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# THE SHARING OF MANUFACTURING FACILITIES IN THE ELECTRICAL AND ELECTRONICS INDUSTRIES AMONG DEVELOPING COUNTRIES 1/

by

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1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO.

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## List of Abbreviations

| | | |
|---|---|---|
| **A** | = | Ampere |
| **kVA** | = | Kilovolt ampere |
| **HV** | = | High voltage |
| **LV** | = | Low voltage |
| **EHV** | = | Extra high voltage |
| **HF** | = | High frequency |
| **LF** | = | Low frequency |
| **UHF** | = | Ultra high frequency |
| **AC** | = | Alternating current |
| **DC** | = | Direct current |
| **PE** | = | Polyethylene |
| **PVC** | = | Polyvinyl chloride |

## Introduction

1. The national income of a country is influenced largely by the extent to which its people make use of electrical energy. Electric power presently satisfies approximately 25 per cent of the world's total energy demand, but an increase of 45 to 50 per cent is expected by the year 2 00. Developing countries consume approximately 5 per cent of the total electric power produced in the world today, even though their areas and populations may reach nearly one half of the world's total. This helps to explain their relatively low national incomes.

2. The increased use of electrical energy in human activities creates optimal conditions for mechanization and automation in many branches of production in the national economy. It also makes possible an accelerated development of radio and telecommunication devices designed for the control of equipment used in providing many types of services to the public, including improved health services and cultural facilities. In addition, the electronics industry is essential to national defence.

3. A fundamental industrialization factor in all countries is the development of the electrical and electronics industries. This includes the increased use of electrical power to replace manual labour, the spread of telecommunication networks and the development of broadcasting and television networks. Development in this field is of decisive importance in developing countries.

4. According to the amount of electricity produced, the developing countries may be divided roughly into four groups. The countries most advanced in this field are Argentina, Brazil, India and Mexico. The second group includes Iran, Iraq, Pakistan, Syria, Thailand and the United Arab Republic. The third group includes Chile, Colombia, Ghana, Indonesia, the Philippines and Turkey. Developing countries with little or no electrical production as yet include Algeria, Angola, El Salvador, the Lebanon, Malaya, Mali, Nigeria, the Sudan and Uruguay.

5. The developing countries provide only to a small degree for their requirements in the electrical and electronics industries. They must therefore secure a considerable part of their supplies by imports. To accelerate industrial development these countries need large production capacities for the manufacture

of necessary production equipment, since they cannot always count on the import availability of such items

6. In the early stages of its development the character of electrical and electronics production is similar to that of mechanical engineering. The developing countries begin by mass-producing articles for either individual or general use; as they gain experience, they begin to manufacture machines and pieces of equipment individually or in small series. References on the subject indicate that the majority of developing countries will retain their present structural composition of industrial branches even in the future, despite possible increases in the production of electrical and electronics equipment.

7. Priority is given to the development of mass production for several reasons. First, the articles thus produced are convenient for more extended markets. Secondly, since non-series production relies on a large number of technical staff, the fact that mass production allows the industry to function with the less highly trained personnel available in the developing countries is a great advantage. Finally, the introduction of its own mass production system helps a developing country to improve its situation with regard to payments in foreign currencies, and thus enables it to import the machinery and equipment whose domestic manufacture is not feasible at present.

8. Production in many branches of the electrical and electronics industries has already been or is being introduced in the developing countries. The following is a classification of these branches from the simplest to the more complex:

(a) Simple products and materials for electrical installations;

(b) Broadcasting receivers;

(c) Electrical equipment for the home;

(d) Cables and cords, especially those for installations, and simple low-voltage cables;

(e) Motors, mainly asynchronized types with relatively low output capacity;

(f) Batteries and accumulators;

(g) Television receivers;

(h) Small transformers for distribution networks;

(i) Electrical equipment, mainly of a simple direct-connected type for low voltage and high voltage, except measuring instruments;

(j) Small generators (currently produced in only a few countries);

(k) Telecommunication equipment for telephones (at present produced in only a few countries).

9. The market demand for electrical and electronic products is rapidly increasing. There are other circumstances favourable to the development of these industries as well - relatively low investment costs, minimal basic material requirements and employment opportunities for a large number of people with varied levels of qualification.

10. In considering the establishment of new electrical and electronics production in developing countries, some of its specific characteristics must be taken into account. Most significant are the following:

(a) Relatively high qualification standards for technical and managerial personnel;

(b) Specialized technological processes requiring specialized equipment and trained workers;

(c) Requirements for special materials, particularly those of the magnetic, insulating and conducting types. Even though only small quantities of such materials may be required, their quality must still be high;

(d) Sensitivity of these materials to climatic conditions. This will apply, for instance, in the tropics during manufacture, storage and transport.

11. The influence of the above factors depend on the number and kind of items to be produced. In order to achieve the desired economic effects, it is important to consider the degree of complexity of the articles to be produced and the existing conditions in the country concerned. After such an analysis, an outline should be made of the most convenient production specialization and concentration and of the kind and degree of co-operation to be sought with other countries.

12. The establishment of electrical equipment production in a country accelerates its rate of industrialization and has favourable effects on its economy. On the other hand, the country may also face difficulties in the development of this industry, such as shortage of foreign currencies for purchasing new, more specialized technological equipment, raw materials etc; splitting up of the production process into small plants and shops; unexploited production capacities; and inefficient production methods combined with relatively high production costs. Because of these problems, the home products may be both inferior to and more expensive than imported goods, despite high customs taxes designed to protect the country's developing industry.

13. The following measures can help eliminate the difficulties involved in establishing electrical production in a developing country:

(a) Capital contributions by the state and investment of foreign capital, including United Nations aid;

(b) Establishment of a material base, including steel plants, within the country;

(c) Technical education opportunities within the country;

(d) Use of licences and other technical aids;

(e) Reduction of industry taxes;

(f) Technical improvement of products, including performance characteristics as well as quality control;

(g) Increase in the efficiency of the production process;

(h) Development of inter-factory and inter-country co-operation.

14. This paper deals with the problems mentioned in this introduction. Its aim is to suggest rationalizations for current manufacturing methods and to point out possibilities for efficient co-operation among enterprises and among countries when new plants are established. This co-operation is considered the most effective means to ensure sound use of equipment and qualified personnel and, therefore, to attain the greatest possible increase in productivity.

# I ELECTRICAL AND ELECTRONIC PRODUCTS AND THEIR MANUFACTURE

15. This chapter deals with only a limited selection from the variety of electrical and electronic products available in the world today. Highly specialized products or those whose manufacturing processes are very complex are not considered here. The selection of products consists mainly of those that have already been manufactured in developing countries. It also includes products that could gradually be introduced for manufacture in these countries when local conditions (e.g. economic structure and public demand) permit.

16. Since this paper deals with the electrical and electronics industry as a whole, individual products are not discussed in detail. Instead, a classification list has been drawn up to provide an over-all view of the products in these fields. It outlines optimal and ordinary degrees of production concentration and the special methods and materials necessary for the manufacture of each group of products mentioned. This classification list can be found in the annex.

## The electrical and electronic product requirements of a developing national economy

17. Practically all branches of developing national economies urgently need electrical and electronic products for their development. A large quantity of technical products is required by many branches, and there is therefore a great need for a well developed base of technology and production within each country. This applies especially in the fields of transport, metallurgy, chemistry, mining and health services. Even in the future, these branches will have to depend on high-quality imports from industrially advanced countries to satisfy their requirements.

18. On the other hand, there are many other branches of the national economy that require large quantities of lower-quality electrical and electronic products. Such items can be manufactured effectively even in developing countries which can co-operate successfully with each other in this area.

19. A large group of electrical products is manufactured to further the development of power engineering. This group consists principally of alternators and smaller power-station transformers, distribution transformers, low-voltage and high-voltage power cables and equipment, switchboards and electrical installation

materials required to provide electrical energy for the general population. In areas where large power stations are under construction, there is an additional need for more complex equipment such as giant generators and transformers, equipment for mobile EHV systems and more effective measuring and protecting devices.

20. The mechanical engineering industry requires electrical engineering products partly to equip its factories and partly for the completion of machinery in production. The equipment in mechanical engineering plants consists mainly of electric machines for arc and resistance welding and small- and medium-size electric motors for many kinds of drives, for electrothermic equipment and for technological processes such as melting, forging, hardening and annealing. The items required for the completion of machinery in production are motors for drives, low-voltage controlling and protecting equipment, switchboards, conductors and cables.

21. Electrical and electronic products in general public demand include bulbs, lighting fittings, electrothermic devices, labour-saving devices (e.g. washing machines, vacuum cleaners, kitchen equipment and sewing machines), refrigerators, air-conditioners, record players, broadcasting and television receivers, battery and accumulator lights, signalling and local communication equipment and electric toys.

22. The development of local communication and signalling and security equipment (public communication networks not included) requires the manufacture of subscribers' telephones, telephone switchboards, private branch exchanges, UHF communication devices, communication cables, batteries, accumulators etc.

23. Some developing countries possess the raw materials necessary for electrical and electronics production - materials such as copper, lead, graphite and high-quality ceramic materials. These resources make future exports and co-operation with other developing countries possible because of saturation of the home markets.

24. In such cases it is necessary to cut down gradually the exports of these raw materials and to increase production and export of semi-products such as cables, conductors, carbon brushes and insulators. The exports should eventually include final products based on large quantities of the available raw materials. Induction motors, distribution transformers, accumulators or accumulator trucks

are some possibilities. Developing countries should concentrate on more efficient exploitation of home labour in the manufacture of these products.

Special technologies and technological equipment

25. In addition to the general techniques of mechanical engineering, there are other specialized technologies used in the manufacture of electrical and electronics engineering products. These technologies and the equipment they require often represent the limits of attainable performance characteristics and quality with respect to electrical and electronic products.

Windings

For electrical engineering products

26. This technology is involved in the preliminary steps of the production of insulating materials, conductors, prefabricated slot insulations and their insertion into the slots. According to the type of machine to be manufactured, there are completely different kinds of windings, which are in turn produced by the use of a variety of materials and technical equipment. The manufacturing process for windings also differs among synchronous machines, according to their individual type. The group of windings referred to above includes induction motors, DC machines, transformers and other electrical equipment. The voltage and size of the machine to be produced and the degree of its production concentration are other factors that may call for various changes in the manufacturing process of the windings to be used.

27. Basic equipment required for the manufacture of windings is as follows:

(a) Devices for mechanizing the preliminary processes, such as prefabrication, and insertion of slot insulations;

(b) Horizontal or vertical coiling machines for transformer windings, including the equipment necessary for pressing down the turns during the coiling;

(c) Tools for prefabricating the coils for rotating machines;

(d) Wrapping machines for coils to be insulated with tape or strip material;

(e) Insulation hardening presses;

(f) Semi-automatic winding machines for magnet coils;

(g) Semi-automatic and automatic winding machines for stators and rotors of rotating machinery.

