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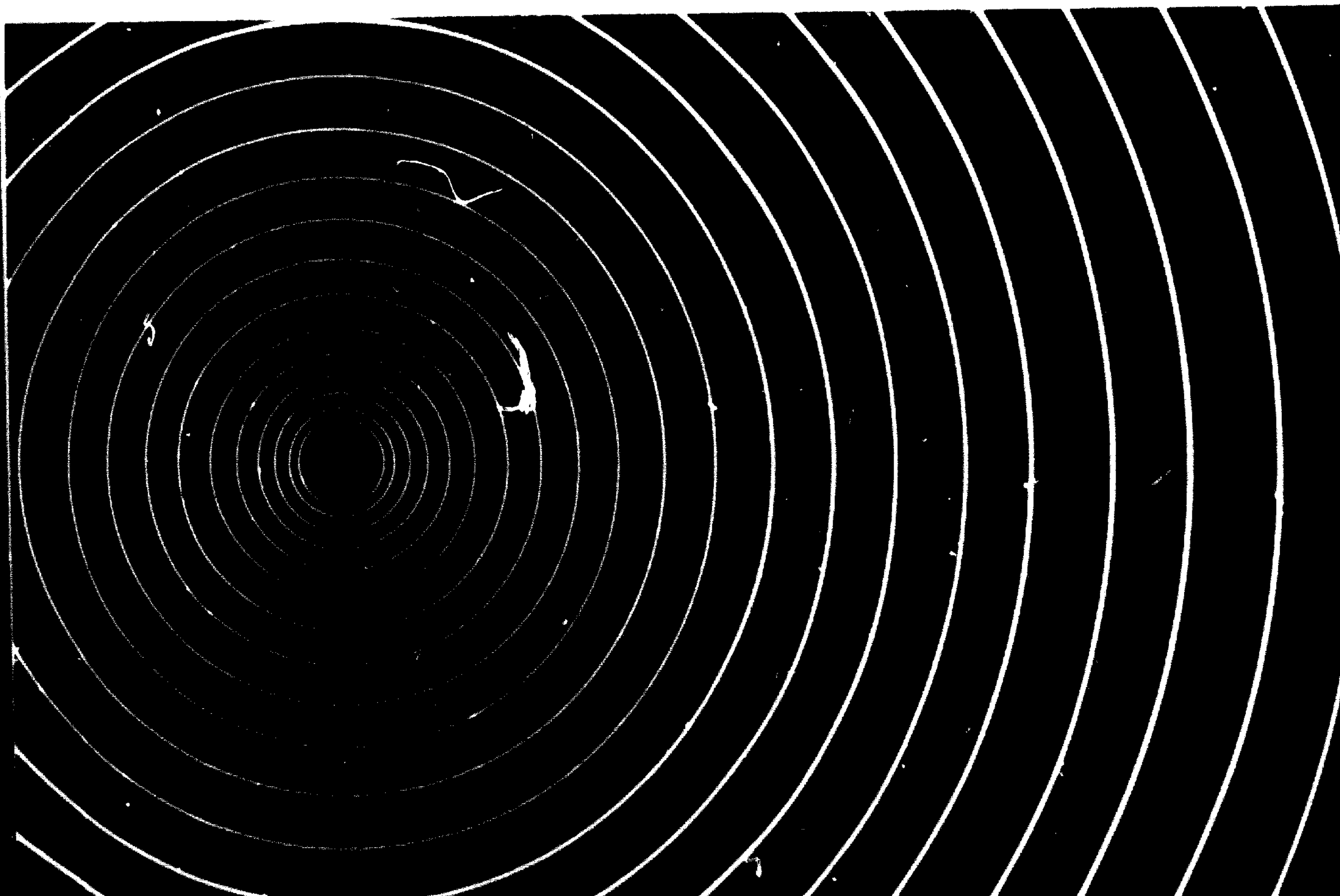
MANUFACTURE OF TELECOMMUNICATIONS EQUIPMENT AND LOW-COST RECEIVERS



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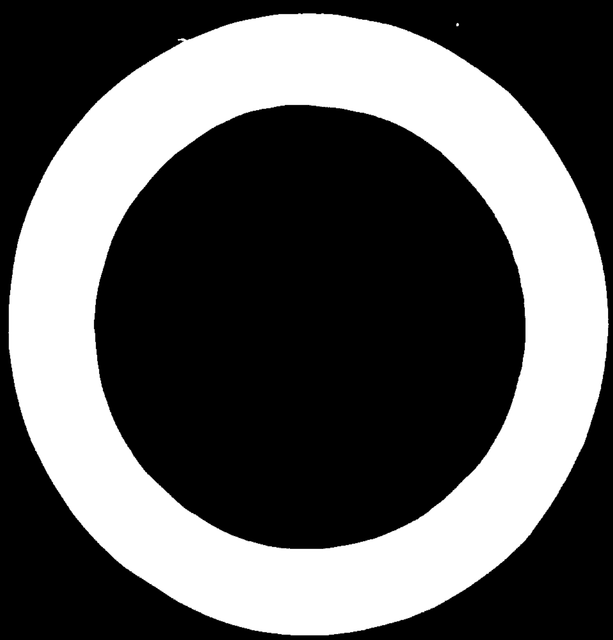

