of manufacture and, not the least, possess a thorough knowledge of engineering economics and value analysis.

The stages of design

17. The initial design stage of a machine or a piece of equipment will start with an analysis of the operational requirements which the machine is required to fulfil. The operational requirements will be expressed, as far as possible, in quantitative terms involving the nature of the transformations of energy and motion required within the machine, and the functional relationship between the energy input to the machine and the output of work carried out by it. The design engineer would usually, from his knowledge of the type of machinery involved, select a number of alternative configurations for the total machine. Each of these will then be analyzed

mathematically to establish the lines of movement of each component, the laods on each part and the relationships between the movements of the operating parts of the machine. From a comparison of the results of the analyses of a number of limited alternative designs, one will be selected which appears to have the best combination of characteristics for the purpose required.

18. The selected basic design would then be further represented in greater detail through drawings, often on a larger scale. At this stage, the actual shapes of the components will be inserted, the materials to be used for each machine part will be selected and the dimensions of each element will be calculated. Usually, individual sketches of each element of the machine would be prepared showing the main dimensions and, in particular, the form of the mating parts where each particular element operates in conjunction with the rest of the overall machine. The sketch designs of the individual elements are then checked against one another by preparing assembly or sub-assembly drawings in which the individual parts of the machine are shown fitted together in appropriate types of drawings. At this stage modifications may be made as necessary, either to correct errors or any interference which show up when the elements of the machine are assembled on a drawing, or to improve the relative functioning of several parts in relation to the rest of the machine. After checking the assembly and sub-assembly drawings and amending where necessary the sketch designs of individual components, the collection of assembly and sub-assembly drawings and the sketch drawings of the component parts of the machine are now transferred to the production design stage togehter with instructions relating to materials, material properties, the level of precision of movements between mating parts of the machine and general instructions relating to the performance of the machine.

19. The production design stage is concerned with the preparation of the final design drawings which will be used for the production of the machine as a whole and for the selection of methods of manufacture for each individual part of the machine. In preparing the production drawings for each machine part, full information as to the shape of the part, the dimensions, the material, the method of production and any special treatment of the material must be provided. The production drawings for each component of the machine must contain all the information required to enable the particular component to be manufactured or selected from a standard list. It should be explained here that certain common components of machinery have been standardized and are normally produced by specialist firms in a range of sizes and specifications for different applications. Among such components are fasteners of all types (bolts, nuts, screws, etc.) plain, ball or roller bearings and sealing components. When the production design is completed, we have a large collection of drawings which may run into many hundreds or thousands of drawings depending on the complexity of the machine in question. There will also be several sheets of instructions and specifications, which may also run into many hundreds or thousands of pages.

20. Where the machine or equipment is simple, all the above mentioned stages of design may be carried out by the same group or even by the same person. However, for almost any complex type of machine or equipment nowadays, this would prove to be an impracticable arrangement either because it would take an unacceptably long time to complete the design of the machine from initial deisgn to production design stage, or it would be difficult to find the required range of expertise in one person. In general, separate individuals or groups would be employed for initial design and for production design.

Development and re-design

21. When a machine or equipment is designed for the first time, the first one produced has to be considered a prototype. In cases where it is intended to manufacture the particular machine in large quantities, it is necessary to subject the first unit produced to a series of tests and operational trials and to adjust or modify the machine to obtain satisfactory performance. This stage of evolving a satisfactory machine is called development and is further discussed in Chapter 4. During the stage of development of an equipment or machine, information may be obtained which will call for modifications to the original design in order to improve the operation of the machine, or in order to facilitate the production of some of its parts. Such information would be transmitted back to the design groups who would undertake the modifications to the original design in order to improve the operation of the machine, or in order to facilitate the production of some of its parts. Such information would be transmitted back to the design groups who would undertake the modifications necessary and provide new sets of final design drawings and specifications for commerial production. Even in cases where the equipment being designed is not to be produced in large quantities, tests will still be carried out to ensure that the design and the manufacture are satisfactory. Hence in many cases, some re-design of one part or other of the prototype machine will be necessary.

Manpower for design

22. The evaluation and design of machinery and equipment requires very thoroughly trained and highly skilled manpower of different types. The leaders in the design process are the creative design engineers who must be thoroughly trained in the theoretical and engineering sciences and must possess a high degree of conceptual ability together with a high level of facility in the use of engineering drawing as a language of communication of their ideas. A design engineer will usually specialize in a particular class of machinery or, at most, in two or three related classes of equipment. Apart from the design leaders, the design team will also include specialist engineers who are experts in particular features which are common to machinery in general, such as lubrication, vibration, power-drives and transmissions etc. Attached to the design team we also find design draftsmen. These may be young engineers still serving their apprenticeship to become design engineers themselves, or they may be very experienced draftsmen who have a long familiarity with a particular class of machinery. The initial design team will usually contain one or two senior design engineers assisted by specialist engineers and a larger number of design draftsmen and senior draftsmen in a ratio that may vary between three to six.

23. If the production design is carried out by a separate team, then it is likely that the composition of this second team will be different from that of the initial design team. Where such specialization is appropriate, the production design team will usually be led by design engineers who are familiar with production processes and especially with the production facilities of the particular factory that is going to make the machine. They will also be more fully informed about the production costs of alternative processes. The production design team may not necessarily require design engineers of the same level of creativity as for the initial design group. However, because of the need to provide a very large number of detail drawings accompanied by a considerable volume of specifications and instruction sheets, the production design team will often be a larger team, but with a higher ratio of draftsmen to engineers.

24. In general, design engineers require to be trained initially to university degree or graduate level while the draftsmen require to have a minimum level of training equivalent to that of an engineering technician. The more capable draftsmen should in course of time upgrade themselves to the level of design engineers through additional study and training, both in theoretical and practical subjects.

CHAPTER 3

MANUFACTURE OF MACHINE PARTS AND COMPONENTS

25. Most machines are an assembly of several parts and components which may be relatively few or which may run into several hundreds. Although many machines contain a small number of components made of wood, rubber or plastics, the majority of machine parts are made of metal. The commonest metals employed are cast iron, steel, aluminium and aluminium alloys, and other metals such as copper, zinc, lead and magnesium, either in the pure state or in the form of alloys. The manufacture of machine parts is therefore a metalworking activity. The basic technologies of metalworking involve casting, metal-cutting and metal-forming.

26. Casting is carried out in a workshop called a foundry . Within a foundry there will be a furnace for melting the metal. After melting, the metal is poured into specially prepared moulds which already contain the impression of the component or machine part that it is desired to produce. Moulds are usually made of carefully mixed cohesive sands, generally known as moulding sands which are placed in metal boxes, or mould boxes. After the metal has cooled, the mould is broken up and the sand is separated from the solid metal which is now in the shape required. The metallic machine part obtained from this process is called a <u>casting</u>. After withdrawal from the mould, most castings have to be cleaned. In a majority of cases, the casting has to be further <u>machined</u> which involves cutting away portions of the casting to obtain surfaces with a particular geometry or to obtain holes of speical shapes within the casting.

27. In producing a machine part through metal-cutting, a suitable piece of the metal is cut from the original raw material in the form of a round bar or other convenient form. The piece of metal is then put in an appropriate machine tool which cuts away unwanted portions of the initial piece and leaves a final shape as required in the design drawing. The process of cutting a piece of metal to shape by removing parts of the metal using cutting tools is usually referred to as <u>machining</u>. In many machining operations, the initial piece of metal may also be a casting which has already been given part of the final shape required during the casting process.

28. A third group of metalworking operations is metal-forming. In the technology of metal-forming, a piece of metal is brought to a required shape by deformation through pressure or by striking blows on the metal with a hammer which alters the shape of the metal into the form desired. Large metal pieces are usually heated to a temperature at which the metal is relatively soft and deforms easily when struck by a hammer or subjected to pressure. This process is called hot <u>forging</u>. Forging can also be carried out on cold metal, but in such cases the metal msut be relatively soft when in a cold state. The process of forming metal in the cold is referred to as <u>cold forging</u> and is only possible for relatively soft metals and alloys. A third form of metal-forming operation which is usually carried out in the cold stage is metal pressing. Pressing is usually carried out on a metal in the form of sheet, usually not exceeding a few millimetres in thickness. The sheet is usually confined between two dies which move together and impart the shape in the die to the piece of sheet metal. During pressing, part of the deformation involved may also result in drawing out the metal. A number of other special types of metal-forming operations are employed in the metal-forming workshop but essentially all of them involve the same process that the metal is shaped into a desired form without cutting away any parts of the original material. After metal-forming,

the piece obtained may be a final machine part or it may be subjected to further machining in order to obtain the shape specified in the design drawing.

29. The basic technologies of metalworking are freely available. In fact, within all African countries, there are workshops already established capable of carrying out all of the standard operations described here. It is therefore a mistaken notion that most manufacturing technology for machine building has to be obtained under a licence, which is the current impression given by many discussions on setting up manufacturing industries. Sometimes, in mass production of particular machine parts, special combinations of metalworking operations may be utilized which offer considerable economic advantages. It is such a package of selected technologies that is usually the subject of licenses.

30. The Regional Centre envisaged in this project must possess all the different types of standard workshops to enable the Centre to undertake the production of any machine part that is possible using standard metalworking techniques. Hence the Centre will require to have a foundry and a metal-forming workshop which will undertake all the operations of hot and cold forging as well as pressing and roll forming. A metal-cutting workshop will also be required. This must contain a wide range of general purpose machine tools as well as some special-purpose machine tools for standard operations like gear-cutting which are necessary in the manufacture of many machines. A good woodworking and pattern-making shop is also needed.

31. A metalworking factory such as will be constituted by the manufacturing division of the Centre requires special laboratory facilities for inspection and control of the operations being carried out, and for quality control of the machine parts that are produced. The range of laboratory facilities required includes a metallurgical laboratory which will monitor the operations of the foundry and provide technical support for the production of good quality castings. A materials testing laboratory is required for testing raw materials received for use in production to ensure their conformance with specifications, and also in some cases to test critical components of a machine design to verify the accuracy of the design assumptions. Facilities for making accurate measurements and for calibrating measuring instruments and gauges must also be provided in a laboratory which is normally referred to as a metrology laboratory.

32. The workshops to be provided for the Centre will normally be equipped to carry out standard production technologies. Any component requiring highly specialized technology to fabricate should be sub-contracted to specialized workshops outside the Centre.

33. The Centre should possess the capacity to design and produce special tools, jigs and fixtures which are often required for use with standard machine tools to enable particular operations to be carried out. This is undertaken in a special precision workshop usually referred to as the Toolroom. This special workshop will also be responsible for the maintenance of all metal-cutting and metal-forming tools. A tool workshop will contain machine tools of higher level of precision in working and facilities for heat treatment of metals and alloys.

CHAPTER 4

ENGINEERING DEVELOPMENT OF MACHINERY AND EQUIPMENT

The concept of development as applied to machinery

34. Few machines work satisfactorily the first time they are produced as a new design. The reason for this is that in the case of a new design, the design engineer is extrapolating his knowledge and experience into an unknown sphere. He will do his best to utilize the ideal models of theoretical analysis to ensure that basic principles are observed in his extrapolation. But since theoretical concepts are simplified versions of real life situations, the extrapolation beyond the existing region of validation often leads to difficulties. Hence, very often, it is after the first prototype of a new machine is made that we begin to learn how to design it more accurately to obtain the successful machine we are in search of.

35. The general course of action is to operate the prototype machine on an experimental basis under observation and to take measurements of various aspects of its operation. Alterations are then made to the prototype, in one form or the other, until a satisfactory machine is obtained. This process is usually described as engineering development. Development of a machine can be carried out with various objectives in view. Where the concept of the machine is basically a novel one, development will usually be undertaken to correct any design faults in the prototype and, in the course of this, to establish more accurately the basic design methodology. Development can also be carried out to extend the performance, or to adapt the functioning of an existing successful machine to a new environment, or to cope with slightly modified inputs.

Development to correct design faults

36. The general procedure during this stage is to run the prototype on a test-bed and to check first of all, the overall operation of the machine. Any faults in the operation will be traced to particular mechanisms or components. These will be inspected and modified as necessary. This process will be repeated until all the faults in the operation have been corrected. At this stage we will then have a machine which works in the sense that it performs the type of operation for which it was originally intended. However, development may not stop at this stage since the performance of the machine may be below expectations. Further development of the basic design is still necessary in such a case.

Development to obtain modified performance (adaptation)

37. For this stage of development of a machine, the basic successful design will be run on test for an extended period. During this phase of test running, measurements will be taken of the basic parameters of its operation. From these measurements, the actual efficiency in operation can be determined and this is compared with the theoretical requirements of performance. Since we now know more accurately from the first stage the physical design requirements for satisfactory operation, it is now possible to make alterations to the design: step by step, to alter one function or the other until we bring the machine to the level of performance required.

38. A similar procedure will be used when it is intended to adapt the performance characteristics of an existing machine to cope with a change in its operating environment, or a slight variation in the working requirements. In this case, as

already explained in the preceding paragraph, the machine will be run under the new conditions and its performance monitored and recorded. Changes will then be made in particular mechanisms or components which, of course, involve some measure of re-design. In the course of adaptation, the degree of re-design may be considerable and may involve not only a change of form of a component, but also of material. Normally such adaptation is undertaken when the new service conditions are not too different from the original situation for which the machine was initially designed. When the differences are considerable, it is usually more rewarding to start afresh with a new design, even though some of the features of the existing equipment may be borrowed.