28. Rationalization in the manufacture of windings is focused on the following points:

(a) Quality of materials, particularly insulants;

(b) Uniformity of products and insulation systems;

(c) Mechanization of inter-shop transport facilities during manufacture;

(d) Mechanization of winding lines;

(e) Programme control of coiling machines if production concentration permits;

(f) Coiling automation for electrical equipment and small transformers;

(g) Hygienic conditions in coiling shops.

Such controls would improve product quality and increase production efficiency by 40 to 70 per cent.

For electronics engineering products

29. Mains and output transformers, choke coils and other electronic components of this type are prefabricated with the use of technologies for windings similar to those used for electrical engineering purposes. Multiple, semi-automatic and programme-controlled coiling machines are used in these processes, and high-frequency coils for receivers are produced with similar methods and equipment. Rationalization in this group is focused on the use of multiple, semi-automatic and automatic coiling machines.

30. In the production of television receivers, special attention must be given to the manufacture of deflection coils and output transformers for horizontal scanning. The deflection coils are wound from adhesive, enamel-insulated wire on special winding machines. The coils are then heat-treated to obtain the desired shape and rigidity. Finally, they are assembled with the appropriate ferrite cores. In countries with severe climatic conditions, the assembled components should be impregnated with silicon varnish.

31. Horizontal-scanning output transformers for television receivers must be insulated against high operating voltages; multiple winding machines are therefore used in their manufacture. Quality control during and after the manufacturing process is important.

32. The following equipment is required for the production of these transformers:

(a) Multiple automats or semi-automats;

(b) Winding machines for deflection coils and transformers;

(c) Machinery and tools for pre-forming and heat-treating of deflection coils and transformers;

(d) Checking devices to ensure quality control of the product as a whole, the insulation between turns and the over-all insulation.

33. Rationalization in this process applies primarily to the use of multiple semi-automatic and automatic coiling machines, special automatic machines for deflection coils and equipment used in the shaping of windings.

Impregnation

For electrical engineering products

34. The technical level of this technology greatly influences the quality of electric machinery, its resistivity to severe climatic conditions and its durability and reliability in operation. The results obtained by the impregnation technology depend on the impregnation itself, the drying and the vacuum treatment. A practical quantity of articles to be processed, good-quality impregnating varnishes and adherence to technical requirements are essential to the quality of the finished product. Impregnation methods must be selected according to the type of winding involved, the type of impregnating materials to be used and the future operating requirements of the impregnated winding.

35. Small rotating machines and machines with fractional horsepower are usually mass-produced or manufactured in large series. Both types of production are organized in lines, and it is therefore necessary that the drying and impregnation processes be organized also in lines so that the process timing will not be affected.

36. Medium-sized machines are usually manufactured in series. A careful impregnation is important in this case because medium-sized machines are usually subjected to severe operating conditions - in drives in the chemical and metallurgical industries in the tropics etc. The higher requirements for these machines can be satisfied simply by vacuum-pressure impregnation in a solvent-free atmosphere. Modern methods of impregnation using solvent-free (i.e. epoxy-based) varnishes are convenient for temperature classes B and F. The class H impregnation can be achieved by the use of silicone elastomers.

37. Large high-voltage machines are manufactured individually. The previous impregnation process used for these machines was vacuum compounding, but modern methods use modified epoxy resins. The insulation itself is made of polyester

or epoxy-bonded mica foil or tape, although the foil is used only for the straight parts of coils. The insulating system is hardened in a heat treatment with the use of special tools.

38. According to their type, transformers are manufactured in series, small series or individually. Impregnation of this equipment is preceded by fan- or vacuum-drying and is completed by a mere dipping or vacuum treatment.

39. Basic technological equipment for the impregnation of products used in electrical engineering includes drying ovens with conveyors equipped with tunnel-type fans, line- or turret-type dipping devices, vacuum-drying chambers, impregnating tanks for vacuum treatment (and, eventually, for pressure treatment as well) and hardening presses. Rationalization in the impregnation process is concerned with mechanization and automation, impregnating varnishes with shorter curing times and automatic quality control.

## Magnetic circuits

### For electrical engineering products

40. The magnetic circuit is the basic part of transformers, rotating machines and some other types of equipment. Starting materials usually consist of magnetically oriented low-loss sheets delivered in sheets or in rolls. Core stampings for small rotating machines are made on sequence stamping presses, while single-operation concentric stamping tools are used in the series and small-series production of medium-sized machines. Core laminations of larger machines (up to one metre in diameter) are pre-stamped in circular form and then treated by a slotting machine or automatic press with sequence stepping.

41. Large machines have magnetic cores made of segmented laminations. After being freed from sharp edges, the bare stampings are insulated by lacquer-coating machines. The sheets for transformer cores are usually insulated with ceramic material. The stampings are annealed before being assembled into magnetic cores. For large machines, the assembly of the magnetic circuit takes place immediately inside the frame. Newer methods of tightening the magnetic cores use bandages, whereas older methods rely on bolts.

42. The basic technological equipment required for the production of magnetic circuits for electrical engineering products includes sequence presses, standard presses for pre-stamping, slotting automats, stepping devices, desharpening

grinders, tightening presses, lacquer-coating machines, decoiling and coiling equipment for magnetic steel delivered in rolls, circular scissors, annealing ovens, waste-treating equipment for steel sheets and stamping tools.

43. Rationalization in the manufacture of magnetic circuits is focused on the quality of magnetic materials and insulations, the introduction of sequence and concentric stamping techniques, stepping devices for stamping presses and mechanization of core assembly and inter-shop transport.

For electronics engineering products

44. The technology of magnetic circuits for mains and output transformers is similar to that of magnetic circuits for electrical equipment. Semi-automats and automats are used to assemble the cores inside the coils of mass- or large-series produced articles. The basic technological equipment used is similar to that required for the manufacture of magnetic circuits for electrical engineering products.

45. Rationalization possibilities in this field are concerned with mechanization of magnetic core assembly, stepping devices for stamping presses and assembling devices for transformers and choke coils.

46. The magnetic circuits of loudspeakers are delicate. Permanent magnets for these circuits are made either from oriented ferrite materials or from special magnetic alloys with a high nickel or cobalt content. The manufacture of these circuits is usually quite different from that of other electronic products.

47. Magnetic conducting components are produced by standard mechanical engineering methods - stamping, heat pressing, turning of cylindrical parts. Magnetic conductivity may be increased by annealing the circuits in conveyorized ovens; the annealed parts are then insulated with metal. For magnetic circuits that will be subjected to more severe operating conditions, special attention must be given to the metal insulation of the air gap and adjoining parts.

48. Basic technical equipment for the manufacture of magnetic circuits for electronics engineering products consists of presses for flat parts, heat-stamping presses and automatic machine tools for cylindrical parts, magnetizing and demagnetizing devices, and turret or conveyor metal insulating equipment.

49. Rationalization possibilities include semi-automatic and automatic lines for stamping and machining magnetic conducting components, mechanization and

automation of metal insulation and mechanization of final assembly of magnetic circuits.

## Electrical insulants

### Laminated insulating materials

50. This group consists of materials in sheet and roll form, including varnished cloth, slot insulations and bushings with directed electric fields. Technological processes comprise the preparation of bonding components (resins) and lacquering, pressing and curing.

51. Requirements for the manufacture of laminated insulating materials include air-conditioned storage rooms for starting materials and finished products, liquid chemical tanks, cutting machines, lacquering machines and presses for laminated insulants.

52. Rationalization possibilities in this area are focused on inter-shop transport mechanization, mechanization of counting and grouping of stampings; automation of lacquering (including checking by differential measurements), continuous control of material thickness by means of isotopes, checking the loss angle, continuous control and graphic plotting of moisture content in dried materials, programmed regulation of temperatures and pressures, and quality improvement of starting materials.

### Mica materials

53. This group includes micanites, commutator micanites, micafolium, mica tape and mica plates. The traditional mica splittings are gradually being replaced as starting materials by mica mat. Mica mat is made of mica pulp which contains only about 5 per cent bonding materials. The manufacturing process for mica mat is similar to that of paper and uses the same traditional techniques. Compared with mica splittings, mica mat has many advantages, such as its flexibility and homogeneity. In addition, the manufacturing process requires less space and makes more efficient use of available labour.

54. Major requirements for production include mills for grinding the mica pulp contained in the mica splitting waste, simple paper-milling machines for making mica mat, and stamping semi-automats and tools for making pressed articles from mica powder.

55. Rationalization possibilities include semi-automized and automized conveyor lines for grinding mica wastes and producing mica mat, and semi-automatic and automatic presses for making mica-based insulating materials.

Porcelain and other ceramics for insulation purposes

56. The starting materials for these products are porcelain, steatite, ceramic dielectric materials, pyrosate, electro-filence and oxide ceramics. The manufacturing process is characterized by high curing temperatures which strengthen the materials for both mechanical and electrical use. The three main steps in the manufacturing process are pressing, pulling and forming, and casting.

57. The basic equipment required includes machines to prepare and homogenize the ceramic paste, forming machines and presses and spray machines for glazing and curing ovens.

58. Rationalization of the manufacturing process is focused on the use of finely ground raw materials of uniform quality, and modern tunnel ovens with high caloric efficiency, and on the mechanization of inter-shop and inter-store transport.

59. The cast epoxy resins also belong to this group of insulating materials. They are used for instrument and scanning transformers, magnet coils and commutators. The mechanical and electrical strength of such products is enhanced by cast epoxy resin insulation. Furthermore, the demand on traditional materials is thereby reduced and the resistivity of the insulated product to severe climatic conditions is increased. However, the technical equipment required for epoxy casting in series or large series is rather expensive. Epoxy casting is therefore economical only in the case of standardized components whose manufacturing processes are confined to a co-operative plant serving the needs of a group of countries.

Cables

60. The technology of cables is composed of several operations, including insulating the conducting core, combining the insulated conductors by twisting them together and insulating the completed system with materials designed to protect it against mechanical and chemical damage. These procedures are called stranding, pressing out the form, and insulation, respectively. In the case of plastic-insulated cables the same operations are called stranding, extrusion

pressing of the plastic, and sheathing, respectively. The linear motion requires some additional equipment for pulling, coiling and decoiling of ready articles.

61. The basic manufacturing equipment required consists of paper-cutting machines, cabling machines, stranders, insulating machines, sheathing presses, extrusion presses (for plastics, lead and aluminium) and auxiliary equipment for pulling, coiling and decoiling.