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

MANUFACTURE OF TELECOMMUNICATIONS EQUIPMENT AND LOW-COST RECEIVERS

Report of the Development Meeting on the Manufacture of Telecommunications Equipment, including Low-cost Receivers for Sound Broadcasting and Television

held in Vienna, 13–24 October 1969

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ANNEXES

EXPLANATORY NOTES

Reference to dollars ($) is to United States dollars.
Billion refers to thousand million.
The following abbreviations are used in this publication:

Organizations

CCIR = International Radio Consultative Committee (of ITU)
CCITT = International Telegraph and Telephone Consultative Committee (of ITU)
EBU = European Broadcasting Union
ECAFE = Economic Commission for Asia and the Far East
ICAO = International Civil Aviation Organization
IEC = International Electrotechnical Commission
ILO = International Labour Organisation
ITU = International Telecommunication Union
LAFTA = Latin American Free Trade Association
UNDP = United Nations Development Programme
UNDP/SF = UNDP Special Fund
UNESCO = United Nations Educational, Cultural and Scientific Organization
UNIDO = United Nations Industrial Development Organization
US/AID = United States Agency for International Development
WMO = World Meteorological Organization

Electrotechnical terms

a.c. = alternating current
AF = audio frequency
AM = amplitude modulation
dB = decibel
d.c. = direct current
FM = frequency modulation
HF = high frequency
Hz = hertz
hi-fi = high fidelity
IC = integrated circuit
IF = intermediate frequency
kHz = kilohertz
kΩ = kilohm
LF = low frequency
MF = medium frequency
MHz = megahertz
MΩ = megohm
mV = millivolt
mW = milliwatt
PABX = private automatic branch exchange
pF = picofarad
RF = radio frequency

TMA = tuner mounting assembly
TRX = message switching
TV = television
UHF = ultra-high frequency
VHF = very high frequency
μV = microvolt
Ω = ohm

Miscellaneous

CKD = completely knocked-down
GDP = gross domestic product
GNP = gross national product
PTT = post, telephone and telegraph administration
R & D = research and development
SKD = semi-knocked-down

Introduction

1. The Development Meeting on the Manufacture of Telecommunications Equipment (including low-cost receivers for sound broadcasting and television) was held in Vienna from 13 to 24 October 1969. The meeting was sponsored by the Engineering Industries Section (Industrial Technology Division) of the United Nations Industrial Development Organization (UNIDO).

2. The aim of the meeting was to provide a thorough review and analysis of the problems involved in setting up production facilities for the manufacture of telecommunications equipment in the developing countries. A broad range of equipment was covered, but special emphasis was placed on the manufacture of low-cost receivers for sound broadcasting and television (TV) because of the impact that this equipment can have both on mass education and in generating the kind of social dynamism essential to development.

3. Papers commissioned for the meeting, by recognized experts, were presented during the various sessions and formed the nodal points around which discussion centred. Aspects of the subjects on which further specialized information was required were treated by experts from the UNIDO secretariat, the specialized agencies of the United Nations and the International Electrotechnical Commission (IEC). In addition, some of the countries represented at the meeting submitted surveys of the status of their individual domestic telecommunications services and of the level of operation of their telecommunications equipment industries. These papers made useful contributions to a realistic appraisal of the magnitude of the problems involved. Annex 3 is a list of the documents presented to the meeting.

4. The inclination of the meeting was essentially towards providing a framework for future constructive action on the part of the developing countries, of UNIDO, and of specialized agencies having a direct or peripheral interest in the subject. A substantial proportion of the time available was devoted to determining the points of maximum effectiveness for assistance both from the specialized agencies and from the industrially advanced countries.

5. There were participants from 17 developing countries in Africa and Asia and the Far East; experts and observers from the telecommunications industries of 12 developed countries were present, as were representatives of the European Broadcasting Union (EBU), the International Telecommunication Union (ITU), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Labour Organisation (ILO), the World Meteorological Organization (WMO) and the International Electrotechnical Commission (IEC). Those who attended the meeting are listed in annex 1.

6. To supplement the work of those participants interested primarily in the production of low-cost receivers for sound broadcasting and television and to familiarize them with current management and production techniques, visits were made to the firm of Kapsch und Söhne and to a Philips factory, both in the suburbs of Vienna.

7. Mr. E. G. Rothblum, Deputy Director of the Industrial Technology Division of UNIDO, welcomed the participants and introduced the Executive Director of UNIDO, Mr. I. H. Abdel-Rahman, who made an opening statement, outlining the purpose of the meeting and expressing his hope that the discussions of the meeting would provide a context in which UNIDO could usefully contribute. He stressed the wide scope and the rapidity of technological innovations, which characterize the telecommunications industries in the industrially advanced countries of the world, stressing the necessity for developing countries to define the posture they should adopt to this technological expansion and, in particular, the ways in which they could participate in it. The full text appears in annex 2 to the present report.