Field tests as part of development

39. There are many classes of equipment whose operation does not take place in a stationary environment. Such equipment include most agricultural machinery and equipment, vehicles, ships and other transportation machinery. For such types of machines and equipment, part of the development is carried out by tests in the field. In the case of agricultural equipment, for example, such field tests will be run on the kinds of soils or on similar farms to those for which the prototype is being developed. The same process of observation taking and recording and of carrying out modifications to form and material will be carried out until a satisfactory machine or equipment is obtained. Similarly in the case of vehicles, extended field tests have to be carried out on similar terrain to that within which the final vehicle or equipment will be commercially exploited. This stage of field trials is especially important in the case of vehicles because many components fail in a vehicle designed for the operating conditions of developed countries when they are operated on the rough road networks and in the dusty tropical conditions of many Third World countries.

40. Another very important aspect of performance that is usually investigated during development is reliability and operating life. Machines which are intended for continuous operation have to be run for extended periods in order to discover the reliability of their components under continuous loading and other conditions of operation. This usually enables the life of different components to be ascertained and some of the requirements for servicing and maintenance to be established. It is during this stage that operating and maintenance instructions are derived, or validated.

Facilities for the development workshop

41. The development workshop or experimental laboratory, as it is sometimes known, needs to be very well equipped with a wide variety of testing and analytical facilities. There will be test-beds which consist of structures on which the prototype will be mounted and on which will be provided different types of instrumentation and recording equipment, according to the type of machinery being developed. In addition to the test-beds, facilities should be provided for inspection, analysis and testing of metals and other materials. This implies that fairly sophisticated laboratories for mechanical testing, chemical analysis, metallurgical analysis and metallography should be provided.

42. The manpower complement of a development division is quite varied. In addition to engineers, we also require metallurgists and corresponding technicians trained to work in the relevant fields with professional level staff.

Priority areas for machinery development in Africa

43. The Preparatory Mission during its visit to different African countries was able to observe the considerable need for machinery and equipment development in all the African countries visited. The observations of the mission left no doubt that a very large proportion of the machinery and equipment imported for use into African countries require a considerable amount of re-design and development in order to better adapt them to the tasks to be carried out, or in order to improve their life and reliability under the field conditions they have to operate. The higher rate of breakdown and the consequently extremely high expenditure on spare parts demonstrate quite clearly that not only are many components inadequately designed for operating conditions in Africa, but in many cases, the maintenance instructions may not be sufficiently adapted to the local circumstances of operation of the machines. This subject will be dealt with at greater length in a subsequent chapter.

CHAPTER 5

ENGINEERING DESIGN AND MANUFACTURING IN AFRICAN COUNTRIES

Manufacturing sector*

44. On the whole, African countries are making considerable efforts to promote their industrial development. This ever-present concern is reflected in various economic measures and initiatives taken by African Governments to establish industries that will promote industrialization.

45. In fact, the African countries already have not inconsiderable industries that are able to meet domestic demand (manufacturing industries) and that of the large export-oriented industries. There is no doubt that the manufacturing industries, which are able to supply a good portion of the African countries' requirements for consumer and capital goods, contribute greatly to Africa's industrial and economic development.

Table 1: Indices of added value in the manufacturing sector according to subregion between 1970-1976 1/

(Base 1970-100)

	1971	1972	1973	1974	1975	1976	1970 1976*
North Africa	101.8	108.0	121.6	117.1	128.6	140.5	5.8
West Africa	101.8	118.0	127.7	134.7	134.8	141.8	6.0
Eastern Africa	108.8	119.5	125.5	128.8	124.1	126.0	3.9
Central Africa	112.7	117.1	131.9	132.4	117.9	120.9	3.2
Total (all subregions)	104.4	114.5	124.7	125.4	127.8	134.3	5.0
Growth rate	4.4	9.7	8.9	0.6	1.9	5.1	5.0

Sources: ECA Statistics Division

The added value of the manufacturing industries in African countries, expressed in constant prices, has been increasing steadily. In 1975, it rose 1.9 per cent and, in 1976, it rose 5.1 per cent bringing the average annual growth rate since 1970 to 5 per cent.

1/ Survey of Economic and Social Conditions in Africa, 1976, Part I, United Nations, 1977.

* Average annual growth rate (expressed as a percentage).

46. Although that rate is less than two-thirds of the 8 per cent target by the international development strategy for the Second United Nations Development Decade, it is, nevertheless, half Lima target. That target was for a growth rate of 11 to 12 per cent per annum so that Africa's share in total world industrial production might rise to 2 per cent by the year 2000.

47. There has been no significant change in the share of the manufacturing sector in GDP in the African countries.*

Table 2: Share of manufacturing sector in GDP 2/

	1970	1976
North Africa	12.1	12.3
West Africa	8.2	8.4
Central Africa	7.1	7.5
Eastern Africa	9.4	10.4
Total all African countries*	10.2	10.7

48. Taking all African countries together, except for South Africa, the share of the manufacturing sector in total GDP rose from 10.2 per cent in 1970 to 10.7 per cent in 1976.

49. On the whole, the annual rate of increase has been encouraging and has been sustained by the following economic factors:

- substitution of local goods for certain imported goods in order to protect local manufacturing industries;
- the raising of import duties on certain substitute products;
- the possibility of obtaining raw materials locally;
- the abundance of indigenous labour.

50. In most cases, the slowdown in the growth of the manufacturing sector is due to ineffective application of industrial protection measures and to difficulties in obtaining such items as raw materials and spare parts.

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* Excluding South Africa.

2/ ECA Statistics Division.

51. These factors seem to have had a particularly great impact on growth of the share of the manufacturing sector in over-all GDP of countries south of the Sahara.

52. The share of the manufacturing sector in GDP was greater in the countries of North Africa than in the countries of Central Africa (12.3 per cent in 1976 as compared to less than 8 per cent).

53. This is undoubtedly due to the fact that there are a greater number and variety of manufacturing industries in such countries.

54. So far as West Africa is concerned, it should be pointed out that Nigeria's growth rate is very high, due to the tremendous investment programme which the Government is implementing and to the interest of Nigerian and foreign private investors in the manufacturing sector.

55. Whatever the growth rate of the manufacturing sector in African countries, the main problem is that of the kind of production currently engaged in and the orientation of that production.

56. At present, manufacturing output in Africa includes both heavy and light industrial goods.

Manufacturing output in Africa

I. Heavy industry

1. Chemical products
2. Petroleum and petroleum by-products
3. Non-metallic ores
4. Base metals
5. Metal products

II. Light industry

1. Foodstuffs
2. Beverages
3. Tobacco
4. Textiles
5. Clothing
6. Shoes
7. Made-up textile goods
8. Wood products
9. Paper goods

57. It would appear from the breakdown of the added value in the manufacturing sector between the heavy and light industries in a number of African countries in the period between 1970 and 1976, that the share of heavy industry in manufacturing output rose considerably, from 32 per cent in 1970 to 39.8 per cent in 1976.

Table 3: Breakdown of value added in manufacturing output between heavy and light industrial goods according to subregion

Subregion	1975		1976	
	Light industrial goods	Heavy industrial goods	Light industrial goods	Heavy industrial goods
North Africa	60.7	39.3	53.7	46.3
West Africa	71.3	28.7	65.4	34.6
Eastern Africa	74.0	26.0	68.1	31.9
Central Africa	67.1	32.9	67.6	32.4
Total all African countries	68.0	32.0	60.2	39.8

Source: ECA Statistics Division

It should be pointed out that total manufacturing output increased at an average rate of 5 per cent annually and that the production of heavy industrial goods rose by 9.4 per cent annually as against 3.4 per cent in the case of light industrial goods.

58. The decline in the growth of manufacturing output of light industrial goods is due to the fact that the real increase in per capita GDP was less than 1.8 per cent per annum, while the over-all growth in GDP levelled off at 4.6 per cent in the 1970s. By contrast, the average annual growth rate for fixed capital formation, estimated at 6 per cent, strongly encouraged a high rate of growth in output of heavy industrial goods.

59. Despite the traditional nature of agro-based industries which are geared towards the processing and enrichment of local raw materials and the production of ordinary consumer goods, the manufacturing industries of the African countries attach special importance to the production of metal goods such as spare parts, machine parts and, under certain circumstances, entire machines.

60. In this very specific area of mechanical engineering, in which goods are either forged or cast (smelted), a number of sectors determine what direction industrial manufacturing will take. They are:

- the agricultural machinery sector;
- the sector of spare parts, components and accessories for river and sea transport equipment;
- the sector of spare parts, components and accessories for road and rail transport equipment;
- the sector of spare parts, components and accessories for machines.

(a) Manufacture of agricultural equipment

61. There are several agricultural companies in African countries that concentrate on the production of agricultural traction equipment; this includes various types of plough, shovels and cart wheels. Production of agricultural implements is rising fairly rapidly. The increased demand for machettes, hoes, axes and similar implements is attracting sizeable amounts of capital to Africa for the purpose of extending or or setting up, inter alia, forges, heat treatment facilities, polishing (grinding) workshops, modern presses and foundries. Some countries have acquired the means needed to follow up the activity of agricultural equipment factories. Some have even introduced assembly plants for power-driven cultivators and tractors and for the manufacture of various parts and components.

(b) Manufacture of parts, components and accessories for river, sea, road and rail transport equipment

62. All African countries which have outlets to the sea or local navigable rivers, have sizeable shipyards. Initially, these shipyards performed simple maintenance and repair operations even though they had workshops specializing in such areas as boilers, engineering, electrical, diesel, and pipes and tubes. In view of the nation's needs a good many African shipyards are shifting over to the assembly of barges, oxygen production, manufacture of valves, pipes, cofferes and locks, repair of braces, cranes and engines, the manufacture of prototypes, the adaptation of certain shipyards and so forth.

63. Nearly all African countries are equipped with a large number of garages for the repair and maintenance of transport equipment. There are also large soldering and engineering workshops for the manufacture of parts and components for various types of vehicle.

64. So far as rail transport is concerened, there is a fairly comprehensive range of engineering facilities. Indeed, nearly all African railways have repair shops, electrical engineering workshops, foundries and forges. Their main activity used to be maintenance, repair and periodic overhaul of the railway engines and they can rewind electrical motors and test the repaired engines in order to measure their power and performance prior to putting them back into service. In view of the supply difficulties, there is a definite shift towards production activities among these workshops.

65. The foundries make molds in order to obtain castings of such things as brake shoes and bushings.

66. The forges manufacture springs while the engineering workshops have already demonstrated their ability to recover and recondition certain metals (for example from brake shoes).

67. While many African countries seem to be paying a good deal of attention to the local manufacture of parts, components and accessories for the agricultural and transport sectors, the same is not true in the case of the manufacture of components and parts for industries in such countries. There are, of course, several engineering workshops, forges and foundries attached to some factories. These workshops do only routine maintenance and repair work,even though they have the equipment, machine tools and special machines needed for manufacturing the parts or components that are currently imported from the industrial countries, the lack of which sometimes holds up production.

68. This situation seems to be encouraged by the fact that African countries lack a national agency to integrate the activities of forges, foundries, engineering, repair and maintenance workshops and to direct their production activities in such a way as to meet national requirements so far as parts, machines, components and accessories for industrial development are concerned.

69. Thus, it is possible to identify three stages of development in the industrial prodction sector in the countries visited. They are:

1. Countries that are developed as regards industrial design and manufacture;

2. Countries that are fairly developed as regards industrial design and manufacture;

3. Countries that are underdeveloped as regards industrial design and manufacture..

70. However subjective this classification may appear, it is obvious that countries such as Nigeria, Kenya and Zaire have substantial means and a technical and technological basis for industrial design and manufacture. Despite the direction taken by industrial design and manufacture, and bearing in mind the lack of competent staff to operate the existing equipment, these countries and many others have the basic infrastructure necessary for the development of the engineering industry.

71. The countries that are fairly developed also have substantial plant and a medium-sized nucleus of industrial design and manufacturing facilities, geared in particular towards agricultural and transport equipment (mainly, assembly and maintenance operations), in keeping with the size of the country.

72. So far as the third category is concerned, these countries have small repair, assembly and maintenance plants whose scope is rather limited. Whereas in some such countries, the level of vocational training does not go beyond that of technician, in other countries there are absolutely no facilities for designing and adapting even a simple part. In order to remedy this situation, a good many of these countries have elaborated industrial development programmes and plans concentrating on mechanical engineering. For instance, Burundi has provided in its development plan for the establishment of a large foundry and the development of engineering workshops and also for the establishment of a polytechnic for training engineers.

Classification of the countries visited, according to level of development as regards industrial manufacture:

1. Developed countries as regards industrial design and manufacture:

   Nigeria
   Zaire
   Uganda
   Madagascar
   Ghana

2. Fairly developed countries as regards industrial design and manufacture:

   Swaziland
   Mali
   Togo

3. Underdeveloped countries as regards industrial design and manufacture:

Upper Volta
Burundi

Workshops and equipment, including machine tools and special machines

73. Generally speaking, all African industries have large industrial maintenance and production units. These units consist of the following technical departments:

1. Repair and maintenance workshops

74. Their role is to make sure that machines work properly, to avoid any sudden stoppage in production owing to minor breakdowns resulting from lack of lubrication, overloading or execessive wear of certain parts.

2. Engineering workshops

75. These are distinguished by the size of their machine tools which are intended for the manufacture of parts for factory plant. The engineering workshops all contain the same equipment whatever the country. The only difference is when such equipment was installed. In most cases, the equipment is old but efficient. Any overhauls or introduction of new equipment took place during the 1970s. The various manufacturing operations are carried out with the following equipment:

(a) Machining

Lathes
Millers
Drilling machines
Shapers
Reaming machines
Planers
Grinders

(b) Shaping

Shearing machine
Punching machine
Guillotine
Folding machine
Rolling machine

(c) Soldering

Electrical soldering machine
Oxyacetylene soldering machine

76. It should be noted that engineering workshops in African countries all have a tendency to include too many stamping operations in the shaping process.