62. Rationalization possibilities include a broader application of new materials, particularly plastics; equalization of the parameters of the technological equipment produced in one line; continuous control of the manufacturing processes, with an eventual automatic correction of individual sections of the production line; and handling and transport mechanization.

## Conductors

63. The group of conductor products includes wires for windings insulated with enamel, cotton, silk, paper or fibre glass; installation conductors; cords; protected conductors; and conductors for motor vehicles, ships etc. A variety of technologies are used in the manufacture of these products.

64. As in the case of cables, the technology of conductors involves many co-operating industrial branches, as for instance, metallurgy for wire calibrating, annealing and tin-plating. The technology of insulation for conductors involves spinning, wrapping and enamelling. Chemical processes also play a part in conductor production. The most important are those used in rubber setting and application, and in the use of synthetic elastomers, plastics, lacquers, papers, glass, resins, impregnants and other materials.

65. The insulating and protecting layers are applied step by step to the metallic core of the conductor. The most significant technology requirements are given by the infinite length of the articles with tiny cross sections, the continuous accuracy of which is imperative.

66. The main articles of technical equipment required for the manufacture of conductors are controlling devices and machinery for wire calibrating, annealing and tinning, rubber insulation, plastics insulation extrusion, stranding, enamelling, paper or rubber tape wrapping and rubber armature moulding.

67. Rationalization possibilities are the same as those for the cable manufacturing process.

## Semi-conductors

68. The basic starting material for the manufacture of semi-conductors is semi-crystalline silicon with some impurities of iridium, gallium etc. Because of its more suitable properties, silicon has replaced germanium in this process.

69. Homogenous silicon monocrystals of high purity and 25 to 50 mm in diameter are made from semi-crystalline silicon by zone purification in high-frequency automatic ovens. Special devices cut the monocrystals into slices whose thickness varies from 0.1 to 1 mm, according to future use. The plates are then ground to an accurate thickness on automatic grinders. The diffusion and epitaxial junctions are made in gas-filled, temperature-controlled ovens. Some components are encapsuled to make them moisture-proof after they have been provided with contact areas, soldered leads etc.

70. More complex components are made by planar-epitaxial methods. The system of junctions, leads etc. is deposited according to the photo-lithographic principle by metallic condensation. Programme-controlled optical systems of high accuracy are used for this purpose. The systems are placed in temperature-controlled electric ovens in protective atmospheres. Checking operations occupy a considerable part of production capacity.

71. Traditional mechanical methods are used as a rule in the manufacture of encapsulations, cooling radiators etc. The production process for solid-state components requires an extremely pure and dustless working atmosphere. The working areas are provided with a special air-conditioning and air-filtering system. Special measures must also be taken regarding the actual working régime.

72. The major equipment required for the manufacture of semi-conductors is as follows:

(a) Zone purification equipment;

(b) Plate-cutting devices;

(c) Plate grinding and polishing machines;

(d) Plate checking and measuring devices from the viewpoint of electrical and mechanical parameters;

(e) Ovens for diffusion processes;

(f) Chambers for epitaxial processes;

(g) Checking equipment for intermediate controls;

(h) Contacting and soldering devices;

(i) Quick-acting presses for encapsulations;

(j) Machines for attaching leads and for applying glass or ceramic bushings;

(k) Die-casting presses for cooling radiators;

(l) Devices checking component parameters;

(m) Photographic miniaturizing equipment for structural parts;

(n) Special programme-controlled stepping equipment containing chambers for the manufacture of microstructures by planar technology;

(o) Special air-filters and conditioners for all working areas.

73. Rationalization possibilities exist in the following areas:

(a) Mechanization and automation of zone refining, plate cutting and washing, and plate grinding and polishing;

(b) Automation and programme controls during the entire manufacturing process;

(c) Programming of chemical and thermal régimes for epitaxial processes in ovens and chambers;

(d) Mechanization of the photo-lithographic process;

(e) Automats and semi-automats for encapsulations and for the adjustment of finished products;

(f) Mechanized and automated controls for final products and semi-products, mechanized evaluation of quality control and calculation of average values, of probabilities etc.

## Vacuum components

### Tubes, bulbs, discharge lamps etc.

74. Glass is the traditional material used in the manufacture of these products, but modern ceramics are also beginning to play a part in the field. The metal parts of these articles are manufactured in traditional mechanical engineering processes which require presses and other automatic or semi-automatic equipment for coiling the grids etc. Absorbed gases are eliminated from the components by vacuum annealing. Systems are assembled by hand, semi-automatically or with the use of special tools.

75. Highly specialized processes are involved in the production of filaments, cathodes and screens for picture tubes. They include the depositing of emissive layers by spraying, the covering of filaments with ceramic layers by dipping on automatic lines, and the sedimentation of luminiphores on the screens of picture

tubes by means of special devices with a programmed motion of glass parts. The sealing of tubes, degassing and vacuum pumping on multiple automatic machines having a high rate of productivity are all accomplished simultaneously. A considerable part of the manufacturing process is concerned with starting, intermediate and final controls.

76. Technological equipment required for the manufacture of vacuum components includes machinery for making grids, filaments and cathodes, and pumping and sealing automats with oil and diffusion pumps.

77. Rationalization in this field is concentrated on automation of metal parts manufacture, mechanization of some assembling processes, and efficient pumping and sealing automats and checking devices.

## Assembly technologies in series and large-series production

### For electrical engineering products

78. Installation materials comprise the main group of electrotechnical articles produced in series and large series. These products include switches up to 25 A, plugs and sockets, installation tubes and junction boxes, contactors, automatic switches and push buttons. The manufacturing process is either fully automized (automats for final assemblies of switches for homes) or partially automized (welding of contacts, laminating, riveting). Labour mechanizing devices include noiseless riveters, thread-cutters and mechanized screwdrivers. Production equipment, assembling automats and mechanizing units vary according to groups of products and production concentration.

### For electronics engineering products

79. Electronics engineering products manufactured in large series are objects of general use such as broadcasting receivers, phonograph amplifiers and television receivers. The basic item of production equipment is an assembling conveyor with a forced motion. This motion is necessary for all other manufacturing processes involved, particularly for insertion of components and for the prefabrication of mechanical parts of traditional mechanical character and electrical parts such as coils and printed plates. Frames for HF coils and filters are automatically die-cast from plastics with a daily output of approximately $10^4$ pieces.

80. The plates of printed circuits are made of plated materials manufactured by the paper industry. The wiring is either printed or photo-lithographed and etched in tanks under the mechanical motion of the plates. After drying and lacquering, the plates are checked by means of control devices and the components

are then assembled either by hand or automatically. A soldering machine containing molten solder serves to connect the assembled components with the printed wiring. Soldered plates are then rechecked with a special device designed for this purpose.

81. The main assembling conveyor controls the assembly of mechanical parts and structural components and the insertion of printed sub-plates and their printed connexion with one another. A large working area should be reserved for function checks of each processing step and of the finished products. However, since space is usually rather limited, semi-automatic equipment to perform these operations is urgently needed. The type and quantity of equipment required depends on product complexity and production concentration.

82. Inter-shop transport, particularly of casings, picture tubes and packaging materials, requires a considerable percentage of the total labour involved in the production process. Transports within a factory are therefore carried out by means of conveyors connecting store-rooms with working areas.

## Special materials

83. The special materials required for the manufacture of electrical and electronics engineering products are essential in the development of these industries and in production rationalization. Their quality and variety determine the performance characteristics achieved, the kind and level of technology used, the degree of production mechanization or automation and the reliability of the products in operation.

84. Although only relatively small quantities of some materials are required, the quality required of them is still considerable. The group of semi-conductors provides one example: production is impossible without small quantities of a large variety of high-quality materials.

85. It is practically impossible for one country to obtain all the required production materials from its own resources. The problem of special materials can partly be solved through international co-operation and improved trade relations. An accurate assessment of a country's special material resources is therefore an important consideration when selecting specialization, co-operation and rationalization goals for electrical and electronics production.

86. It is impossible in this paper to enumerate all the special materials involved in this field. However, the following outline covers the most important groups:

Metallic materials

Standard copper and aluminium for conductors

High-purity metals and alloys for semi-conductors, including germanium, antimony, indium, tin, aluminium, gallium and Au-Ga alloys

Materials for commutators and springs, such as bronze

Materials for contacts, such as tungsten and Au-Ni alloys

Materials and alloys for vacuum purposes, including kovar, tantalum and molybdenum

Magnetic materials and alloys, such as transformer sheets, dynamo sheets and Al-Ni alloys

Chemicals

For semi-conductors, e.g. nitric acid, acetic acid, trichlorsilane, silicon grease, photo-sensitive lacquers

For ceramics and piezo-ceramics, e.g. ferrites, titanium oxide, aluminium oxide, zinc sulphate

Luminescent materials, materials for luminescent screens, fluorescent lamps, zinc oxide, scintillation materials etc.

Plastics and moulding materials

Dielectric (styroflex, polyethyleneterephthalate, polystyrene)

Structural (laminated paper, glass fabrics etc.)

Papers and laminates

Dielectric (e.g. condenser paper)

Structural (e.g. laminated paper and glass fabrics)

Glass materials and glass semi-products

Glass materials for bulbs, ultra-violet glass etc.

Beading glass

Quartz glass

Varnishes

Insulating (e.g. for conductors)

Impregnating (e.g. for windings and condensers)

Cement and adhesives

Sealing compounds for bulbs etc.

Silicon vacuum sealing compounds etc.

Sealing compounds

Cerasine, epoxies, polyesters etc.

Technical and rare gases

Nitrogen, hydrogen, helium, krypton, xenon etc.

Minerals and other materials

Talc, kaolin, quartz, magnesia, graphite etc.

87. It is sometimes possible to improve the qualities of technical materials during actual production processes. Refining of gases and calibration of sheets for condensers are examples of such improvements.

## II DEVELOPMENT POSSIBILITIES IN ELECTRICAL AND ELECTRONICS PRODUCTION

88. There are currently two forms of development in the electrical and electronics production of developing countries. One involves the introduction of new production processes for articles not previously manufactured, while the other concerns the rationalization of current production methods.

### Criteria for the establishment of new manufacturing processes

89. Economic considerations are of primary importance in introducing new products and processes into electrical and electronics production in developing countries. Attention must also be given to the technical and labour problems connected with specific types of products and their respective production volumes.

90. In deciding whether to establish the manufacture of a new group of products in a developing area, consideration must be given to the possibility of a long-term production guarantee for that group. Future specialization for a larger area may thus become possible. The requirements to be met before such a long-term guarantee can be assured are cheap and easily available special basic materials, ability to manufacture locally the most important components, an adequate and qualified technical staff and modern technical equipment.

91. These factors are all of approximately equal importance. An objective evaluation of the production feasibility of various articles may be made by using the following equation:

$$S_T = S_1 : S_2 .. S_3 . S_4 \quad \text{where}$$

$S_T$ represents the over-all long-term guarantee on an area;

$S_1$ is the ratio of the amount of available cheap materials to the amount of all required special materials (materials guarantee);

$S_2$ is the ratio of the number of economically attainable components to the total number of components needed (components base guarantee);

$S_3$ is the ratio of the number of qualified personnel in the area to the number employed by prominent producers, i.e. organizations that presently have a significant influence on international markets (labour co-efficient); and

$S_4$ is the ratio of the estimated value of technical equipment for the proposed production to the estimated value of a prominent producer's identical equipment (equipment factor).

92. The results obtained by estimating $S_1$, $S_2$, $S_3$ and $S_4$ for several areas and by then calculating the product $S_T$ indicate the most suitable location for the manufacturing facilities.

93. A similar process may be used in choosing suitable groups of products. Possible new groups may be classified technically by this method and the most suitable selected when the results have been obtained.

94. Even when $S_T \geq 0.05$, a sufficient long-term guarantee can still be secured for a given area. If $S_1 = 0$, indicating that there is no outlook for even minimal local production of special materials, no long-term guarantee of electrotechnical and electronics production is possible. In this case, the area concerned must rely on a steady flow of imports to satisfy its production requirements.

The technical base

95. The expression "technical base" designates the research, development, design and technological capacities required in connexion with the preliminaries involved in technologies and technical services for a new group of products. The factors that must be considered in creating the technical base that will assure a reliable start and proper control and correction of products and production technologies are complexity of articles, type of production series and technologies used, scope of co-operation with producers, and licences and technical assistance required.

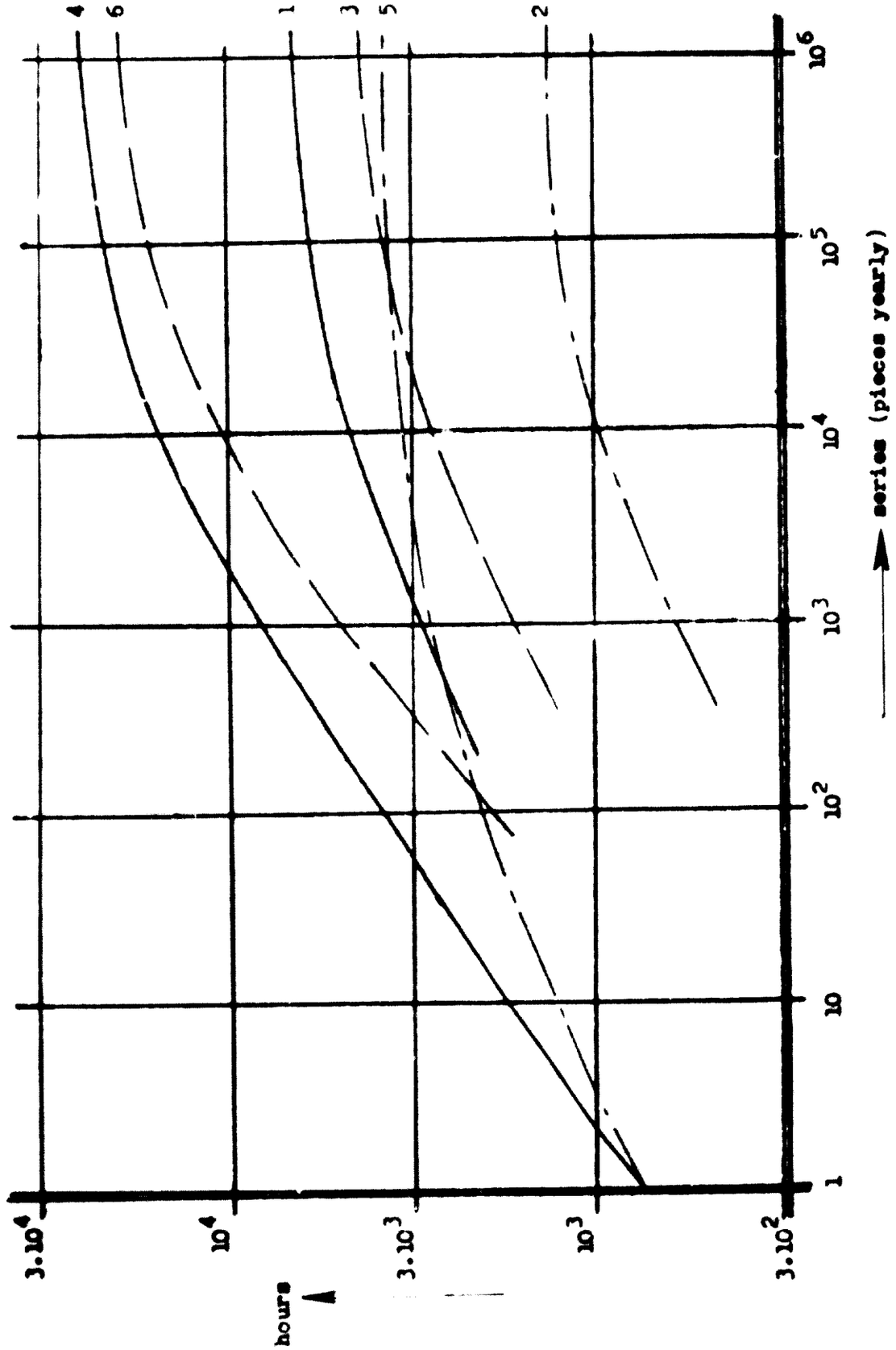
96. The complexity of products and the amount of production influence the scope requirement of the technical base, particularly in electronics engineering, but also in electrical engineering. A small series of articles requires a large staff for research and development, whereas a large series and mass production mainly require more intensive technological research and development.

97. Figure 1 below shows the necessary technical capacities plotted against estimated production series for a unit complexity of equipment. The example of a unit complexity of final electronics production is a part of an apparatus containing one vacuum tube or one transistor, including all adherent mechanical and electrical components. Other products may have their similarly chosen complexity units.

98. A later paragraph in this paper describes a case of electronics production referring to figure 1. The curve 1, representing required technical capacity

Figure 1

**Technical capacities required for the establishment of a new production**
of final electronic articles



as a whole, has been drawn for the case of a licensed production that includes special technological devices. Unavoidable modifications of licence design from the viewpoint of additional labour capacities (performance modifications, other wavelengths, other finishing etc.) are shown by the curve 3 of the figure. This curve represents the capacities required for technological modifications (different starting materials, protecting of products against harmful climatic conditions, air-conditioning of working areas etc.).

99. In the case of a new production that has been established without purchased licences, the curves 4, 5 and 6 are added, 4 representing over-all capacity of technical work, 5, development and design of the article and 6, required technological work and development of technological equipment.

100. An example would be a factory that in the past had had a licensed production of a group of products using vacuum tubes. This factory now aims to establish a more complex final production of a seven-transistor single-range broadcasting receiver. It is therefore assumed that the factory obtains licence papers and imports special technical equipment. A further assumption is that an output of $10^5$ pieces yearly is attained, which means that the curves 1, 2 and 3 will be used. For $10^5$ pieces the results indicated are 5,000 hours by the curve 1 (total hours of technician work), 1,500 hours by the curve 2 (partial development work) and 3,500 hours by the curve 3 (modification of technologies added to the licence). Since a seven-transistor set is involved these figures are then multiplied by 7; the resulting total needs are 35,000 hours on technical capacity, 10,000 hours on design modifications and 25,000 hours on technology modification.

101. The law represented in figure 1 is valid for all new production processes to be introduced. It is always necessary, however, to arrange a convenient complexity unit. The limits of necessary capacities may be found from statistical data concerning typical cases of establishing new production processes.

102. Special workers' training must also be considered. This will somewhat reduce the capacity of the technical staff. That means that only what remains of that capacity can be used for the establishment of new productions.

103. From the viewpoint of product effectiveness, it is important to allow the lapse of as little time as possible between the start of research and the establishment of the new manufacturing process. The fashion life of a design is

rather short; therefore, it is advisable to begin research with a large technical staff in order that production may be started as soon as possible. A maximum period of three years between the start of research and the establishment of production may be allowed for most complex articles; otherwise the design may be in danger of becoming outdated.

104. There are also certain limitations connected with licensed production, particularly with respect to remote territories where communications with the licenser are limited owing to poor facilities. Experience has shown that only a limited complexity of articles with a maximum of 100 active electronic circuits (integrated circuits included) is feasible in such cases. More complex articles require about the same capacity with respect to research, development, and technological staff as does the licenser. This would be a labour-wasting combination, and it is therefore better for a developing country to develop its own technical capacities gradually by starting with simpler products on the basis of partial licences and then establishing its own qualified technical base for additional, more complex articles which may be introduced later by home facilities.

105. For most complex products it may be advisable to do all the research and development in the area of the plant where laboratories and other research and development facilities are situated. Functional samples and prototypes are made with the facilities of future series production. When the fabrication by a trial series has been mastered, the normal series production starts simply by changing its directing staff. Until this time it is convenient to have the trial fabrication under the central direction of the technical research department.

Rationalization of current manufacturing processes

106. Technological improvements in materials and working methods are the main points of production rationalization and include better exploitation of production resources, lower production costs, enhanced production effectiveness and better product quality.

107. The higher the level of production, the greater the possibility of exploiting progressive technologies. Progressive technologies obviously involve stepping up the series and production concentration. Specialization of shops and plant equipment is necessary in meeting these requirements. The development of international co-operation is also useful.

108. There are two contradicting tendencies in the process of production rationalization. On the one hand, there is the trend to a steady technical advance by exploiting new scientific discoveries; on the other hand is the tendency to a stabilization of production based on economic grounds. The result of this contradiction is a gap between potential full production development and the actual state of production techniques.

## Main principles of rationalization procedure

### Specialization of production

109. This leads to a specialized and individual kind of production which has its own manufacturing equipment and trained personnel. Specialization is determined either according to article (e.g. final products, semi-products, components) or according to technical process (e.g. casting, welding, coiling). Production specialization and concentration, combined with a policy of co-operation, are basic conditions for the establishment of higher-level production. The result of these factors is a production agglomeration which makes possible a qualitative change of methods, the introduction of efficient machinery and the simplification of production organization.

### Technological feasibility

110. This principle concerns the design for the product to be manufactured. If the design is technologically feasible, the use of the most economical methods and modern production organization will produce a functional final article. The design must allow for the planned scope of production, local production conditions and material resources, and technical equipment. The latter must be considered in terms of equipment on hand and items still to be purchased.