3. Forging

Power hammer
Pneumatic drill
Press
Heat treatment
Polishing (grinding)

4. Founding

77. There is a tendency in all African countries to obtain cast iron parts. Accordingly, the main activities of a foundry can be found, that is to say:

(a) Fusion: this is done using cupolas with plugs for casting iron and cupolas using a mixture of coke and oil (diesel oil) for non-ferrous metals;

(b) Induction furnace: this can be used instead of cupolas and its introduction is a sign of the modernization which is starting in African foundries. This type of furnace is operated by large generating sets;

(c) Casting: in spite of the fact that there are a few simple shakers and compressors it is not uncommon to see casting done by hand. There are large sand preparation sections equipped with mixers and erectors;

(d) Coring: in most cases, this is done by hand. However, there are also moulding machines which manufacture moulds without cores; they have large conveyors capable of carrying several dozen moulds;

(e) Trimming: grinding machine.

78. On the whole, African countries want to introduce industrial manufacturing equipment to produce goods not only for everyday household consumption but, that would act as an incentive to industrial development. However, a good many African countries are hampered by the problem of what to choose and by the wishes of investors regarding which sector they wish to invest in.

79. There is a fairly widespread tendency in Africa to set up large secondary iron and steel works containing sophisticated machinery and furnaces even though there is no steady supply of raw materials for them.

80. These factories are equipped with very modern continuous-casting electrical furnaces which produce liquid steel for casting, billets for the manufacture of rods, angles, shapes and sections, iron ingots and other products. These factories also have cold-rolling sections for manufacturing wire, cold-rolled plates in order to obtain plates and sheets (hoop and strip or corrugated) which are then galvanized. This large and sophisticated equipment operates at far less than full capacity and is sometimes brought to a complete standstill by the lack of imported raw materials. In many cases, the engineering workshops attached to these factories continue to work at full capacity in order to meet the needs of related factories.

Manufacture of machine parts

81. The large industrial infrastructure in Africa forces African countries to ensure that they have local means to guarantee that the equipment used for the production of everyday consumer goods is working properly. Accordingly, certain engineering workshops, forges and foundries connected to the various machine parts factories are beginning to be used rationally.

82. There is a very marked trend in factories to recondition worn parts, and to modify imported parts and subsequently manufacture these modified parts. This trend is widespread in the other industrial sectors dealing with agricultural and transport machinery.

83. Factories manufacturing agricultural traction equipment manufacture a number of large parts of ploughs such as:

- cranks for ploughs
- drag links
- pipe box for wheels of plough
- box part of carts
- plough soles
- cart axles
- cart handles

84. The parts for the machinery to manufacture agricultural implements are often new parts or imported used parts that are reconditioned. When necessary, when these imported parts cannot be reconditioned, they are manufactured on the spot on the basis of old models.

85. Some tractor-assembly plants are beginning to manufacture the chassis and certain parts.

86. As far as rail transport is concerned, although the major activity is repairing coils and armatures, they also recondition braces and brake shoes.

87. Springs, brake shoes, bushings and other small but important parts are manufactured out of salvaged iron and steel.

88. No African country has quite reached the point yet where it is able to manufacture complete machines. There are large assembly plants for, inter alia, vehicles, bicycles, motorcycles and tractors. However, it should be pointed out that the various African workshops manufacture components, accessories and even entire new components such as:

- barges
- tanks (large cylinders for sugar factories or petroleum facilities)
- the bodies for various types of vehicles
- compressors for sugar-cane processing machines
- metal containers
- tanks for power stations
- large transport trailers
- pylons
- water towers
- steel scaffolding

89. In order to be able to manufacture complete machines there must be a complete mechanical engineering and foundry, that is to say, a plant that can handle all the various operations involved in making components and parts, starting from the design phase right through to the final assembly. As was pointed out in paragraph 9b of the introduction, the various mechanical engineering and smelting operations in Africa are not integrated.

90. However, engineering workshops and foundries do have large laboratories which sometimes have sophisticated instruments and large machinery used for quality control of the machine parts and components which they manufacture. Sometimes, they are equipped with instruments for analyzing metals.

91. Foundries have chemical laboratories which, though lacking spectrometers, are equipped with machines for measuring hardness; they also have basic laboratories for testing the permeability, resistance and humidity of sand and the size of the grains. In such cases, African foundries carry out various operations in order to reduce the number of rejects.

92. Such laboratories also have equipment for testing carbon and ferro-alloys (C and S: analyses). These laboratories are equipped with microscopes and they undertake very basic operations to check the humidity and resistance of the sand and to reduce the number of rejects.

93. The engineering workshops also have large laboratories equipped with quality control machinery and staffed by metallographists and metrologists.

94. Hardness tests are thus carried out by means of precision instruments (such as electronic scales and micron comparators.

95. Generally speaking, the laboratories are well equipped with instruments and devices for analyzing alloys and substances and for performing quality control operations. The only difficulty is the shortage of technicians capable of using these devices and instruments.

96. For example, owing to the shortage of specialists in metals analysis or the utilization of precision-measurement instruments, laboratories are either immobilized or operating at much reduced efficiency.

97. It must be admitted that the level of the cadres and workers in African engineering workshops, foundries and forges is not that high. On the whole, technicians and semi-skilled workers are recruited in technical training schools or - in the case of semi-skilled workers - trained on the job. It is not always easy to find technicians and semi-skilled workers who can be put to work right away.

98. While they have a sound theoretical background, a certain amount of time is needed to give them practical experience, for example, of soldering or of general mechanics. This is probably due to the lack of proper co-ordination, in certain African countries, between the technical schools and the factories. Were such co-ordination to be introduced, it would facilitate the search for ways and maans of training technicians and skilled workers and would increase the productivity of factories, particularly at the present stage of industrial develoopment in Africa.

99. In principle, the technicians and semi-skilled workers in African factories have good skills and are well disciplined. The technicians and semi-skilled workers

are supervised by engineers trained in various disciplines or local or foreign universities.

100. But, so far as the organization of production is concerned, there is little method to it and this makes it difficult to determine how production can be increased. Indeed, engineers are appointed to management posts in factories with very little regard to their background. In most African countries it is not unusual to find a mechanical engineer, electrical engineer or an electronics engineer who has been given the responsibilities of a methods engineer. Since the work of such engineers is geared more specifically towards the rational utilization of plant equipment, it is clear that the methodology of production is somewhat neglected and that time studies are unheard of in the production process.

101. Accordingly, rather scant attention is given to the supply function so far as raw materials are concerned.

102. African factories often run up against sudden shortages of raw materials which results in a stoppage in production. This is due to lack of programming of supplies of raw materials, spare parts and components for machines.

103. There are various research institutions in Africa covering all technical and chemical fields. They cover:

- Research into energy and technology;
- Research into agriculture and food.

Moreover, there is a lack of technical institutes dealing specifically with design.

104. However, there are several planning departments in Africa which concentrate on design of machine parts and components. These are the planning offices involved in the design and manufacture of goods. Some of these departments work on imported models which are adapted to local requirements; however, most of them work with parts, components and accessories that are designed and manufactured by local factories. In very many cases imported machinery and equipment is taken apart and studied so as to see how the various components and parts are put together.

105. This practice enables African factories to adapt equipment and machinery to local working conditions and, above all, to acquire a certain facility for manufacturing spare parts and components, and it comes in useful when such parts become worn or break.

106. This task is facilitated by the fact that there are various planning departments and technical research institutes. Nearly every African factory has a planning department which is responsible for designing parts, components and accessories which are manufactured by the factory. These departments engage in two types of activity:

(a) Design

107. The parts, components and accessories to be manufactured are entirely designed and cast in the foundry attached to, or manufactured on the lathes and planing machines in, the factory. This is true in the case of cart axles, bushings for trains, anchors, barges, various steel products, chassis for tractors and coachwork of various vehicles and trailers.

(b) Interpretation of the foreign model and its adaptation

108. So far as the manufacture of various spare parts and machine components is concerned, the planning departments usually use the original models. The design comes from abroad and the planning departments adapt the design to local production.

109. This is true, for example, in the case of agricultural implements and components and parts for refrigerators and air conditioners produced locally.

110. In addition, certain planning departments are able to recondition various components and parts of various devices, for instance engine braces for boats and brake shoes.

111. Generally, these departments carry out various types of study, including mechanical and electrical studies and they interpret industrial designs for the manufacture of prototypes.

112. These offices are often headed by technicians and they have various designers on their staff, all of whom are recruited from technical schools within the country or from abroad. Several large factories have their own technical training schools for skilled workers and technicians. However, it must be pointed out that the level of the technicians in charge of the planning (design) departments is such that design activities may be limited to simply copying the original model or to reconditioning activities.

113. The designers currently employed in the planning (design) departments of African factories have demonstrated their skills in developing and finalizing sketches for the parts, machine components and accessories to be manufactured. However, it is desirable for the technical cadres who are in charge of these technical design offices to have advanced technical training in the area of mechanical engineering.

Technical vocational training

114. At present, all African countries are concerned about the major problem of technical vocational training for national cadres at various levels. This concern is reflected in the growing numbers of students enrolled in technical courses, in the number of schools being built and in the introduction of polytechnical faculties in the national universities.

115. There are three levels of technical training in African countries, namely:

(a) Middle-level technical workers

116. After six years of primary school, students are admitted to technical school usually for a period of four years. In some African countries, students first do a one-year introductory course followed by a three-year course study. At this level, students are given a middle-level secondary technical training. The emphasis is on technical design and interpretation and general mechanics.

(b) Technicians

117. In most cases, students who complete the above technical course, go on to train as technicians. This takes three or four years, depending upon the country. Technicians are given a full secondary technical training.

118. At each level the following subjects are taught: electronics, electromechanics, electrical engineering, thermology, metalworking, general mechanics and automechanics.

119. There are also methods offices available to students and these serve as the basis for the planning departments. At both levels, there are well-equipped laboratories or workshops for practical work. Mechanics is the most popular subject at both levels.

(c) Engineers

120. Most African universities have engineering faculties, and in particular they have polytechnical or technological faculties. These accept students who have completed their secondary education. There are courses, lasting three or four years, in the following subjects: mechanics, electrical engineering, civil engineering, electromechancis, telecommunications. Some African countries also have advanced technical teacher-training institutes.

121. So far as the training of skilled workers in general is concerned, this is done either on the job or in training centres which have been set up by United Nations bodies in various African countries to train workers for a specific period in the following fields: automechanics, electrical engineering, soldering, carpentry, forging and design.

122. There is no training programme for foundry workers. Moreover, the training provided for mechanical engineers - who, in principle, should be involved in design and manufacture - is not adequate.

123. However, there is a technical structure and a small core of technicians who initiate and develop work in the area of design and manufacturing activities in African factories.

CHAPTER 6

THE ROLE OF THE AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING

124. The original recognition of the need to establish the Centre arose out of the desire of the African Ministers of Industry to promote the establishment of industries producing capital goods, especially those producing machinery and machine parts. The major obstacle to the realizing of this desire was recognized to be the inadequate development and, in some cases, the absence of any national capability for the conception and design of machinery and equipment.

125. The idea behind the creation of the Centre has therefore been primarily to establish an institution which will assist the African countries to develop the facilities and the manpower for engineering design, and especially to promote the possibility of producing machines and machine parts at the local level. Among other problems which the Centre is expected to help to solve are:

126. (i) The need to produce machinery and equipment more closely adapted to the conditions of utilization within African countries;

(ii) The need to find a solution to the very considerable problem of producing spare parts for existing machinery and equipment at the local level, at least for the most important items.

All these objectives have been part of the decision to give priority to the development of the capabilities for engineering design within the African countries.

127. During the course of the visits made by the Preparatory Mission to various African countries, it was possible to observe that already at the level of the individual countries, a great need has been felt for the services of engineering design in order to promote manufacturing. Indeed the Team observed that there were many well equipped workshops with considerable capacity for manufacturing machine parts and components which are currently being used only for maintenance work. Most of these machines were very much under-utilized. The capacity for production of capital goods already exists in many workshops within the countries visited, but this capacity cannot be utilized without the ability to design what is to be made. It was not surprising therefore that the news of the creation of the Centre was very well received in all of the institutions and government ministries visited, and equally welcomed by many engineers in industry as well as in technical education institutions at university and other levels.

Functions of the Centre

128. As the main functions of the Centre the mission recommends the following activities:

(a) Adaptation of foreign designs of machinery and industrial equipment
The mission observed that even in some of the factories manufacturing articles for local use, the goods being produced are being made to foreign designs originally conceived for the developed countries. The result of this was that, very often, both the performance of these articles as well as the methods of production were not fully adapted to local conditions. This often resulted in the products being much

more expensive than necessary in addition to being badly adapted for use. In respect of certain imported goods such as vehicles and transportation equipment, there was a considerable wastage of investment due to rapid deterioration in components not well adapted to local conditions. Moreover, a great deal of transportation equipment was seen abandoned for lack of relatively simple spare parts which were not readily available.

(b) Development of indigenous design of equipment.
There are several cases when the adaptation of an existing equipment is only a compromise solution to the requirements of operation. In such cases, a truly viable answer to the local need is to develop new equipment whose design parameters are based on the actual conditions of work. Besides it is very important to develop local capability in each country for the design of machinery and equipment because this will provide some degree of national technological independence and also make it possible to promote or undertake industrial manufacturing. Design and manufacturing in industry are the source of high added-value in production and constitute one of the foundations of the economic strength of the developed countries.

(c) Co-operation with existing national institutions involved with design and manufacturing.