### Design standardization

111. The principle of design standardization applies to everything connected with the manufacture of the product - the system of machinery and equipment, components, starting materials and product sub-assemblies. The development proceeds from an individual to a standard solution and to the use of identical standard components in the production preliminaries and in the manufacturing process itself. The methods used in the application of this principle are standardization, grouping of types and unification of components, semi-products and materials. Also important are the machine and equipment production designs and the application of uniform parts.

112. Design and technology normalization and grouping of types are essential, not only as conditions for the rationalization of the manufacturing process itself, but also for rationalization of technical preliminaries and management. The latter is especially important in developing countries where there is a shortage of qualified labour.

Use of advanced methods

113. The application of this principle reduces the requirement for manual labour because it is thereby replaced by more efficient methods of operation, such as welding (instead of machining), precision casting and die casting.

114. New production methods must allow time for designs to stabilize and should rely on the combination of technical processes and standards instead of on individually conceived operations. Technological programmes must therefore be outlined for general types of components and processes, rather than for individual parts and operations.

Replacement and modernization of production equipment

115. This includes the replacement of generalized production devices by specialized machinery and equipment. Manual labour requirements are thus reduced and greater product volume and quality are attained.

116. In order to modernize machinery effectively, each machine in the line must be analysed, with special attention being given to the least effective machine because it limits the total output. Production equipment must meet the requirements of the proposed manufacturing process.

117. An adequate tool outfit is especially important to successful production. As a matter of fact, the tool design is a part of the manufacturing process. It is therefore helpful when the tool design department applies the best technologies in the preparation of production tools. Central tooling shops are an advantage in making uniform parts of special tools, and especially in manufacturing complex tools. Such a central shop can also meet the requirements of other plants since it may have a qualified staff and a set of expensive special machine tools and checking equipment.

Organization of the production process and transport and handling

118. This principle is concerned with the location of working areas, which should be arranged according to the sequence of individual operations. The article

being manufactured should move steadily along the production line and should be finished in the shortest possible time.

119. Manufactured components must also be in continuous motion during the assembly process. Forced stepping conveyors for assembly shops are of special advantage in large-series and mass production.

120. The following steps should be taken to shorten total production time:

(a) The supply of components and starting materials should be secured by agreement with co-operating organizations.

(b) Optimal production volumes and régimes should be planned.

(c) Necessary papers and sets of tools and equipment should be complete. (This applies also to non-technological operations such as hoisting, transport, storage etc.)

(d) Workers should be conveniently located, with personnel qualifications corresponding to production requirements.

(e) Check-points for starting, intermediate and final controls should be established.

(f) A maintenance crew should be responsible for the smooth operation of all technical devices.

(g) The planning of production operations and the necessary documentary evidence should be established.

Elimination of limiting factors in newly established productions

121. Two serious limiting factors are a general labour shortage and a specific shortage of highly qualified personnel. These problems must be solved in the course of planning the establishment of a new production.

122. New, technically complex productions require a higher average qualification level of personnel, because the new technologies to be used are also more complex. If development is merely a question of rationalizing existing processes, the requirements are quite different. In this case, the production preliminaries require a large, qualified staff, but after having been rationalized, the production itself provides more employment opportunities for less qualified workers.

123. Another limiting factor may be a lack of power resources. The power requirements in the field of electrical engineering are about the same as those required in the traditional production processes of mechanical engineering. The power required in the electronics industry is somewhat lower, except where large electric machines, transformers, equipment, high-voltage cables and special testing processes consume large amounts of power.

Transport facilities

124. This factor must also be taken into account when a new production is to be established. In addition to the traditional problems, there are some that are characteristic of electrical and electronics production. For instance, large rotating machines and transformers, power cables, castings and magnetic steel sheets are very heavy, and the requirements for transports systems are therefore considerable. Using another example, the preliminaries required for some special materials, particularly insulating materials, include a special treatment to protect the materials against atmospheric effects. In addition, some articles (e.g. kinescopes, bulbs and porcelain components) must be handled with special care during transport.

Development planning

125. A plan for the development of the electrical and electronics industries in developing countries should include studies of the methods of advanced countries with respect to specialization and concentration. These studies would help developing countries to formulate a common plan to meet their respective requirements.

126. The demand for the manufacture of electrical and electronics products in a developing country is determined by the product requirements of other developing branches of the national economy and the amount of such products required for industrial co-operation and direct export.

127. The actual state of electrical and electronics production may be defined in terms of: (a) one country or group of countries, (b) a producing unit or (c) the type of articles produced by a unit.

128. In assessing the production level in one country or a group of countries (a), the main points to be considered are the geographical location of production units, the climatic conditions at those locations and the present state of transport facilities between the production units, the main suppliers and the consumers, with respect to distances involved, road conditions and suitability of transport vehicles.

129. Many factors require study in determining the level of production in one unit (b): annual volume expressed in units of value; degree of series and production volume of main assortments; over-all total and producing area; value, technical level and age of buildings and basic equipment; number of workers,

including percentage of women, and their classification according to qualifications; average shifts; state and level of services, particularly of tooling shops, technical controls, internal transports, maintenance and storage; and state and level of production operations direction, planning and supporting evidence.

130. The factors to be studied in analysing the main product groups (c) are the technical level of manufactured products and the origin of technical information; main materials required for production and their source (local or import); components and semi-products secured through co-operation (inter-country or international); tool outfit; weak points in production and how to eliminate them; production expenses (according to products), classified as material, wage and overhead; and profit.

Evaluation and exploitation of reserves

131. Reserves in a production process consist of the amount of available but unexploited personnel, equipment and material supplies. The evaluation and exploitation of such reserves can bring production in a developing country to full realization of its industrial potential.

132. Reserves must be evaluated according to product groups by comparing the quantity of articles produced in an advanced manufacturing process with the amount produced in the developing country in question. The development of reserve potential may be hindered because of unexploited personnel resources; poor choice of product types, designs or starting materials; low output of one machine or of a group of machines; untimely exploitation of basic resources; inferior production management; and insufficient co-operation with other countries. It is important to isolate the factors for each product group that limit the degree of development attainable during a certain period of time.

133. Improvements in the production process will accelerate industrial development. A developing country should concentrate particularly on increasing product output, lowering production expenses for current output, using expensive equipment more efficiently, increasing product quality and introducing new products into the production process, with emphasis on more effective exploitation of domestic resources.

134. It may often happen that several sources of reserves will be required for one or more products at the same time. Each rationalization project must therefore

be planned according to the reserves available. Many variables must be considered in preparing rationalization measures and in selecting the reserves required for their implementation. Several alternative drafts, as well as computers, are necessary for sound planning.

## III POSSIBILITIES FOR SPECIALIZATION AND CO-OPERATION IN VARIOUS PRODUCTION BRANCHES

135. The development of the electrical and electronics industries in most developing countries involves the establishment of technically and technologically simple production processes whose aim is to satisfy mass requirements. All plants concerned are rather small, with a low technical or organizational production level and with partially unexploited production equipment; expenses are therefore high. In many cases the work of factory personnel involves only the assembly of imported parts and components.

136. The main points of future development in the electrical and electronics industries of developing countries should be, on the one hand, the expansion and rationalization of present processes and, on the other, the establishment of new, technically and technologically superior productions. These goals can be reached only through the realization of a complex development project

137. One condition for the success of such a project is production specialization and concentration on a scale that allows optimal exploitation of technical capacities, raw materials and basic resources. There are at present many cases where the degree of production specialization and concentration exceeds the needs and the capacities of a single country.

### General purpose electronic products

138. These articles are mass produced. Complete production cycles for them should be established in all developing countries, as these products should not have to be imported from industrially advanced countries.

139. Techniques may gradually be mastered for the manufacture of loudspeaker casings for wire broadcasting, phonograph amplifiers, broadcasting receivers, music boxes, television receivers and tape recorders. The manufacturing processes for these products are closely related to the production of plastic casings and mechanical parts, particularly with respect to stamping and the application of protective surface coatings.

140. The factory must purchase many of the components required for final production. These consist of semi-conductors and vacuum tubes, picture

tubes, passive components, ferrites, loudspeakers, motors for phonographs and tape recorders, pick-ups and magnetic heads, deflection aggregates for picture tubes, phonograph records, magnetic tapes, and batteries and accumulators.

141. Some of these articles, however, may in future be manufactured within the developing country. Such items include standard passive components, loudspeakers (assembled from purchased components), motors for phonographs and tape recorders, phonograph records and batteries.

142. Some of these products are suitable for co-operative manufacture by a group of countries. These consist of semi-conductors and vacuum tubes, picture tubes, ferrite parts, magnetic circuits of loudspeakers, paper cones for loudspeakers, deflection aggregates for picture tubes, phonograph pick-ups, magnetic heads, and tapes, and accumulators.

143. The special materials used in the manufacture of some of these products (e.g. semi-conductors and vacuum tubes, picture tubes, magnetic circuits, magnetic tapes and accumulators) necessitate a centralized production location. The manufacture of picture tubes, for instance, is a very delicate operation, because of the bulk and sensitivity of the components to be transported during the production process. Climatic conditions must also be taken into account in choosing a centralized production site, especially with respect to semi-conductors and magnetic tapes.

144. Co-operation among developing countries in the manufacture of general purpose electronic products should increase with the growth of the market. Eventually, each country of the group will be able to develop its individual manufacturing potential.

145. All specialized productions of a group of countries require a perfect technical base. The technical staff involved will have the additional task of preparing technical papers to further optimal application of each article in all countries of the group. The papers might deal with such subjects as examples of optimal application of semi-conductors and vacuum tubes, projects of production types of loudspeakers with standard magnetic circuits, and optimal wiring of deflection aggregates.

146. Technical capacities could be enhanced by a research and development centre for each group of products. This centre would play an important role in projecting complete manufacturing systems for new general purpose electronic products in all developing countries. In addition, it would provide the personnel of newly established plants with technical papers dealing with their respective group of products. The development centres would also help co-ordinate production co-operation among the countries and would be responsible for patents and licences in co-operation with the central patent office of the group. A centre for sub-productions should also be established.

147. One of the most important tasks of development centres would be to supervise the activities of the subordinate development departments of individual factories. Co-operation among such departments is important because they are responsible for the various production modifications necessary to meet the individual needs of each country in the group.

148. Also essential to the development of general purpose electronics production are the appropriate licences and technical equipment.

Radio-technical equipment

149. The group of radio-technical products includes communication receivers and systems, television transmitters, broadcasting receivers, receivers for communication services, radar of all types, mobile and portable radio-communication equipment (including aircraft equipment), all equipment for radio navigation, amplifiers for public address systems and cinemas, all types of beam communication equipment and equipment for broadcasting and television studios.

150. Since many of these items are technically and technologically complex, importing them from industrially advanced countries cannot be avoided. The production of some articles, however, may gradually be established in developing countries. Among these products are amplifiers for public address systems and cinemas, single communication receivers, mobile and portable radio-communication equipment and simple equipment for beam communications.

151. A specialized production system for a group of countries may be established in several product categories: amplifiers for public address

systems and cinemas, communication receivers, UHF mobile and portable radio-communication equipment and beam communication equipment.

152. The more complex articles must be imported at present, although developing countries may eventually be able to produce such items as semi-conductors and vacuum tubes, reliable passive and structural components, microphones, power loudspeakers and loudspeaker systems, quartz crystals for controlled frequencies, professional phonographs and tape recorders, and batteries and accumulators.

153. Some types of semi-conductors and vacuum tubes, power loudspeakers, quartz crystals and batteries and accumulators may also be suitable for future production in developing countries.

154. The demand for amplifiers may increase to such an extent in the near future that their manufacture in two or more developing countries may be justified. In this event, technical papers dealing with production methods must be supplied by the originating plant.

155. Licences and technical equipment should be purchased for the manufacture of mobile and portable radio-communication equipment, beam communication equipment, quartz crystals, and batteries and accumulators.

156. For the production of semi-conductors and vacuum tubes, quartz crystals and accumulators and batteries, the plant site selected must be near the source of required materials. In planning the manufacturing facilities for these articles, it should also be remembered that semi-conductors and quartz crystals must be protected against harmful climatic conditions.

## Computers

157. This group of products includes electronic calculators; analogue computers; electronic central units and input and output sets for computers, memories and large capacity memories, data-handling equipment; tape perforating machines (card punching system); and electric typewriters.

158. The more complex products must be imported. However, products that could eventually be manufactured within a developing country include electronic calculators, analogue computers and electronic central units

for small computers. A production system established in one country could cover the needs of several others. Many of the components necessary for the manufacture of these products will have to be imported: semi-conductors, micro-electronic circuits, precision condensers, precision potentiometers, passive electronic components and ferrite components. Licences should be obtained for the production of these articles as well as for input and output sets, memories and large capacity memories.

159. A licence is recommended for a small computer from a computer series, while the more complex types could be temporarily imported. This procedure permits the exploitation of common programming equipment.

160. Again, the plant site selected, particularly for the manufacture of semi-conductors and ferrite components, must be conveniently located with respect to the source of required materials. Since favourable climatic conditions are important in the manufacture of semi-conductors and precision condensers, the plant site must be chosen with this in mind. The selection of locations for final production is also influenced by local possibilities for technical staff education and training.

161. Conditions must be arranged for future independent development activities in the sphere of computers. The very complex requirements of computer techniques and their application in the national economy will necessitate the establishment of a special authority of the government (and [illegible] group of countries) to survey research and development of computer techniques.

## Telecommunication equipment

162. This group of electronic products includes subscribers' telephones, telephone automats, dispatching equipment, private branch exchanges, local automatic telephone centrals, interurban automatic telephone centrals, carrier frequency equipment for up to 60 channels as well as for more than 60 channels, impulse transmission equipment, data transmission equipment and telecommunication and measuring devices. The manufacture of subscribers' telephones, private branch exchanges and carrier frequency equipment for less than 60 channels can gradually be introduced in developing countries. All other products must be imported for the time being.

163. For complete installations of telecommunication equipment local LF cables and concentric cables for longer distances are also required. These items will be discussed in another section of this paper.

164. The organization under government contract to establish a telecommunications network in a country usually refuses any participation of domestic industries. This situation could be eliminated if the government were to stipulate such participation as part of the agreement.

165. The establishment of specialized plants for a group of countries will often be practical. For example, the fabrication of subscribers' telephones and of private branch exchanges may be organized in two or more countries. Uniform technical information must be exploited in that case.

166. Materials and equipment required for the final production of telecommunication equipment are plastics, electroacoustic transducers, relays, crossbar selectors, ferrite materials, accumulators, rectifiers and passive components.

167. The above-mentioned components may be gradually secured in developing countries on the basis of licences. It is practical to organize a combination of final production and major component manufacture. A centralized production of co-ordinated components may be taken into consideration in the case of greater needs. This increased fabrication allows them to be largely automized (e.g. electroacoustic changers, relays etc )

168. Optimum separation of manufacture must allow for local material conditions, chiefly in the case of plastics, ferrites, accumulators, rectifiers.

169. Relays and crossbar switches are rather sensitive articles. Severe climatic conditions necessitate protective measures in the storage and transport of relays, crossbar selectors and private branch exchanges.

## Electronic equipment

170. This category includes general purpose electronic measuring sets, maintenance and repair equipment for electronic devices, laboratory measuring equipment for research and control and medical equipment.

171. At present, developing countries must import complex electronic equipment. Some electronic products, however, are suitable for manufacture in developing countries. Among them are simple electronic measuring sets (voltmeters, oscilloscopes) and maintenance and repair equipment for electronic products. The manufacture of these products should be organized in a co-operative production system to be shared among several developing countries.

172. Repair and maintenance equipment should be produced at a location convenient to the plant where the articles to be serviced are manufactured. For example, television receivers and the equipment designed for their repair and maintenance should be manufactured in the same general area. It is recommended that the latter be manufactured in the leading plant. This plant issues technical instructions for the production of the basic articles and is equipped with basic technical devices for the manufacture of repair and maintenance equipment.

173. In the interests of final product quality, the majority of the components required for the production of electronic equipment should be imported from developed countries. It might be possible to replace such imports with domestically manufactured articles when the developing country has gained sufficient statistical experience and has succeeded in producing components of good quality.

174. Climatic conditions must be considered in selecting plant location and packaging techniques. The latter are important in protecting the finished articles against moisture, moulds, severe weather and physical shocks.

175. It is recommended that more complex equipment be manufactured on the basis of purchased licences.

Semi-conductors and vacuum tubes

176. The articles in this group are transistors for receivers, switching transistors and diodes, power and transmitting transistors, microwave semi-conductors, rectifier and power diodes, power multi-layer and special semi-conductors, microelectric components, receiver and picture tubes,

power and transmitter tubes, microwave tubes and special vacuum tubes. This production assortment is needed for final production use and also to secure spare parts for imported and widely used equipment.

177. The fact that domestic products must be of a higher quality than imports should be considered in planning a new production process. A developing country should therefore plan a scope of production in accordance with its resources of materials, equipment and technical talent. On this basis, the components whose manufacture is recommended in a developing country in the first stage of development are transistors and vacuum tubes for receivers, solid-state diodes for rectifiers, power diodes and picture tubes. All other products must be imported, although future domestic production may be possible for such components as low frequency amplifiers and carrier frequency systems.

178. Plants should be established by a group of countries because of production concentration requirements and product complexity. Only when the output of principal types of products exceeds $5.10^{6}$ pieces per year might it be feasible to establish manufacturing facilities in other countries of the group. The country with the most suitable material base and climate should be selected for the location of the plants. The problem of the transport of bulky, shock-sensitive articles should also be considered in choosing plant sites. If picture tubes are to be manufactured, it is necessary to consider the establishment of a glass factory that would use domestic mineral resources.

179. In order to reach a better unification of all countries' requirements, it is necessary to issue catalogues of products and to indicate common choices and their modifications.

180. Caution must be used in considering production of advanced types of vacuum tubes. They may be quickly outmoded owing to the rapid advance of solid-state techniques and increased use of microelectronic circuits. The successful manufacture of new groups of products requires the purchase of licences for specific processes and special technological equipment.

## Passive components

181. This group of products includes fixed condensers and resistors for receivers, electrolytic condensers, potentiometers, power condensers (for power factor compensation, interference supression, amplifiers, transmitters etc.), soft and hard magnetic ferrites, switches, pushbuttons, variable condensers and special components. A variety of technologies and starting materials is required for the manufacture of these products.

182. Passive components are required in developing countries for use in domestic production programmes and as spare parts for imported equipment. The components that may be manufactured domestically at present are fixed condensers and resistors for receivers, electrolytic condensers (including those for starting windings of single-phase motors), soft magnetic ferrites, switches for electronic equipment, and variable condensers. The other products in this group must be imported.

183. Certain products should be manufactured in one plant serving the needs of a group of countries: fixed toll-type condensers, electrolytic condensers, resistors for receivers, magnetically soft ferrites, switches and variable condensers. Condensers and resistors for receivers may be in such great demand that it would be feasible to manufacture a uniform type in several countries. This would be advisable if the demand for one type exceeds $10^7$ pieces per year. In the interests of unifying requirements it is necessary for co-operating developing countries to make common selections of types. New production systems should be established with a view to the growing competition from microelectronics products.

184. The production facilities for toll-type and electolytic capacitors must be located in a suitable climate. The plant location must also be convenient to domestic material resources.

185. Licences should be purchased for resistors, ferrites, switches and variable condensers in order to promote good product quality and operational reliability.

## Loudspeakers and electroacoustical products

186. Included in this category are loudspeakers for receivers, power loudspeakers for public address systems, loudspeaker sets (high fidelity), head receivers, transmitter insets and receiver capsules for telecommunication equipment, general purpose microphones and microphones for studios.

187. Production in developing countries can gradually be established for loudspeakers for receivers, head receivers, general purpose microphones and transmitter and receiver insets for telecommunication equipment. All other products of this type must be imported at present. Establishment of new kinds of production must be suitable for the purpose of the final equipment.

188. The manufacture of these products can be concentrated in one plant for a group of countries, with the exception of loudspeakers for receivers which can be produced in individual countries. In the manufacture of loudspeakers, the common plant should use uniform and centrally produced magnets or ready-made magnetic circuits and paper cones. The plant producing magnetic circuits must be situated in a country whose material resources include the required nickel, cobalt, aluminium and ferrite materials. The manufacture of paper cones is complex and requires quality materials for paper sheets.

189. The materials used in the manufacture of loudspeakers and electroacoustic articles are not especially sensitive, except to climatic conditions. Protective packaging is therefore required only for articles that will be subjected to severe climates.

190. Licences and specialized technological equipment are necessary if high product quality is to be attained. Licences are especially important for oriented magnets made from alloys and ferrites and for paper cones.

191. Competent production of magnets and standard magnetic circuits in a country with an adequate material base may help to increase the export market of these products. Their improved quality would make it possible to export them even to industrially advanced countries.

## Batteries and accumulators (storage batteries)

192. This group of products includes cells and batteries for pocket lamps and receivers; special cells and batteries (for hearing aids etc.); accumulators for receivers, trucks and motor vehicles; and stationary accumulators.