129. The team observed in practically all the countries visited that there are small groups both in the private and pbulic sectors that occasionally undertake some design work, not necessarily as part of their main objectives, but out of necessity. Thus, there exist at least some embryonic groups concerned with design and manufacturing which the Centre could assist and support to develop and expand. The support should be primarily through technical co-operation which will enable such local groups to acquire the experience that the Centre can provide.

(d) Training of engineers and technicians for design and engineering development
One of the best ways of assisting local institutions to develop their engineering design capability is through training of their manpower. The training which should be offered by the Centre will take different forms, but in general should take place at the Centre within a framework which will enable the trainee design engineers to pass through a wide range of actual work experience from detail design to initial equipment design and finally to see the manufacturing of the equipment that has been designed. The Centre should make it possible, during the training, for the trainee design engineers to work under the close guidance of the experienced designers in the Centre, so as to have an effective transfer of competence on the job. The Centre should also offer refresher courses in specialized areas of design and on new design techniques.

(e) Organization of an information service on the engineering design of machinery and on the work of the Centre.

130. Another important facet of the programme of technical co-operation which the Centre should offer will be the regular dissemination of information and reports on the work going on at the Centre, on new methodologies and new discoveries, on

the progress and successful achievement as well as, when necessary, on the failures of any programmes. In this way there will be a truly effective transmission of the experience of the Centre throughout the participating member States.

The need for national centres

131. In order to spread more effectively within the African region the advances made at the Regional Centre and the benefits of its work in engineering design and manufacturing, it is to be hoped that national centres will be identified, or created which will establish contact and maintain close liaison with the Regional Centre as well as undertaking their own tasks at the local level. In this connexion, the creation of a national centre does not necessarily mean the construction of new buildings nor the existence of an institution with design offices and workshops centralized in one location. It will be quite effective, at least at the start of the programme, to identify in each country a network of existing institutions each capable of contributing from a part of its existing organization towards a pool of activities which can fulfil the functions of a national centre. For example, there are some small design offices in a number of industrial development centres and within some State-owned utilities such as national railways and national electricity supply services. There are also a number of foundries and forges both in private firms as well as in the technical colleges, and there are laboratories and workshops in some universities. A suitable integration of the activities of such separate units could initially constitute the national centre and the most developed of the participating organizations could be used as the administrative centre for planning and co-ordination.

132. The functions of the national centres could include the following:

(a) The training of engineers and technicians, in particular draftsmen, for the design and development of machinery and engineering equipment.

(b) The design and production of equipment and machinery and special tools in selected sectors to suit the peculiar needs of the country.

(c) General promotion and development of national capability for machine design and production through technical assistance to local workshops and other private organizations. A major function of the national centre would, of course, be to assure liaison with the Regional Centre and to channel information on national priorities to the Centre.

Relation between the African Regional Centre for Engineering Design and Manufacturing and other proposed regional technological centres

133. Within the framework of institution development proposed in support of industrialization in the African countries, two other regional centres are currently the object of separate studies. The two centres are the African Regional Centre for the Transfer, Adaptation and Development of Technology and the African Centre for Industrial Consulting and Management.

134. The concept of the African Regional Centre for the Transfer, Adaptation and Development of Technology has been expanded and defined in some detail. It is expected that this Centre is going to function primarily as a technology consulting organization to assist African countries in identifying, selecting, negotiating and

when necessary purchasing the rights to use particular technologies and to transfer such technologies to particular skilled groups within the individual countries. The technology transfer Centre will also give assistance in providing training for nationals of its member States in various fields of technology as well as in the procedures of negotiating and implementing technology transfer. Conceived in this form, it is possible for such a Centre to cover a wide range of technologies. It is not clear what meaning is to be given to the aspects of adaptation and development of technology which are in the title of this Centre. Because of the very specific nature of technologies, their adaptation and development normally take place in specialized institutions, each of which is devoted to a particular field of technology. Each of such institutions will be a major industrial research centre devoted to a related range of problems. Consequently, it is impracticable to have one centre devoted to the adaptation and development of technologies in general. The definition of the proposed centre for technology transfer as essentially a technology consulting organization is more appropriate and more realistic.

135. The second projected Regional Centre for Industrial Consulting and Management can be seen from the project document to be envisaged primarily as a project consulting organization. It is also envisaged that the Centre for Industrial Consulting and Management will provide facilities in management consulting to improve the organization and operation of existing industrial enterprises within the region.

136. It can be seen that the three proposed centres serve clearly demarcated needs of industrial development. There is, of course, a wide scope for co-operation between the three regional centres. The Regional Centre for Engineering Design and Manufacturing will have as its main ocntribution to progress in the African countries, the development of the capability to conceive and design industrial machinery and capital goods. If it is necessary to enter into industrial scale production of any particular machine or equipment designed at the Centre, this will have to be done within the framework of a new industrial organization created for the purpose. At that stage, consulting engineering services will be required to design a project for a new enterprise. This is where the role of the Centre for Industrial Consulting and Management would be called in. In designing the new enterprise to manufacture and market a new product, the Centre for Industrial Consulting and Management would be working essentially in a similar pattern as would any industrial consulting firm. If there are any special problems of technology for the production of the newly designed machine or article, reference could be made to the Centre for Technology Transfer. This latter Centre would then assist in identifying a number of suitable alternatives of production technologies already existing and could further render additional services in negotiating the acquisition of the technology selected.

137. If properly conceived and implemented, the three proposed regional centres are complementary and would form a very effective network of institutions providing services for industrial promotion and development within the region.

CHAPTER 7

ORGANIZATION AND STRUCTURE OF THE CENTRE

138. Having regard to the objectives and functions defined for the Centre, it is designed to take the form of a medium-sized industrial establishment with its activities centred around the design and production of machines and machine parts. Any institution of this type has to concentrate its activities within a limited number of machine sectors in order to be effective. From the results of the field survey carried out in a sample of the African countries, the Preparatory Mission Team recommends that the activities of the Centre should initially be organized to cover the following three machine sectors:

(i) Agricultural machinery and equipment (including farming operations and processing of agricultural products);

(ii) Transportation equipment;

(iii) Materials handling and construction machinery equipment.

139. The organization of the Centre should provide for the activities of design, engineering development and manufacturing in addition to programme planning, liaison with African countries and of course a service department for administration.

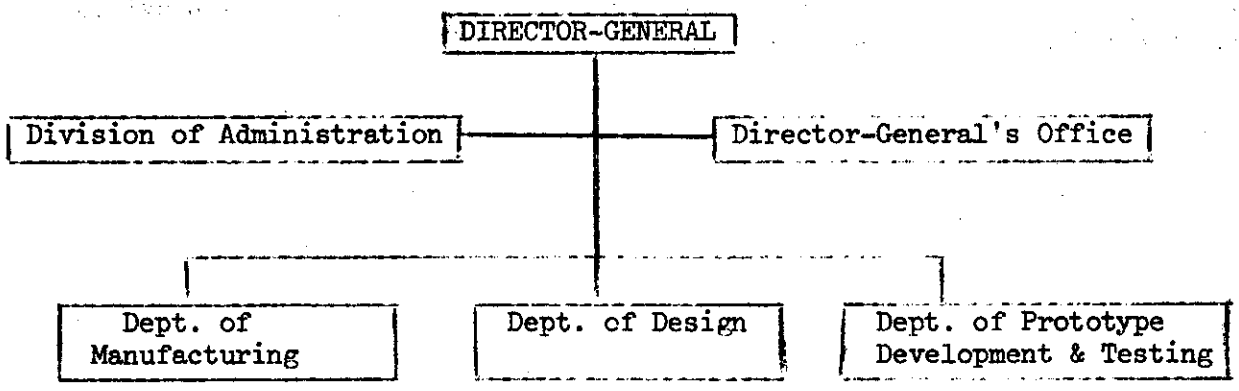
Organization of the Centre

140. The following main units are proposed for the organization of the Centre:

(a) Director-General's Office
(b) Department of Design
(c) Department of Manufacturing
(d) Department of Engineering Development and Testing
(e) Division of Administration

141. The general organization chart is shown in Fig. 1. The responsibilities attached to the various units are described briefly as follows;

Fig. 1: General Organization of the Regional Centre



Director-General

142. Chief Executive Officer of the Regional Centre. Responsible directly to the Executive Board of the Centre of which he is a member.

Director-General's Office

143. The Office of the Director-General will be responsible for

(i) servicing the meetings of the Council and of the Executive Committee;

(ii) programme planning;

(iii) liaison with member States;

(iv) public relations and information.

144. The executive level officers envisaged for this office are:

- One Assistant Director (i/c programme planning)
- One Company Secretary/Legal Officer
- One Public Relations Officer
- Three Programme Officers
- One Personal Assistant to the Director-General

Division of Administration

145. The Division of Administration will be a service division and will include sections responsible for personnel, finance and general services. The library of the Centre could also be included as a substantive section within this division but could be developed later into an information and documentation centre incorporating the library.

146. The executive level officers envisaged for this division are:

- One Assistant Director (Administration)
- One Chief, Personnel Section
- One Chief, Finance Section
- One Chief, General Services Section
- One Chief, Librarian

147. The operating units of the Centre are the major departments, each under a director. The three departments are the Department of Design, the Department of Manufacturing and the Department of Engineering Development and Testing.

Department of Design

148. Under the Director for Design, this department will be responsible for:

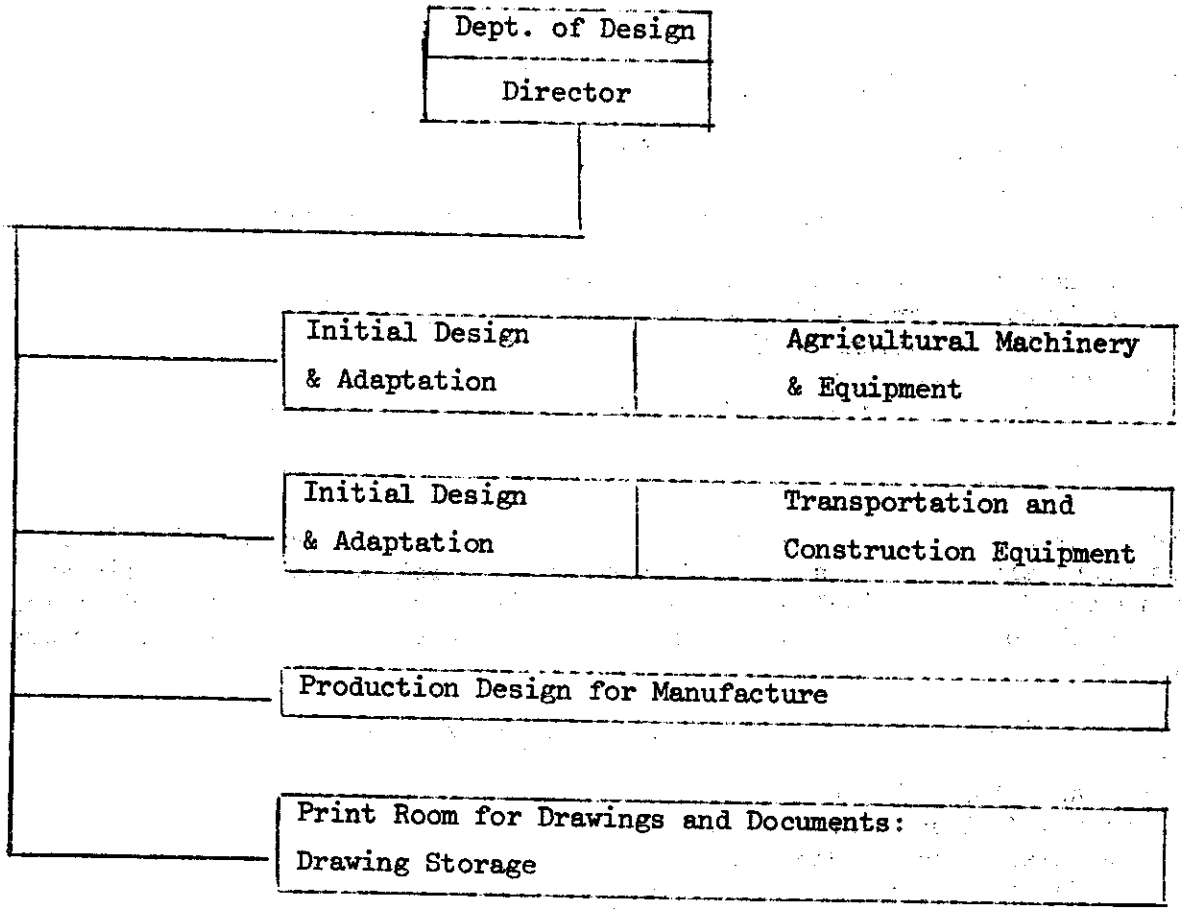
(i) Initial design of prototype machines and components;

(ii) Adaptation and re-design of existing machines, components and spare parts;

(iii) Preparation of final design drawings for production purposes.

149. The department will be organized into two product divisions and one production design division. The Department of Design will maintain and operate a print room for the reproduction of all drawings and documents and properly organized print and documents stores. The general organization of this department is shownin Fig. 2.

Fig. 2: General Organization of the Department of Design



Department of Manufacturing

150. Under the Director of Manufacturing, this department will be responsible for:

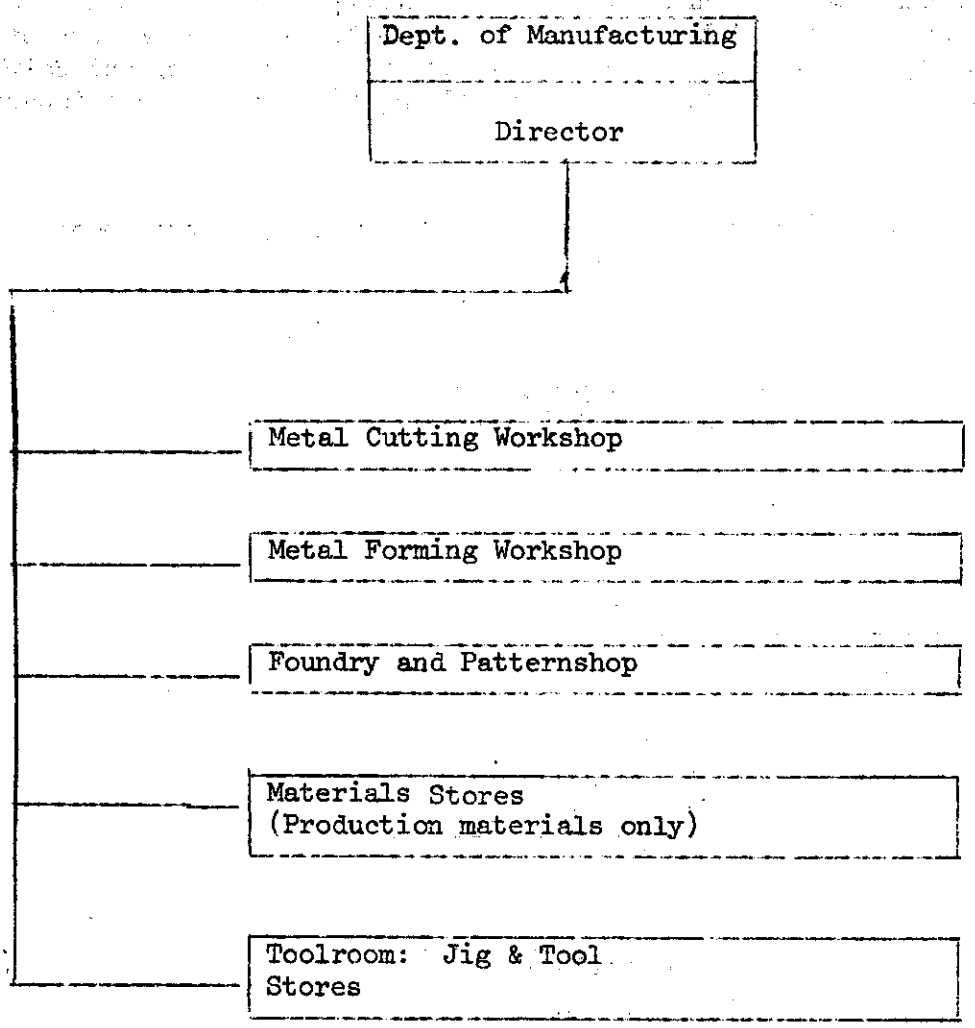
(i) The production of machine parts, components and prototype machines designed by the Centre;

(ii) The production of jigs, fixtures and special tools for use in the workshops;

(iii) The production of spare parts to designs accepted from external sources under special arrangements.

151. The department will maintain and operate the three main workshops of the Centre and the responsible for the Raw Materials Stores for production. A special workshop for the production and manufacture of tools, jigs and fixtures will be a part of this department. The organization of this department is shown in Fig. 3.

Fig. 3: General Organization of the Department of Manufacturing



Department of Engineering Development and Testing

152. Under the Director for Engineering Development, this department will be responsible for:

(i) the testing, analysis and engineering development of prototype machines and components designed at the Centre,

(ii) testing and performance analysis of imported machinery and equipment with a view to their adaptation,

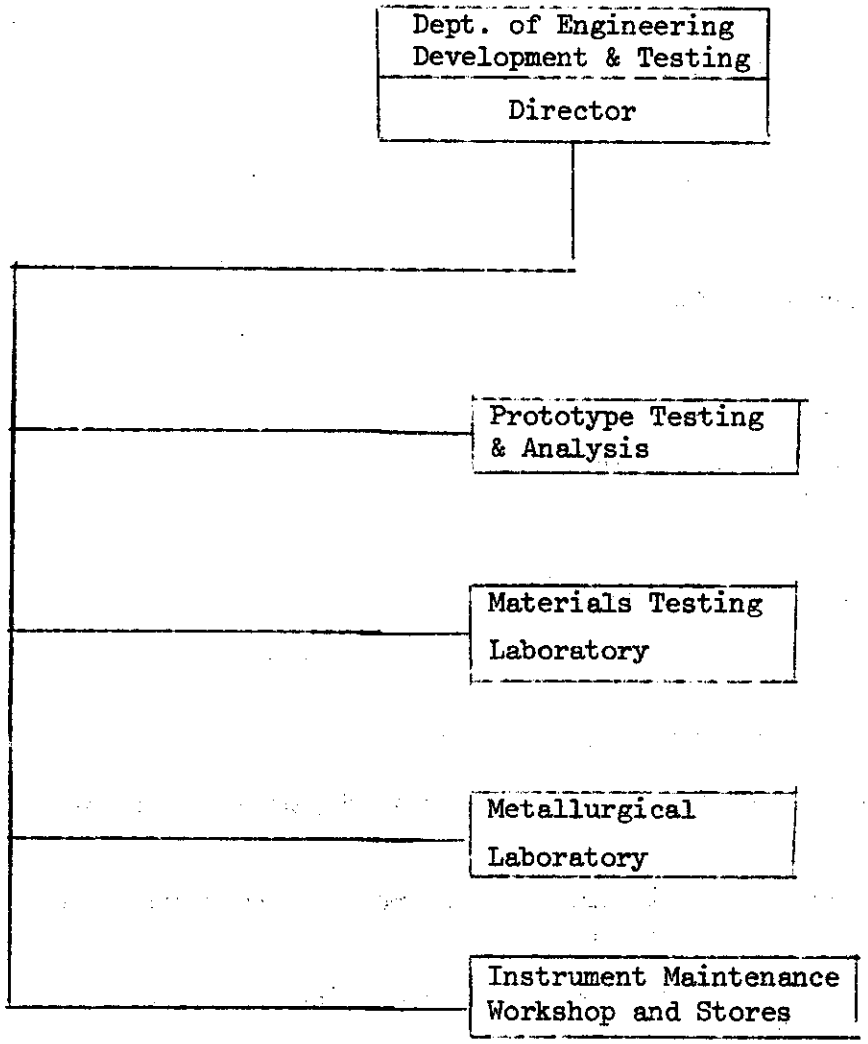
(iii) in collaboration with the Department of Design, the proposal of regional standards for machinery and equipment in common use within the African region,

(iv) materials testing on behalf of all the technical departments of the Centre;

(v) metallurgical testing as required for the design and manufacturing operations of the Centre.

153. The department will maintain and operate the prototype development and testing workshop, the materials testing laboratory and the metallurgical laboratory of the Centre. This department will also be responsible for the maintenance and calibration of all instruments used at the Centre. The general organization of this department is shown in Fig. 4.

Fig. 4: General Organization of the Department of Engineering Development and Testing



Staff establishment

154. The staff establishment for the organization proposed is estimated at 354, distributed as follows:

Director-General's Office	Grade level
Director-General	D.2
Asst. Director (Programme Planning & Liaison)	P.5
Company Secretary/Legal Officer	P.4
Programme Officers (3)	P.3
Public Relations Officer	P.3
Personal Assistant to the Director-General	P.2
Secretary-Typists (5)	GS 6/7
Typists (4)	GS 5/6
Total: Director-General's Office 17.	
Department of Design	
Director	D.1
Secretary-Typist	GS 7/8
Division of Agricultural Machinery and Equipment	
Chief Design Engineer	P.5
Senior Design Engineers (2)	P.4
Design Engineers (2)	P.3
Draughtsmen (4)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
Division of Transportation and Construction Equipment	
Chief Design Engineer	P.5
Senior Design Engineers (2)	P.4
Design Engineers (2)	P.3
Draughtsmen (4)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
Division of Production Design	
Chief Design Engineer	P.5
Senior Design Engineers (2)	P.4
Design Engineers (2)	P.3
Draughtsmen (10)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typists (3)	GS 5/6
Print Room and Drawings Storage Section	
Senior Technical Officer	P.2
Technical Officers (2)	GS 8/9

	Grade level
Technical Assistant (1)	GS 7/8
Typist (1)	GS 5/6

Total: Department of Design 48.

Department of Manufacturing

Director	D.1
Senior Production Engineer (Production Planning)	P.4
Secretary-Typist	GS 7/8

Metal-cutting Workshop

Chief Production Engineer	P.5
Senior Production Engineers (2)	P.4
Foremen (6)	GS 8/9
Master Craftsmen (2)	GS 7/8
Skilled Workmen (30)	GS 6/7
Serretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Labour (2)	GS 1/2

Metal-forming Workshop

Chief Production Engineer	P.5
Senior Production Engineers (2)	P.4
Foremen (6)	GS 8/9
Master Craftsmen (2)	GS 7/8
Skilled Workmen (30)	GS 6/7
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Labour (2)	GS 1/2

Foundry and Patternshop

Chief Foundry Engineer	P.5
Foundry Technologist (1)	P.3
Foremen (5)	GS 8/9
Skilled Workmen (25)	GS 6/7
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Labour (2)	GS 1/2

Toolroom Jig and Tool Stores

Senior Production Engineer	P.4
Production Engineers (2)	P.3
Foremen (6)	GS 8/9
Skilled Workmen (20)	GS 6/7
Secretary-Typist (1)	GS 6/7
General Labour (2)	GS 1/2

Total: Department of Manufacturing 169.

	Grade level
Department of Engineering Development and Testing	
Director	D.1
Secretary-Typist	GS 7/8
Division of Prototype Testing and Analysis	
Chief Testing Engineer	P.4/P.5
Senior Testing Engineers (2)	P.4
Testing Engineers (2)	P.3
Technical Officers (6)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typists (3)	GS 5/6
General Labour (2)	GS 1/2
Materials Testing Laboratory	
Chief Materials Engineer	P.4/P.5
Materials Engineer (1)	P.3
Technical Officers (8)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Labour (1)	GS 1/2
Metallurgical Laboratory	
Chief Metallurgist	P.5
Chemist (1)	P.4
Technical Officers (8)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Labour (1)	GS 1/2
Instrument Maintenance Workshop and Stores	
Senior Instrument Technologist	P.4
Technical Officers (2)	GS 8/9
Instrument Mechanics (4)	GS 6/7
Typist (1)	GS 5/6
General Labour (1)	GS 1/2
Total: Department of Engineering Development and Testing 54.	
Division of Administration	
Assistant Director (Administration)	P.5
Secretary-Typist	GS 7/8
Personnel Section	
Chief Personnel Officer	P.4
Personnel Officers (4)	P.2/P.3

	Grade level
Secretary-Typists (2)	GS 6/7
Typists (2)	GS 5/6

Finance Section

Chief Finance Officer	P.4
Accounts Officers (3)	P.2/P.3
Internal Archive Officer (1)	P.3
Cashier (1)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typists (2)	GS 5/6

Clinic

Medical Officer	P.4
Nursing Sisters (2)	GS 8/9
Medical Orderly (1)	GS 2/3

General Services Section

Chief of General Services	P.4
Executive Officers (2)	GS 8/9
Technical Officer (1)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6
General Services Staff (incl. drivers, messengers, cleaners) (10)	GS 1/2

Library

Chief Librarian	P.4
Library Officers (3)	GS 8/9
Secretary-Typist (1)	GS 6/7
Typist (1)	GS 5/6

Total: Department of Administration 42. (These estimated costs for staff and other expenses are shown in tables 1-3.

Buildings and Physical Plant

155. The site area required for the establishment of the Centre is estimated at 4.5 hectares. This area will be utilized as follows:

(i) One main office building containing the Director-General's Office, the Design Department and Administration Division including the Library of the Centre. This is envisaged as a three-storey block with a total floor area of 2,025 square metres.

(ii) One welfare and services building containing the staff canteen, lecture hall and recreational facilities and a clinic. This is envisaged as a two-storey block with a total floor area of 1,350 square metres.

(iii) Four single-storey workshop buildings each of floor area 2,000 square metres, allocated as follows:

Block 1 - Department of Engineering Development and Testing
Block 2 - Department of Manufacturing: Metal-cutting Workshop
Block 3 - Department of Manufacturing: Metal-forming Workshop
Block 4 - Department of Manufacturing: Foundry and Patternshop

Part of the site will also be used for outdoor machine testing.

156. The estimated investment costs for buildings, machinery and equipment for the Centre are given in Table 4.

Table 1: Estimates of staff costs*
(Net base salaries according to UN salary scale)

Grade level	Project Personnel	m/m	Total	m/m	1st year	m/m	2nd year	m/m	3rd year	m/m	4th year	m/m	5th year
	Professional Category												
D.2	Director-General												
D.1	Directors of Dpartments												
P.5	Chief Engineers and Deputy Directors												
P.4	Senior Engineers, Chiefs of Sections, Administrative Secretary Physician, Chief Librarian, Chemist, Senior Instruments Technician												
P.3	Engineers, Programme Officers, Public Relations Officers, Personnel Officers, Accountants												
P.2	Personal Asst. to the Director-General, Senior Technician												
	Sub-total												
	Unforeseen 30%												
	Total												

* To be furnished later.