193. The material situation in developing countries is of considerable importance for this type of equipment. It should be suitable for a profitable conversion of raw materials into final products for exports even outside the group of associated countries.

194. When materials such as zinc, pyrolusite, lead and nickel must be imported, the manufacture of cells and batteries for pocket lamps and receivers should be established gradually in one country in order to meet the needs of a group of countries. A common plant may also be established for the manufacture of storage batteries for motor vehicles and receivers. The purchase of licences and specialized technical equipment is recommended. Other products in this group must be imported, including components for communication equipment.

195. The location of a centralized storage battery plant should be convenient with respect to the transport of both raw materials and final products. All production of this equipment must be secured on the basis of international standardization of sizes and ratings. In addition, protection against harmful climatic conditions should be provided.

## Lighting sources

196. Lighting products include general purpose bulbs and gas-filled bulbs for the home, bulbs for motor vehicles, miniature bulbs for pocket lamps, iodine lamps for projectors, special bulbs, fluorescent lamps and discharge lamps for public lighting and cinemas.

197. Iodine lamps for projectors, special bulbs and discharge lamps for public lighting and cinemas must be imported. General purpose lamps for the home are suitable for domestic production by individual countries.

198. Gas-filled bulbs for the home, bulbs for motor vehicles and miniature bulbs for pocket lamps are suitable for inter-country co-operative manufacturing projects. The purchase of licences and specialized technological equipment is recommended.

199. When planning manufacturing facilities to meet the needs of a group of countries, a centralized automatic glass-bulb plant should be considered. Such a plant should be established near the source of minerals required for glass articles and other products such as tungsten filaments, gases, jacketed wires etc.

200. Light sources and glass bulbs are delicate and therefore require special handling and protective packaging during transport. Co-ordinated production of the rarer types should be supported by information exchanged among co-operating countries.

## Electric rotating machinery

201. Classified under this heading are turbo-alternators, hydro-alternators, motors of more than 1,000 kW, AC machines (100 to 1,000 kW), DC machines (up to 1,000 kW), induction motors (up to 100 kW), fractional horsepower motors and small generators.

202. Giant machines, particularly those for power engineering and large drives, are technologically complex and heavy; they must therefore be imported. Domestic production is not desirable because machines of this size are not in great demand.

203. It is recommended that one country produce AC machines of 100 to 1,000 kW and DC machines of up to 1,000 kW for a group of countries. The present state of the metallurgical industry is favourable to the manufacture of this type of product. The production of castings is usually more complex because it requires a large quantity of forgings and magnetic materials and conductors.

204. The same country would also be suitable as the site of a technical base for machines of up to 100 kW. This base should provide technical preliminaries for machines of 100 to 1,000 kW and design preliminaries for unified type series machines of up to 100 kW and fractional horsepower machines. The base should also give technical assistance to other countries.

205. The manufacturing processes of some other products (e.g. induction motors of up to 1,000 kW, fractional horsepower motors and small generators) are relatively simple and should be introduced gradually in all developing countries.

206. One country should produce certain semi-products ands components for use by a group of countries: dynamo steel in sheets and rolls, cast-iron and cast-steel components, cast non-ferrous metals, forgings, electrolytic copper and aluminium, bearings (beginning with imports), carbon brushes etc.

207. Production in a single country is recommended for the following specialized sub-assemblies and components: conductors for windings of electric machines, electric insulating materials, commutators, brush holders, some moulded parts of plastics and insulants and complex tools.

Transformers

208. These products include transformers for power systems, special transformers (e.g. for rectifiers) and distribution and small general purpose transformers. Giant transformers for power systems and special transformers are technically complex and heavy; they must therefore be imported.

209. At least one country in an associated group should establish a large assembly plant with the technical and testing equipment required for maintenance and repair of power transformers. The cost of such an assembly plant would undoubtedly be much less than the cost of transporting such items to the manufacturer for repair.

210. The manufacture of the other products in this group should be gradually introduced in each country. This particularly concerns distribution transformers of up to 1,600 kVA and small general purpose transformers of various types. These products are in great demand for use in supplying electricity to residential areas and for distribution networks, plant transformer stations and other branches of the national economy.

211. Magnetically oriented cold-milled transformer sheets and transformer oil should be produced by one country in a group. Semi-products and components to be manufactured on this basis include conductors for windings, electrical insulating materials, laminated paper cylinders, insulating boards, transformer bushings and gas relays.

212. Specialized production of magnetic sheet must be related to basic metallurgy. The question of transformer oil versus chemical industry (natural oil) must also have some basic study.

## Electrical equipment

213. This group of products includes HV, MV and LV electrical equipment; instrument transformers, lightning arresters and fuses and starters and regulators. All MV switchgear is complex and the market for it is limited; such products should therefore be imported.

214. A production system for HV switchgear may be organized in one country for use by a group of countries. Licences must be purchased for some of these items. Uniformity and type-series standardization are of great importance. Material requirements, particularly for insulants, are rather high.

215. A technical base should be established for HV and LV equipment. It would handle technical production preliminaries and provide assistance in the design of the organization and methods of local factories. Regarding LV equipment, special care must be taken in selecting products, production specialization and concentration and the level of production management.

216. The manufacture of all types of LV equipment should be introduced gradually in all developing countries. These products include contactors, switches, disconnecting switches, fuses, starters, regulators, resistors, plugs and sockets. Magnetic materials for instrument transformers and insulating oils, resistor materials and castings are semi-products and components which should be imported.

217. Each country should have its own specialized production for the manufacture of plastic insulation, cast resin insulation, conductors for wiring, springs and LV porcelain (eventually ceramic) insulators. Casting epoxies and springs deserve special attention because their manufacture requires relatively complex technological equipment. As such equipment is expensive, it is advisable that it be shared among countries.

## Distributing boards

218. This category of products includes HV distributing boards for power systems, HV and LV distribution boards for industry, explosion-proof distributing boards and control desks and equipment for watchmen's offices. Equipment for watchmen's offices and some control desks and explosion-proof distributing boards should be imported because of their complexity.

219. One country in a group should produce HV distributing boards for power systems and industry. In addition to other benefits, this procedure would secure the markets for appropriate HV switchgear products.

220. Each country should gradually develop production of LV distributing boards for industry, thus securing the markets for LV equipment. The demand for these products is considerable and the manufacturing process is relatively simple.

221 Specialization and co-operation are based on the fact that the production of distributing boards consists mainly in the assembly of their components. Actual production is confined to the manufacture of casings. The major items required for the assembly of distributing boards are electrical equipment, copper and aluminium bus bars, measuring, protecting and controlling equipment, and conductors for wirings.

## Electric rectifiers

222. Selenium and silicon rectifiers form this group of products. The development of this branch requires production of complex components, including semi-conducting silicon diodes and selenium plates. Manufacture of these products in individual developing countries is not feasible at present, although manufacture of the simpler rectifiers may be established by one country to supply a group of countries. Such products would include selenium and silicon diode rectifiers. More complex rectifiers, particularly those with thyristors, must be imported. In all cases, licences and technical assistance will be necessary.

## Electrothermic equipment

223. Classified under this heading are electric resistance ovens, equipment for mid-frequency and high-frequency heating and dielectric and microwave heating. With the exception of resistance ovens, these products are complex and must be imported.

224. Continuous and stationary electric resistance ovens may be manufactured in one country to provide for the needs of a group of countries. The mechanical engineering industry requires these products chiefly for annealing and hardening processes. Simple equipment production may be developed with the purchase of licences for such products as multipurpose ovens. Additional processes (e.g. hardening, annealing, cementing, nitridation etc.) may then be introduced.

225. Some specialization has to be made for the manufacture of sub-assemblies and components, chiefly of resistance materials for heating elements, refractory ceramic materials for brick-lining of ovens, of apparatus for measuring, protection and control.

## Electric welding machines

226. This group of products includes electric resistance welding machines and electric arc welding machines

227. Because these products are technically complex, they should be imported for the time being. Imports should include traditional resistance welding machines (for spot welding, seam welding, butt welding, welding presses etc.), single-purpose welding machines for mass production (particularly for processes involving thin sheets), rotating DC generators for hand arc welding and semi-automats and automats for welding in a $CO_2$ atmosphere.

## Electrical products for the home

228. These products include electrothermic devices, motor-driven electric appliances and lighting fittings. Such items are in great demand and should therefore be produced in all developing countries. However, a choice of types must be made for the highest possible production concentration.

229. The following groups of products require special manufacture in each country:

(a) Electrothermic devices, including electric irons, resistance heating armatures, heating plates, electric cooking ranges, electric grills, ultraviolet and infra-red radiation devices;

(b) Motor-driven electric equipment such as fans, air-conditioners, vacuum cleaners, hair-dryers, massage equipment, electric mills, mixers and robots;

(c) Electric devices for shaving, hair cutting, and similar purposes;

(d) Electric refrigerators and washing machines;

(e) Electric toys;

(f) Electric tools;

(g) Electrical lighting fittings, including explosion-proof armatures, armatures for humid and wet atmospheres, reflectors and general purpose armatures for home and office.

Licences should be purchased for groups (c) and (f), and these products may be manufactured in one country to meet the needs of a group of countries.

230. The production of equipment for the home requires specialization and co-operation in the production of semi-products and components. It is recommended that one country in a group manufacture compressors for refrigerators, resistance materials, special bulbs and discharge lamps and, eventually, glass and ceramic semi-products. Specialized factories in each country should produce small motors, switches, safety cut-outs, plugs, sockets, cables, cords, lamp-holders and similar items.

Cables and conductors

231. This group of products consists of power and communication cables, insulated power and communication conductors, and conductors for windings.

232. Articles recommended for import are power cables of up to 22 kV, specialized power cables (e.g. self-supporting cables, single core cables, trailing cables), telecommunication cables (e.g. small tube coaxial cables) and special cables (e.g. signalling cables).

233. Specialization of cable and conductor production in developing countries should be planned in accordance with available facilities and product demand. This applies especially to the manufacture of basic HV and LV distribution systems, telecommunication networks, and cables and wires for housing and industry. It would be feasible to fabricate conductors for windings of several standard temperature classes because production of various electric machines and apparatus is assumed. One country of a group should produce HV power cables of from 1 to 22 kV and LV power cables of up to 750 V.

234. Individual countries should gradually establish the production of insulated power and communication conductors, local communication cables, cables for housing, and round or profile, enamel- or fibre-insulated conductors for windings.

235. One country should supply the others in the group with various specialized semi-products and components: bare copper and aluminium conductors, lead, PVC, PE, many types of rubber, electrotechnical paper, bonding and impregnating lacquers, oils, glass fibres and fabrics, synthetic fibres and foil, cotton, silk and similar products. Specialized production should also be established for accessories for cables, such as heads, joints and shoes.