Table 2: Estimates of staff costs
(based on UN rates and allowances)

Grade level	Project Personnel	m/m	Total	1st year m/m	1st year	2nd year m/m	2nd year	3rd year m/m	3rd year	4th year m/m	4th year	5th year m/m	5th year
	Technical Grades												
GS 9	Draughtsmen, Technical Officers, Foremen	2,268	3,474,576	60	91,920	96	147,072	480	735,360	816	1,250,112	816	1,250,112
GS 8	Master Craftsmen, Technical Assistants	144	184,176	-	-	-	-	24	30,696	60	30,696	60	30,696
GS 7	Skilled Workmen, Instrument Mechanics	3,216	3,023,040	-	-	-	-	600	564,000	1,308	1,229,520	1,308	1,229,520
	Total	5,628	6,681,792	60	91,920	96	147,072	1,104	1,330,053	2,184	2,510,328	2,184	2,510,328

Table 3: Estimates of staff costs
(based on UN rates and allowances)

Grade level	Project Personnel	m/m	Total	m/m	1st year	m/m	2nd year	m/m	3rd year	m/m	4th year	m/m	5th year
	Administrative Support Personnel												
GS 9	Executive Officers, Nursing Sisters, Library Officers	276	442,556	12	18,372	36	55,116	36	55,116	96	146,976	96	146,976
GS 8	Secretary/Typists	240	306,960	48	61,392	48	61,392	48	61,392	48	61,392	48	61,392
GS 7	Secretary/Typists	1,104	1,037,760	180	169,200	216	203,040	228	214,320	240	225,600	240	225,600
GS 6	Typists	936	676,728	24	17,352	120	86,760	192	138,816	300	216,900	300	216,900
GS 3	Medical Orderly	24	7,416	-	-	-	-	-	-	12	3,708	12	3,708
GS 2	General labour	900	180,000	72	14,400	84	16,800	192	38,400	276	55,200	276	55,200
	Total	3,480	2,631,420	336	280,716	504	423,108	696	508,044	972	709,776	972	709,776

Table 4: Estimated capital costs of buildings, machinery and equipment

Facility	Building costs (Million US$)	Machinery & equipment costs (Million US$)
Main Office	0.80	0.50
Welfare Block	0.55	0.25
Block 1 - Engineering Development	0.60	1.00
Block 2 - Metal-cutting Workshop	0.60	1.80
Block 3 - Metal-forming Workshop	0.60	1.50
Block 4 - Foundry and Patternshop	0.60	1.80
Library (incl. initial literature)	-	0.25
Transportation and Outdoor Equipment	-	0.25
Raw Materials Stocks	-	0.20
Miscellaneous Tools and Fittings	-	0.10
Total	3.15	7.65

CHAPTER 8

WORK PROGRAMME OF THE CENTRE

During first five years

157. The first five years of the Centre will obviously be taken up with building up its facilities and organization. However, from the beginning of the third year, there should be enough staff in house to enable some programme activities to start.

158. The most important item on the work programme of the Centre will, of course, be the development of liaison and consultation with member States to determine the areas of need and their priorities for the work of the Centre. This will result in the identification of the particular classes of machinery and equipment which should receive attention from the point of view of adaptation through re-design and development.

159. In so far as the manufacture of spare parts is concerned, the greatest need has been observed to lie in vehicles and transportation equipment generally. It is necessary to emphasize here that whilst the Centre can undertake itself or assist workshops at national level to develop spare parts production, little benefit will result unless there is some standardization in types of vehicles and a reduction in the variety of vehicles and transportation equipment used in the African countries.

160. Accordingly, an early part of the work programme of the Centre could consist of type-testing and analysis of the more popular vehicles and transportation equipment in the African countries with a view to assisting in the selection of type characteristics to be used as the basis for preparing regional standards in this field.

161. It is basic to the role of the Centre to assist in the training of design engineers and draughtsmen for the member States. In the case of design engineers, the training will be through on-the-job attachments at the Centre for qualified graduate mechanical engineers. Programmes for this purpose should be developed by the Department of Design and could become operative by the beginning of the third year of build up when the design offices should be ready and fully equipped.

162. For design draughtsmen, whilst some may be trained directly at the Centre, it may be more productive to train the teachers from the technical colleges who are going to teach the subject. Draughtsmen will be required in large numbers in every country and the approach should be to assist the countries themselves to develop national training programmes. In any case, direct training of design draughtsmen at the Centre should only be for candidates who have already completed a basic course as mechanical engineering technicians at the technical colleges in their country.

163. The work programme of the Centre during the first five years should therefore include the following subjects:

(i) Visits to member States to undertake surveys of existing institutions, organizations and firms with design and/or manufacturing interests and to establish personal contacts and liaison arrangements with such

institutions, as well as with the organs of government covering such interests.

(ii) As a result of the above, selection of categories of machines and equipment for adaptation design and development in the areas of concentration provided for at the Centre, namely agricultural processing machinery, vehicles and transportation equipment, construction machinery and materials handling equipment.

(iii) Development of training programmes and courses for design engineers and for design draughtsmen, including courses to be offered at country level.

(iv) Type studies of machinery and analysis of performance requirements of equipment in selected industry and transportation sectors with a view to proposing regional equipment standards. This is to be carried out in close liaison with the African Regional Organization for Standardization (ARSO) and with the national standards bodies.

(v) Assistance to national institutions and workshops in the development of spare parts production for machines and engineering equipment.

(vi) Provide an information service on design problems and design techniques to national institutions concerned with design and/or manufacturing of tools and machines.

CHAPTER 9

PROGRAMME OF ACTION DURING FIRST FIVE YEARS

164. The first five years after a decision is taken to go ahead with the establishment of the Centre will be a build-up period in terms of constructing the physical facilities, procurement of staff and equipment and development of programmes.

Action programme for the establishment of the Centre

Year 1: The first year should be devoted to the following tasks:

(a) Completion of intergovernmental agreement, i.e. ratification of the constitution by the participating governments;

(b) Decision on the host country;

(c) Appointment of the director-general, directors and assistant directors;

(d) Completion of the host country agreement;

(e) Acquisition of the site within the host country;

(f) Design of workshops and office buildings;

(g) Selection of equipment.

Year 2: During the second year, the following tasks should be carried out:

(a) Award construction contracts: start construction in phases, starting with main office block;

(b) Design of workshop installations and materials handling facilities;

(c) Place equipment orders;

(d) Start recruitment of engineers, technologists and technicians and identify training of opportunities for them.

Year 3: Tasks that should be undertaken in the third year are:

(a) Completion of main office block, workshops and other buildings;

(b) Development of working procedures for the principal activities of the Centre, including administrative systems;

(c) Development of work programmes based on consultation with member States;

(d) Installation of equipment in all workshops;

(e) Recruitment of foremen and skilled workers;

(f) Build up raw material stocks.

Year 4: Tasks to be realized in the fourth year are:

(a) Complete installation of all equipment in workshops;

(b) Complete recruitment of all personnel;

(c) Commence design projects in at least each of three areas;

(d) Prepare plans for technical assistance to member States;

(e) Commence training programmes.

Year 5: In the fifth year, the Centre should be in full operation. All normal work programmes should be in progress, including design production and development of prototypes; seminars and training courses.

Liaison with industries in member States should be especially developed.

CONSTITUTION OF THE AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING

Preamble

The Governments of the African States on whose behalf this Consitution is signed:

Aware of the need to promote the establishment of industries producing machinery and machine parts as an essential foundation for national industries within the African countries,

Recognizing that a major obstacle to the manufacture of machinery and machine parts in the African countries is the inadequate development of national capability in the conception, design and adaptation of machinery within their countries,

Recognizing that the establishment of an African Regional Centre for Engineering Design and Manufacturing will promote, directly and through the intermediary of national institutions, the development of the capability for conception and design of machinery and machine parts and their manufacture within the African countries,

HEREBY AGREE AS FOLLOWS:

ARTICLE I

Establishment

The African Regional Centre for Engineering Design and Manufacturing (hereinafter referred to as "the Centre") is hereby established and shall operate in accordance with the provisions of this Constitution.

ARTICLE II

Objectives of the Centre

1. To create an organization suitably staffed with professional engineers, technologists and other necessary cadres which will be capable of undertaking the design of machinery and equipment in areas of priority essential to the African countries for their economic development.

2. To provide within the Centre the necessary manpower and facilities to enable the Centre to manufacture prototypes or limited quantities of machinery and equipment designed or adapted at the Centre.

3. To provide an organization capable of developing and bringing to satisfactory operating status, machines and equipment designed for or adapted to specific tasks under the operating conditions required in any particular African country or group of such countries.

4. To assist individual African countries in the creation or improvement of national institutions or teams capable of undertaking the design and adaptation of machinery and equipment in selected sectors of industry.

5. To assist individual African countries in the establishment or improvement of engineering workshops, foundries and forges for the production of machine parts, components or simple machinery for small-scale and rural industries.

6. To undertake on behalf of or assist individual African countries in the production of prototype machines and equipment developed in answer to local needs and specifications.

7. To assist in the further training and development of skills of technical personnel employed in African institutions engaged in the design and/or manufacture of machines and machine parts in individual countries.

8. To organize and maintain within the Centre a data bank on engineering design and manufacturing in various sectors of industry which are of economic interest to the African countries.

9. To assist in the development of machinery specifications and standards within the African region with a view to the reduction of unnecessary variety in the machinery and equipment into African countries.

10. To co-operate with national institutions and organizations within the African countries which are devoted to similar or related objectives.

11. To co-operate with national institutions in other countries, and with international institutions which are devoted to similar or related objectives.

12. To disseminate within the African countries information on the activities of the Centre and on technological progress in design and manufacturing which may be of assistance to institutions and organizations operating in this domain.

ARTICLE III

Functions of the Centre

In order to attain the objectives set out in Article II of the present Constitution, the Centre shall perform any or a combination of the following functions, namely:

(a) On request from Governments of its member States, to assist in the creation of national centres for engineering design and manufacturing.

(b) Assist member States, at their request,

(i) in the adaptation of machinery and equipment imported into their countries;

(ii) in the development of machines and equipment based on indigenous design;

(iii) to undertake the design and manufacture of equipment, machines and tools specially selected for the particular country.

(c) Provide, on request, technical assistance to national workshops.

(d) Assist the member States to promote national capability for engineering design and manufacturing.

(e) Provide effective assistance to the member States in the further training of engineers and technicians for the design and development of machinery and equipment.

(f) Co-operate with existing national institutions which are working in the field of engineering design and manufacturing.

(g) Organize an information service on the activities of the Centre and on the fields in which the Centre is working.

ARTICLE IV

Membership of the Centre

The member States of the African Regional Centre for Engineering Design and Manufacturing shall consist of such member States of United Nations Economic Commission for Africa and the Organization of African Unity that adhere to this Constitution as provided for in Article XVIII of this Constitution.

ARTICLE V

Obligation of member States of the Centre

The member States of the Centre shall co-operate in every way possible with a view to assisting the Centre in achieving its objectives. They shall, in particular,

use their best endeavours to:

(a) take all such steps as may be necessary to implement the decisions of the Council and of the Executive Board.

(b) facilitate the exchange and dissemination of information on the kinds of spare parts, components, instruments, industrial equipment and simple machine tools manufactured in their countries.

(c) make available any reports, agreements and information relating to the development of any facilities for engineering design and manufacturing which they possess and which are not classified as confidential, whenever such information is requested by the Regional Centre.

(d) make available to the Centre any mechanical workshops, forges or foundries within their countries to whom the Centre might subcontract the manufacture of machine parts, under conditions agreed with the appropriate organ of the Centre.

(e) provide suitable national personnel for the operations and activities of the Centre from all categories within the organizational structure of the Centre, on suitable conditions agreed with the appropriate organ of the Centre.

(f) pay their annual contributions and such special contributions as may be determined by the Council or by common agreement for particular programmes or projects carried out in their countries and insure a proper accounting for any grants or loans received from or through the good offices of the Centre.

(g) accord such facilities, privileges and immunities as may be required under Article XIV of this Constitution.

ARTICLE VI

Organs of the Centre

The Centre shall have the following organs:

The Council

the Executive Board

the Management, and

such other subsidiary organs as may be established in accordance with the provisions of this Constitution.

ARTICLE VII

The Council - establishment, composition and function

1. There is hereby established the Council of the Regional Centre (hereinafter referred to as the "Council"), which shall be the supreme policy-making organ of the Centre.

2. The Council shall consist of:

(a) The Minister or Commissioner responsible for industry in the Government of each member State of the Centre.

(b) The Executive Secretary of the United Nations Economic Commission for Africa or his representative.

(c) The Executive Director of the United Nations Industrial Development Organization or his representative.

(d) The Administrative Secretary General of the Organization of African Unity or his representative.

(e) The Director-General of the Centre, ex officio, who shall undertake the functions of Secretary to the Council.

3. The Council is the supreme policy-making organ of the Centre. For the purpose of the achievement of the objectives of the Centre, the Council shall, in particular, have the following responsibility:

(a) To approve the general policies and principles governing the activities of the Centre;

(b) To approve the 5-year programme of work, the corresponding budget and accounts of the Centre;

(c) To determine the annual and special contributions to be paid by the member States of the Centre and matters related thereto;

(d) To elect the members of the Executive Board, having regard to equitable geographical and linguistic distribution;

(e) To appoint, on the recommendation of the Executive Board, the Director-General of the Centre and to prescribe his terms and conditions of service, provided that in making any appointment under the sub-paragraph the Council shall take the opportunity to appoint a competent person with considerable experience and the requisite qualifications in the field of engineering design and manufacturing, and in management;

(f) To examine proposals submitted to it by the Executive Board relating to the objectives of the Centre and to take decisions thereon, or when necessary to make its own proposals on any of such objectives with a view to their application by the Centre or the member States;

(g) To select the location of the Centre;

(h) To approve periodical reports on the activities of the Centre;

(i) To create its own special or technical committees as it may consider necessary or desirable;

(j) Subject to the provisions of this Constitution, to prescribe and/or approve the staff, financial and other regulations of the Centre;

(k) To undertake such other functions as may be necessary, or desirable for the realization of the objectives of the Centre.

ARTICLE VIII

Sessions of the Council

1. The Council shall meet in ordinary session once every two years. It may meet in an extraordinary session if it so determinesor if requested by at least two thirds of the member States of the Centre.

2. The ordinary and extraordinary sessions of the Council shall be held at the headquarters of the Centre, unless convened elsewhere in pursuance of a decision taken at a previous session of the Council.

3. Decisions of the Council shall normally be by consensus.

4. Subject to this Constitution, the Council shall determine its own procedure including that for the convening of its sessions, quorum, the conduct of business thereat and at other times, and for the rotation of the office of Chairman and other offices among the members of the Council.

5. The provisions that the Council may make under paragraph 4 of this Article for the dispatch of business at times when it is not meeting, may, if it so determines, include arrangements under which the exercise of any function of the Council under this Constitution is delegated, subject to such conditions as the Council may specify, to a committee of the Council, the Executive Board or the Director-General of the Centre.

6. The Council may on the recommendation of the Executive Board and subject to its procedure, invite such persons, Governments or institutions as it deems desirable to attend all or particular sessions of the Council as observers.

7 If a member of the Council is unable to attend a meeting of the Council and it is not convenient to postpone the meeting, the member State of the Centre which he represents may, by notice in writing delivered to the Director-General of the Centre, appoint some other person who is a Minister or Commissioner as the case may be, or a Deputy, Junior or Assistant Minister of its Governments to act as a member of the Council for that meeting, and a person so appointed shall, in respect

of the meeting for which he is appointed to act, have all the rights and duties of a member of the Council.

ARTICLE IX

Executive Board - establishment, composition and function

1. There is hereby established the Executive Board of the Centre.

2. The Executive Board shall consist of:

(a) the Executive Secretary of the United Nations Economic Commission for Africa, ex officio, Chairman;

(b) one third of the number of the member States of the Centre elected by the Council in accordance with the provision of sub-paragraph (d) of paragraph 3 of Article VII of this Constitution, who shall hold office in accordance with the provisions of paragraph 3 of this Article;

(c) a representative of the United Nations Industrial Development Organization;

(d) a representative of the Organization of African Unity;

(e) the Director-General of the Centre, ex officio, who shall undertake the functions of Secretary to the Executive Board.

3. (a) one third of the member States as directed by the Council shall retire two years after they have been elected to the Executive Board and shall be replaced by the same number of member States elected by the Council for that purpose;

(b) one third of the member States as directed by the Council shall retire three years after they have been elected to the Executive Board and shall be replaced by the same number of member States elected by the Council for that purpose;

(c) the remaining one third of the member States shall retire four years after they have been elected to the Executive Board and shall be replaced by the same number of member States elected by the Council for that purpose.

4. A member State of the Centre elected to serve on the Executive Board shall be represented thereon by the head of the national institution concerned with engineering design and manufacturing, or in the absence of such an institution, by a suitable person with qualifications and responsibilities in this field of activity.

5. The Executive Board shall:

(a) subject to such directions of a general nature as the Council may give, have the responsibility to approve the work programmes of the Centre.

(b) approve the annual work programme, and the corresponding budget of the Centre submitted to it by the Director-General of the Centre.

(c) mobilize and co-ordinate assistance from co-operating Governments, States and institutions referred to in Article XIII of this Constitution.

(d) submit through its Chairman to each ordinary session of the Council, a periodic report on the activities of the Centre including financial statements on its income and expenditure;

(e) propose for the consideration of the Council, the annual and special contributions to be paid by member States of the Centre;

(f) determine from time to time, the offices of the Management other than those of the Director-General of the Centre and appoint persons to such offices;

(g) propose for the approval of the Council, the staff, financial and other regulations governing the activities of the Centre;

(h) recommend to the Council the person to be appointed Director-General of the Centre;

(i) establish such special or technical committees as it may deem necessary or desirable and prescribe for such committees rules for the conduct of their affairs; and

(j) exercise such other powers and perform such other functions as are conferred or imposed upon it by this Constitution.

6. The Executive Board may delegate any of the powers and functions conferred or imposed on it by this Article to a Committee of the Executive Board, or to the Director-General of the Centre.

ARTICLE X

Meetings of the Executive Board

1. The Executive Board shall meet in ordinary session once a year. It may meet in an extraordinary session if so requested by its Chairman or by two thirds of its members.

2. Meetings of the Executive Board shall be held at the headquarters of the Centre or such other convenient place as may be determined by the Executive Board.

3. Where for any reasons the Chairman of the Executive Board is unable to attend a meeting of the Executive Board, the members of the Executive Board present shall elect from among themselves one of them to act as Chairman for that meeting.

4. Subject to the provisions of paragraph 3 of this Article, the Executive Board shall adopt its own procedure including that for the convening of the meetings, quorum and the conduct of business thereat and at other times.

5. Subject to such directives as the Council may give, the Executive Board may invite such persons and representatives of such Governments, or organizations other than those referred to in paragraph 2 of Article 9 of this Constitution, as it may deem necessary or desirable, to attend its meetings as observers.

ARTICLE XI

The Director-General and the Management

1. The Centre shall be headed by the Director-General who shall be appointed as provided for in this Constitution to serve in such office for a term of five years and be eligible for reappointment for another term of five years.

2. The Director-General of the Centre shall be the Chief Executive Officer of the Centre. He shall in accordance with the policies, decisions and directives of the Council and the Executive Board, have responsibility for the organization, direction and administration of the Centre.

3. The Director-General and the Directors of Departments of the Centre shall constitute the Management.

4. The Director-General shall, with the assistance of the Management, among other things:

(a) service and assist the organs of the Centre in the performance of their functions;

(b) keep the functioning of the Centre under continuous examination and, where appropriate, report the results of his examination for action by the Council or the Executive Board;

(c) submit the draft work programmes and corresponding budgets of the Centre to the Executive Board for its consideration;

(d) submit periodic reports on the activities of the Centre including financial statements on its income and expenditure, to the Executive Board for its consideration;

(e) carry out the work programme of the Centre and co-ordinate the work of the Centre with that of such other institutions active or interested in the objectives of the Centre as the Executive Board may determine;

(f) undertake such work and studies and perform such services relating to the objectives of the Centre as may be assigned to him by the Council or the Executive

Board and also make such proposals thereto as may assist in the efficient and harmonious functioning and development of the Centre, to the Council or the Executive Board as may be appropriate; and

(g) convene, in consultation with the Chairmen of the organs of the Centre, the meetings of such organs in accordance with the provisions of this Constitution or as may be provided for thereunder.

5. The Director-General of the Centre shall be entitled to attend and participate at all sessions of the organs of the Centre or be represented thereat by a senior official of the Management designated by him, except that with respect to the sessions of the Council or the Executive Board, only the Director-General of the Centre or the person for the time being acting as such, shall attend and participate.

ARTICLE XII

Financial provisions

1. The financial resources of the Centre shall consist of annual and special contributions from the member States of the Centre; assistance, aid, loans, gifts, bequests or grants from Governments, international organizations, financial institutions, public or private institutions, associations, bodies or individual persons; and fees and other charges levied by the Centre for services rendered under the provisions of this Constitution.

2. Subject to such financial regulations as the Council may make, the budget of the Centre shall be administered by the Director-General of the Centre under the supervision of the Executive Board.

3. The Director-General of the Centre may with the approval of the Executive Board receive directly, gifts, bequests, aid and other resources from Governments, public, private and international institutions, associations, bodies or individual persons and from Governments, States or institutions with which the Centre has established relations under the provisions of Article XIII of this Constitution, and may for this purpose, enter into related agreements.

ARTICLE XIII

Co-operating States and institutions

1. In pursuance of its objectives, the Council may seek and maintain active co-operation with Governments or States not parties to this Constitution and with institutions (collectively referred to in this Constitution, as "co-operating States and institutions"), which are desirous of assisting the Council or its member States in achieving the objectives of the Council.

2. Subject to the provisions of this Constitution, the Council may enter into arrangements with co-operating States and institutions, defining methods of co-operation in general or relating to individual activities or projects.

3. The Executive Board may entrust the United Nations Economic Commission for Africa on behalf of the Centre with:

(a) the collection of and the accounting for contributions due from member States of the Centre under the provisions of this Constitution; and

(b) seeking assistance from co-operating States and institutions for the implementation of approved projects of the Centre and acting as executing agency for such projects in respect of which it has been able to obtain assistance from co-operating States and institutions under the provisions of this sub-paragraph.

4. The United Nations Economic Commission for Africa shall, through its representative, keep the Council and the Executive Board, as the case may be, informed of the contributions and assistance received and acts undertaken by the United Nations Economic Commission for Africa under the provisions of paragraph 3 of this Article.

ARTICLE XIV

Status, capacity, privileges and immunities

1. To enable it to achieve its objectives and perform the functions with which it is entrusted, the Centre shall possess in the territory of each member State of the Centre juridical personality. For these purposes, the status, capacity, priviledges, immunities and exemptions set forth in paragraphs 2 to 11 of this Article shall be accorded to the Centre in the territory of each member State of the Centre.

2. The Centre shall for the purposes of this Constitution have the capacity:

(a) to enter into contracts;

(b) to acquire and dispose of movable or immovable property; and

(c) to institute legal proceedings.

3. The Centre, its property and assets shall enjoy immunity from every form of legal process except insofar as in any particular case it has, through the Director-General of the Centre, expressly waived its immunity;

Provided however that no waiver of immunity shall extend to any measure of execution.

4. The headquarters of the Centre shall be inviolable. The property and assets of the Centre shall be immune from search, requisition, confiscation, expropriation, and any other form of interference whether by executive, administrative, judicial or legislative action.

5. The archives of the Centre, and in general all documents belonging to it or held by it, shall be inviolable.

6. The Centre, its property, assets, income and transaction shall be exempt from all taxation and from customs duties and prohibitions and restrictions on imports and exports in respect of article imported or exported by the Centre for its official use. The Centre shall also be exempt from any obligation relating to the payment, withholding or collection of any tax or duty, in accordance with existing practices as applied to the United Nations Economic Commission for Africa and the Organization of African Unity.

7. Representatives of the member States of the Centre who are not otherwise officials of the United Nations or of the specialized agencies of the United Nations, shall enjoy such privileges and immunities as are provided for mutatis mutandis by Article IV of the Convention on Privileges and Immunities of the United Nations.

8. Officials of the Centre who are not otherwise officials of the United Nations or of the specialized agencies of the United Nations shall enjoy such privileges and immunities as are provided for mutatis mutandis by Article V of the Convention on Privileges and Immunities of the United Nations.

9. Without prejudice to the foregoing provisions, the member States of the Centre undertake to accord to all representatives of the member States of the Centre, all officials of the Centre, representatives of the Organization of African Unity and co-operating States and institutions and experts providing advice or assistance to the Centre, such facilities and courtesies as are necessary for the exercise of their functions in connexion with the Centre.

10. The Director-General of the Centre shall have the right and duty to waive the immunity of any official of the Centre who is not an official of the United Nations or of a specialized agency of the United Nations in cases where in his opinion the immunity would impede the cause of justice and can be waived without prejudice to the interest of the Centre.

11. All persons undergoing training or taking part in a scheme for the exchange of personnel at the headquarters of the Centre or organized elsewhere within the territory of a member State of the Centre in pursuance of the provisions of this Constitution shall have the right of entry into, sojourn, or exist as is necessary for the purpose of their training or the exchange of personnel. They shall be granted facilities for speedy travel and visas, where required, shall be granted promptly and free of charge.

12. Officials of the United Nations or specialized agencies of the United Nations performing functions in connexion with the Centre shall respectively enjoy appropriate privileges and immunities provided under the Convention on Privileges and Immunities of the United Nations and the Convention on Privileges and Immunities of the Specialized Agencies.

13. The Centre shall co-operate at all times with the appropriate authorities of the member States of the Centre to facilitate the proper administration of justice, secure the observance of national laws and prevent the occurrence of any abuse in connexion with privileges, immunities and facilities mentioned in this Article.

14. The Director-General of the Centre shall conclude with the member State in whose territory the headquarters of the Centre is established an agreement concerning the privileges and immunities to be granted to the Centre.

ARTICLE XV

Amendments

1. Any member State of the Centre may submit proposals for the amendement of this Constitution.

2. Any such proposals shall be submitted to the Director-General of the Centre who shall transmit them to the other member States of the Centre.

3. The Constitution shall be amended by a two-thirds majority of the member States of the Council.

4. The Council shall make rules for the application of the provision of this Article.

ARTICLE XVI

Withdrawal and suspension

1. Any member State of the Centre wishing to withdraw from the Centre shall give the Director-General one year's notice in writing. If at the expiration of such period the notice is not withdrawn, the member State which submitted the notice shall cease to be a member of the Centre.

2. During the period of one year referred to in paragraph (1) of this Article, a member State of the Centre which has given its notice of withdrawal, shall have all the rights of a member State, observe the provisions of this Constitution and shall remain liable for discharge of its obligations thereunder.

3. (a) The Council may be a two-thirds majority of the votes of all the member States of the Centre suspend a member State which:

(i) In spite of written reminders, has failed to meet its financial obligations towards the Centre for three consecutive years;

(ii) Has failed to fulfil its other obligations under this Constitution; or

(iii) Has failed to comply with the decisions of the Council.

(b) In suspending a member State under the provisions of sub-paragraph (a) of this paragraph, the Council may prescribe the duration of such suspension or the conditions in which such suspension shall take effect.