## Electrical insulating materials

236. Under this heading are classified laminated insulants in sheets, laminated wound insulants, lacquered insulants, slot insulations and mica materials. The production of electrical insulating materials is dependent on the development of the chemical industry, especially with respect to the available supply of high-quality chemicals and chemical materials. Products of this type, essential in the manufacture of electrical insulating materials, include a variety of impregnating varnishes, papers for laminates, rubber materials, resins, plastic foil, moulding materials, glass fabrics and mica materials.

237. If conditions are favourable, it is recommended that one country of a group produce at least those materials needed for the insulation of machines and equipment whose manufacture is proposed for gradual introduction in the area in question. Essential materials include basic types of slot insulations, bars, tubes, insulating cylinders and basic types of mica materials.

238. The amount of material to be imported depends on the availability of chemicals. Special development is necessary in at least two branches; an example would be mica insulants, including laminates, varnished materials etc.

## Porcelain and ceramic for electrical insulation

239. These products include line insulators for HV and EHV equipment, HV and EHV insulators for apparatus, LV and communication insulators, fuse bases and other materials for installations, and other ceramic products.

240. The feasibility of production is determined chiefly by available material resources. The import of line insulators and apparatus insulators for HV and EHV equipment, and ceramic and steatite products is recommended as these articles are rather complex.

241. One country of a group should produce fuse holders and installation materials made of porcelain or ceramics, and LV and communication insulators. In addition, the production of less complicated types of HV insulators could gradually be introduced.

## Installation materials

242. Production of these materials already exists in many developing countries. It is certain that production will soon be introduced in other countries as well, since these materials are in great demand and their manufacture is relatively simple. Mass production requires well planned special manufacturing facilities and a concentration in several groups of products: switches, plug-sockets, socket-plugs, safety cut-outs and push-buttons; connecting materials, including terminal boards; tubing materials, including wiring tubes; junction boxes and inlets; and fuses.

243. The effectiveness of co-operation in this branch is influenced by the level of standardization and safety regulations in the countries of a co-operative group. Unification in these respects is important for successful exporting of installation materials.

## Electrical measuring and protecting devices

244. These products are complex and their manufacture is complex. They should therefore be imported, even in future.

## IV RECOMMENDATIONS

245. Central industrial authorities must be established in developing countries in order to promote effective development of the technically complex manufacturing processes for electrical and electronics products. These processes are characterized by a high degree of specialization and technical standardization. International co-operation is therefore necessary if this type of production is to be successful.

246. The following centralized authorities are recommended:

(a) Commissions of technical specialists from the country concerned and others recommended by UNIDO. These commissions would formulate a general plan for the development of the electrical and electronics industries in the country concerned, using information reports now held by UNIDO. The general plan would be based on studies of existing conditions and would contain an outline of industrial branches to be developed in the country. The plan would also include information on the state of licences and technical know-how, the extent of international co-operation within a group of countries, the degree of specialization in the country under study and investment aims for production development. In addition to the plan, a draft is necessary for a scientific and research base and for the establishment of an authority to systematize standardization and patent policies as well as other related policies.

(b) A leading and projecting office concerned with implementation of the approved general plan. This office would promote the gradual establishment of a science-development base for the electrical and electronics industries. It would also prepare a list of projects approved for investment, including organizational and technological projects

(c) A testing system for the control of quality, standards and safety regulations

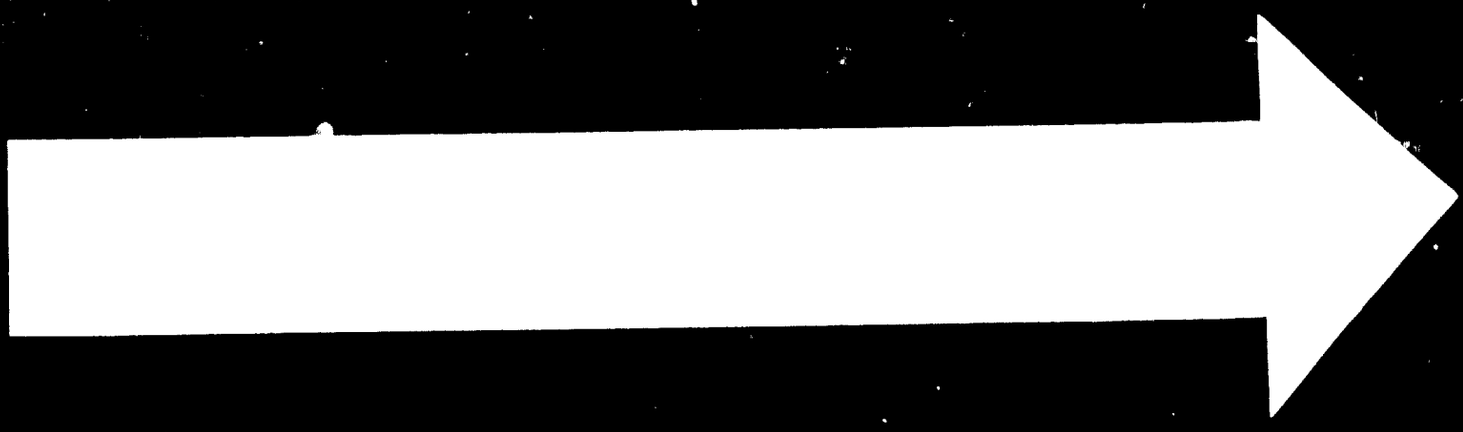
(d) A system of technical schools, including electrotechnical and electronics schools. This is important for the development of an educational system and for the training of technical personnel in developing countries. Specialized education in factory schools is also extremely important and effective. Such a programme should include the education of apprentices.

## Annex

## Product classification list

### A Electronic products

| Product | Production concentration |
|---|---|
| **Structural components** | |
| Terminal plates, connectors, fuses | Mass |
| Switches, transformers, chokes, relays | Large series |
| **Passive components** | |
| Condensers, resistors | Mass |
| Power condensers | Series |
| Potentiometers | Large series |
| **Incadescent lamps** | |
| General purpose bulbs | Mass |
| Miniature lamps | Large series |
| Discharge lamps, fluorescent lamps | Large series or mass |
| **Batteries** | |
| General purpose batteries | Mass |
| Batteries for solid-state receivers | Large series |
| **Loudspeakers** | |
| For portable receivers | Large series |
| For public address systems, cinemas | Series |
| **Semi-conducting elements** | |
| For solid-state receivers | Mass |
| For industrial rectifiers | Series or large series |
| For amplifiers, transmitters | Series |
| **Vacuum tubes** | |
| For receivers | Mass |
| For amplifiers, transmitters | Series |
| **Telecommunications and broadcasting equipment** | |
| Record players | Large series |
| LF amplifiers for gramophones | Large series |
| Simple tube receivers | Mass |
| Portable receivers | Large series |
| LF amplifiers for public address systems | Series |
| General purpose tape recorders | Large series |
| Antenna boosters and wirings | Series |
| Television receivers | Large series |
| Service apparatus for receiver techniques | Series |
| Portable and mobile UHF equipments | Series |
| Manual switchboards | Small series |
| Subscribers' telephones | Large series |
| Loudspeaking tel phones, dispatchings | Series |
| Private relay branch exchanges | Series |



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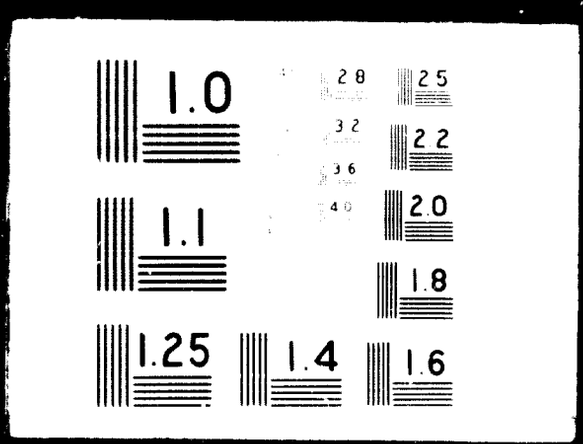

## B. Classification of electrical engineering products

| Product | Production concentration |
|---|---|
| **Rotating electric machines** | |
| Large machines including alternators (above 1,000 kW) | Individual |
| Machines of medium size (100-1,000 kW) including traction machines | Series |
| Small machines up to 100 kW | Series, large Series |
| Fractional horsepower machines, tachogenerators, speed indicators, selsyns | large series, mass |
| **Transformers** | |
| Power station transformers | Individual |
| Network transformers | Series |
| Special transformers for rectifiers etc. | Series |
| Small general purpose transformers | Large series |
| **Electric apparatus** | |
| Extra high-voltage apparatus | Small series |
| High voltage apparatus | Series |
| Low voltage apparatus | Series, large series |
| Instrument transformers | Series |
| Lightning arresters, fuses | Series, mass |
| Starters, regulators | Small series |
| **Electric switchboards** | |
| High-voltage and low-voltage power station switchboards | Individual, series |
| High-voltage and low-voltage industrial switchboards | Individual, series |
| Explosion-proof switchboards | Individual |
| **Rectifiers** | |
| Selenium rectifiers | Series |
| Silicon rectifiers, thyristors included | Series |
| **Electrothermical equipment** | |
| Resistance furnaces | Individual, small series |
| Mid-frequency and high-frequency thermics | Individual, small series |
| Dielectric and microwave thermics | Individual, small series |
| **Electric welding machines** | |
| Resistance welding machines | Small series |
| Arc welding machines, hand-operated and semi-automatic | Series |
| **Electric appliances for the home** | |
| Electrothermics | Large series |
| Appliances containing electric motors | Large series |
| Lighting fittings | Series, large series |

| | |
|---|---|
| **Cables and conductors** | |
| Plastic-sheathed power cables up to 100 kW | Series |
| Coaxial telecommunication cables | Series |
| Local telecommunication cables | Series |
| Insulated conductors | Series |
| Communication conductors | Series |
| Conductors for ceilings | Series |
| **Electrical insulating materials** | |
| Laminated insulating materials in sheets | Series |
| Wound lamination insulants | Series |
| Varnished insulating materials | Series |
| Slot insulation | Series |
| Micafolium and mica tape | Series |
| **Ceramic insulating materials** | |
| Suspension high-voltage and extra high-voltage insulators | Large series, mass |
| Pressed ceramics | Mass |
| Low-voltage and communication insulators | Mass |
| **Electrical installation materials** | Large series, mass |
| **Electric measuring and protecting instruments** | Series, mass |

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