(c) Where the duration of a suspension or the conditions in which it shall take effect are not prescribed, the Council, may, as it deems fit, revoke such a suspension by a two-thirds majority of the votes of all the member States of the Centre.

(d) A member State of the Centre which is suspended under the provisions of sub-paragraph (a) of this paragraph shall, during the duration of its suspension and subject of the provisions of sub-paragraph (c) of this paragraph, cease to derive any benefit from the activities of the Centre or be represented on any of the organs of the Centre and shall be subject to such other disadvantages as the Council may determine.

(e) The suspension of a member State of the Centre shall not relieve that member State from the fulfilment of its financial obligations incurred prior to its suspension, unless the Council decides otherwise.

(f) The revocation of a suspension or the termination of voluntary withdrawal from the membership of the Centre shall be subject to such terms and conditions as the Council may stipulate and shall be communicated by the Director-General to the member State concerned and to the Executive Secretary of the United Nations Economic Commission for Africa.

ARTICLE XVII

Settlements of disputes

Any dispute that may arise among the member States or between a member State and any organ of the Centre other than the Council regarding the interpretation or application of the Constitution shall, unless amicably settled, be referred to the Council, whose decision shall be final.

ARTICLE XVIII

Final and transitional provisions

1. This Constitution of which the English and French texts are equally authentic shall be deposited with the Executive Secretary of the United Nations Economic Commission for Africa.

2. The Constitution shall enter into force when signed on behalf of at least one quarter of the member States of the United Nations Economic Commission for Africa and the Organization of African Unity and shall be open for signature at the Meeting of Plenipotentiaries on the Centre held in ..... from .. to ..... and thereafter at the Office of the Executive Secretary of the United Nations Economic Commission for Africa.

3. Instruments of ratification, acceptance or approval shall be deposited with the Executive Secretary of the United Nations Economic Commission for Africa.

4. A State referred to in Article IV of this Constitution which is desirous of becoming a member State of the Centre after the coming into force of this Constitution, may do so by depositing with the Executive Secretary of the United Nations Economic Commission for Africa its instrument of accession to this Constitution.

5. The Executive Secretary of the United Nations Economic Commission for Africa shall transmit certified copies of this Constitution and information concerning ratification, acceptance, approval or accession to this Constitution to member States of the Centre and all member States of the United Nations Economic Commission for Africa and the Organization of African Unity.

6. The Executive Secretary of the United Nations Economic Commission for Africa shall call the first meeting of the Council and, until the Secretariat is established, its functions shall be performed by the Secretariat of the United Nations Economic Commission for Africa.

IN WITNESS WHEREOF the undersigned ACCREDITED PLENIPOTENTIARIES being duly authorized by their respective Governments have signed this Constitution on the dates appearing under their signature.

Country	Name and Signature of Plenipotentiary	Date
Algeria		
Angola		
Benin		
Botswana		
Burundi		
Cameroon		
Cape Verde		
Central African Empire		
Chad		
Comoro		
Congo		
Djibouti		
Egypt		
Equatorial Guinea		
Ethiopia		
Gabon		

Country	Name and Signature of Plenipotentiary	Date
Gambia		
Ghana		
Guinea		
Guinea-Bissau		
Ivory Coast		
Kenya		
Lesotho		
Liberia		
Libya		
Madagascar		
Malawi		
Mali		
Mauritania		
Mauritius		
Morocco		
Mozambique		
Niger		

Country	Name and Signature of Plenipotentiary	Date
Nigeria		
Rwanda		
Sao Tome and Principe		
Senegal		
Seychelles		
Sierra Leone		
Somalia		
Sudan		
Swaziland		
Togo		
Tunisia		
Uganda		
United Republic of Tanzania		
Upper Volta		
Zaire		
Zambia		

CRITERIA FOR THE LOCATION OF THE CENTRE

The African Regional Centre for Engineering Design and Manufacturing, as can be seen from the main body of the report will be a complex and sophisticated organization. It will also be a considerable investment in terms of its capital installations and the operating costs. Such a Centre requires a wide range of complex inputs and surrounding services to enable it to function properly.

The question of location of the Centre is one which should be carefully considered and every effort made to site the Centre in a location where it can be speedily built up without undue delays and where it is likely to survive. For normal continuous operation and to avoid a waste of the resources assembled at the Centre, the location chosen should be such as to provide regular and dependable logistic and other support.

In accordance with the request of the Economic Commission for Africa and the briefing instructions given to the Preparatory Mission, the Team proposes the following considerations as being important in evaluating the relative merits of alternative locations for the Centre.

(i) Host country contribution

As can be seen from the project report, the capital budget of the Centre has been estimated on the basis that no costs will be incurred in respect of land. The host government should provide the land as a donation to the Centre if the cost of its establishment are to be kept within reasonable limits.

A site of the area of 4.5 to 5 hectares will obviously be difficult to obtain within the existing boundaries of an existing major city, hence it is important that good road connexions exist to the site chosen, or can be provided by the host government.

It is also envisaged that the host government will make a substantial contribution towards the cost of construction of the main buildings of the Centre to enable the project to be started at an early date.

The site should be well served by utilities such as water and electricity and the host government should provide access to them.

(ii) Suitable industrial environment

A Centre of the complexity and level of sophistication planned for this project can best survive only in a location possessing a suitable industrial environment. By suitable industrial environment is meant the existence of a substantial network of manufacturing industry with which the Centre can establish linkages of collaboration. Such collaboration will involve, among other things, the following:

(a) the possibility to provide specialized manufacturing services not available at the Centre.

(b) access to technological institutions such as universities or technical colleges able to assist or collaborate with the Centre in investigating fundamental or basic engineering scientific problems which may arise in its work.

(c) good contacts with professional engineers in industry concerned with manufacturing and able to collaborate with the Centre, especially in design and manufacturing work.

(d) easy availability of engineering raw materials either from local production or through importation.

(e) a substantial pool of trained industrial technical manpower, especially at technician and craftsmen levels.

(f) existence of good facilities for industrial research and standardization to assist the Centre with original design evolution and type-testing.

(iii) Good communications

Good communications are required, especially maritime and air transport facilities. These are essential for easy transportation of raw materials, equipment and personnel to and from the host country as well as within it.

Reliable telecommunications with other African countries as well as with developed countries will enable the Centre to carry out its objectives and work programme more effectively.

(iv) Local costs and foreign exchange

Local costs for engineering and industrial activities tend to be high in the African countries generally, but the situation is especially aggravated in countries with high inflation and foreign exchange problems.

It is essential that local costs be reasonable both from the point of view of capital costs of construction and procurement of a variety of services by the Centre as well as by its staff who may come from other countries.

Availability of foreign exchange is necessary to enable the Centre obtain raw materials and other inputs from outside the host country without undue delays and obstructions.

(v) Fair geographical and linguistic distribution of regional technological centres.

The Preparatory Mission Team considers this to be a factor for The Council of the Centre to interpret and therefore makes no proposals.

Evaluation of probable locations

A number of African countries have already offered or indicated an interest to host the Centre. Questionnaires have been sent to all such countries to give the particulars of the facilities and support to be provided. A sample of this questionnaire is included in this Annex.

When the completed questionnaires are received by the ECA, the relative merits of alternative locations will be evaluated together with the offers of contributions by the host government to the construction of the Centre.

Attachment
Annex II

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA

QUESTIONNAIRE
FOR COUNTRIES OFFERING TO BE HOST COUNTRY TO THE AFRICAN REGIONAL CENTRE FOR INDUSTRIAL DESIGN AND MANUFACTUPING

A. CANDIDATURE (country to fill in statement of candidature)

B. IMMUNITIES AND CONCESSIONS FOR THE ORGANIZATION

The immunities and concessions normally provided for multi-national organizations under the United Nations auspices are as follows:

(1) Immunity of assets, property and funds from search, requisition, confiscation, expropriation and any other form of seizure, except in the case of real estate that may be requisitioned in the public interest with due financial compensation.

YES ☐ NO ☐

(2) Exemption from taxes, duties and levies of any kind whether existing or to be imposed or issued in the future.

YES ☐ NO ☐

(3) Freedom of assets from all restrictions, regulations, controls and liens of any nature.

YES ☐ NO ☐

C. IMMUNITIES AND CONCESSIONS FOR STAFF

The immunities and concessions provided for international staff of the Centre are as follows:

(1) Immunities from legal restriction, alien registration requirements and national service obligations.

YES ☐ NO ☐

(2) Exemptions of the incomes and allowances of the staff of the Centre from taxes whether existing or to be imposed or issued in the future.

YES ☐ NO ☐

(3) Granting of foreign exchange facilities to the staff of the Centre who are non-nationals on the same basis as for the staff of international organizations.

YES ☐ NO ☐

D. COMMUNICATIONS FACILITIES

(2) What preferential treatment would your country offer to the Centre as regards local and external communications?

Rapid Installation ☐

Installation at nominal charge ☐

Service at preferential charges ☐

E. AIR TRANSPORT FACILITIES

F. PHYSICAL INFRASTRUCTURE

(i) Offices and Workshop Buildings (see Annex for details)

In addition to B and C above, the host country will be expected to provide other services and physical infrastructure as set out in the Annex to this questionnaire. Please indicate which of these your country would make available:

(a) Appropriate office and workshop premises with good connections to water and electricity utilities. YES ☐ NO ☐

(b) Adequate land for building YES ☐ NO ☐

(c) Both YES ☐ NO ☐

IF YES on what terms would they be made available to the Centre?

At market rent ☐

At subsidized rent ☐

At nominal rent ☐

Free of charge ☐

(ii) Housing facilities

Will your country assist the personnel of the Centre to buy or rent suitable housing accomodation?

(a) Purchase	YES	☐	NO	☐
(b) Rent	YES	☐	NO	☐
(c) Both	YES	☐	NO	☐

G. EDUCATIONAL FACILITIES

What facilities are available in your country for education at:

	English	French	Arabic
Preparatory level	☐	☐	☐
Primary level	☐	☐	☐
Secondary level	☐	☐	☐
University level	☐	☐	☐

H. OTHER FACILITIES AND SERVICES

Indicate the extent of availability of the following facilities:

(a) Hotels
(b) Libraries
(c) Hospitals
(d) Private medical services
(e) Printing facilities
(f) Maintenance and repair facilities for office equipment
(g) Existence of jobbing workshops capable of undertaking sub-contracts for machine parts
(h) Any other facilities which you consider would be useful to the centre.

Name of Country .....

Signature and title of Government Official .....

Date .....

Annex III

LIST OF PRINCIPAL OFFICERS OF GOVERNMENT DEPARTMENTS AND PRIVATE COMPANIES MET BY THE TEAM

Nigeria

1. Dr. R.A. Adeleye
   Federal Commissioner for Industries
   Federal Ministry of Industries
   Lagos.(Nigeria)

2. Mr A.O. Oluwunmi
   Director
   Industrial Institution Policy and Planning
   Federal Ministry of Industries
   Lagos.(Nigeria)

3. Mr. A.O. Fadaka
   Assistant Director
   Policy & Planning
   Federal Ministry of Industries
   Lagos.(Nigeria)

4. Mr. A. Ibrahim
   Federal Ministry of Works & Housing
   (Nigeria)

5. Dr. J.A. Nwogwugwu
   Federal Ministry of Economic Development
   (Nigeria)

6. Mr. O.A. Osula
   Nigerian Society of Engineers (Nigeria)

7. Prof. E. Enahoro
   Head
   Department of Mechanical Engineering
   University of Lagos
   Lagos (Nigeria)

8. Mr. J.A. Dina
   Secretary
   Federal Institute of Industrial Research
   Oshodi (Nigeria)

9. Mr. O.A. Olunloyo
   Head, Industrial Analysis
   Federal Institute of Industrial Research
   Oshodi, Nigeria

10. Mr. O. Akinola
    Head, Engineering Division
    Federal Institute of Industrial Research
    (Nigeria)

11. Mr. H.E. Ayanwu
Mechanical Engineering
Federal Institute of Industrial Research
Oshodi (Nigeria)

12. Mr. K. Ammicht
Division Manager, Finance and Administration
Volkswagen of Nigeria Limited
P.M.B. 12663
Lagos (Nigeria)

13. Mr. V. Schelle, Sales Manager
Volkswagen of Nigeria Limited
(Nigeria)

14. Mr. Hildabrandt, Production Manager
Volkswagen of Nigeria Limited
(Nigeria)

15. Mr. Tschorn, Quality Control Manager
Volkswagen of Nigeria Limited
(Nigeria)

16. Mr. Gbadamosi, Company Secretary
Volkswagen of Nigeria Limited
(Nigeria)

17. Mr. C. Igoh, Public Relations Manager
Volkswagen of Nigeria Limited
(Nigeria)

18. Mr. J. Ogunbumuyi, Personnel Manager
Universial Steels Ltd.
(Nigeria)

19. Mr. J.O. Ajayi, Sales Manager
Universal Steels Ltd.
(Nigeria)

20. Mr. F.A.B. Longe, General Manager
Metal Box Toyo Glass Nigeria Ltd.
Kilometre 32, Lagos Badagry Express Road
(Nigeria)

21. Mr. T. Ogunbekan, Maintenance Engineer
Metal Box Toyo Glass Nigeria Ltd.
(Nigeria)

22. Mr. F.I. Akinbobola, Electrical Engineer
Metal Box Toyo Glass Nigeria Ltd.
(Nigeria)

23. Mr. J. Fadina
Laboratory Supervisor
Metal Box Toyo Glass (Nigeria)

24. Mr. D. Pollen
Batch/Furnace Manager
Metal Box Toyo Glass (Nigeria)

25. Mr. H. Okolo
Ag. Technical Director
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21. Ghana Railways Workshops
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9. Mr. John K. Vilakazi
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