8. The following officers were elected:

Chairman	Lt. Col. M. R. Khan	(Pakistan)
Vice-Chairmen	G. Tedros	(Ethiopia)
	J. R. Larrea	(Argentina
Rapporteur	R. Scott-Jackson	(United Kingdom)

The discussion leaders, within the areas of their special competence, were F. K. Berlew (United Kingdom), R. P. Besson (France), G. H. Ebel (United States), H. Ebenberger (Austria), R. Froom (ITU), J. H. Gayer (United States), R. Line (UNIDO), F. F. Papa Blanco (ILO), H. Schanzmann (Federal Republic of Germany) and C. J. van den Brink (Netherlands).

9. The substantive items on the agenda were the following:

Administrative and financial matters;
Technical matters;
Manufacture;
Distribution and servicing;
Training.

10. Consideration of the agenda items was followed by sessions devoted to a review of the scope of the meeting, the drafting of suggestions and recommendations and discussion of the Draft Report. Agreement was reached regarding its general form and content.

11. The suggestions and recommendations of the meeting, covering a wide range of subjects, fall into six principal groups, as presented in this report. Part I is devoted to the general discussion, and Part II contains the recommendations.

Part I GENERAL DEBATE

A. ADMINISTRATIVE AND FINANCIAL MATTERS

12. The first substantive item on the agenda was a consideration of administrative and financial matters. These include: the factors that influence financial participation in the creation of domestic production facilities in the developing countries; the choice of the types of equipment that would offer the best possibilities for local manufacture; the determination of the capacity and location of plants; labour requirements; the problems involved in joint ventures; and the control of various kinds of costs.

13. An efficient telecommunications system is a vital element of the infrastructure of an economy, whether it is industrially advanced or otherwise. It is an indispensable condition of any sort of organized economic activity. It is also capable, through the national and local broadcasting networks, of exerting a profound influence on the cultural and social life of a country.

14. In the recent past, production of telecommunications equipment and systems was necessarily dominated by the most highly industrialized countries. However, the prevailing climate of world opinion and the legitimate aspirations of the developing countries make it imperative that the means of creating, enlarging and maintaining this vital element of the infrastructure be more widely shared. The present concentrations of technology and manufacturing capacity are no longer acceptable to most of the developing countries. Few of these countries have reserves of foreign currency sufficient to pay for the importation of the quantities of equipment needed to modernize and enlarge their present systems. Furthermore, as a result of the very considerable investment in human resources made over the past two decades through the expansion of education and training, many developing countries have a substantial number of well-educated and well-trained people available who need scope to exercise their skills. This scope can probably be supplied only by industry: administration has already absorbed more than it can usefully employ.

Telecommunications industries in the developing countries

15. In most developing countries the telecommunications industry, where it exists at all, is frequently incapable of responding to the present requirements for equipment For example, when Pakistan came into existence in 1947, there was no

domestic telecommunications industry at all, and, by 1955, the total investment was only about Rs4 million.[1] However, by 1967, the total production capacity of the industry in respect of consumer goods was estimated at approximately Rs110 million per annum.

16. Ceylon, after an initial proliferation of uneconomic firms, has at present about five enterprises engaged in the assembly of radio receivers, mostly with imported items, but with some local component manufacture and wire drawing. The official estimate of the value of production is approximately Rs500,000[2] per annum, but this is probably below the true figure. At all events, production is still minimal.

17. Most of the African countries represented at the Development Meeting are in a similar position. The Democratic Republic of the Congo relies almost entirely on imports, although an assembly line for radio receivers was put into operation in 1964. This line originally had an output of 110,000 sets per year, but this level has been considerably reduced in recent years because of the high duties imposed on the importation of components. At present, imported radio receivers actually cost less than locally produced sets. There is also an assembly line for telephone handsets, which, theoretically, has a capacity of 1,200 units per month. The local product has about the same price as the imported article, but the assembly line can function only if the handsets are purchased by the Post, Telephone and Telegraph Administration (PTT), there being no other domestic market outlet and exports being out of the question.

18. Kenya, Uganda and the United Republic of Tanzania also import the bulk of their telecommunications requirements, although assembly lines for the manufacture of radio receivers are functioning in Kenya and Tanzania. Both of these assembly lines import their supplies in the form of kits of the semi-knocked-down (SKD) type, in which imported assemblies and subassemblies are fitted to chassis and cabinets and then marketed. From the point of view of foreign currency saving, little is achieved; however, the change-over from semi-knocked-down to completely knocked-down (CKD) is envisaged for the near future, and the local labour content of the finished product will be greatly increased. At present, there are no plans to manufacture telecommunications equipment locally. Information currently available for the countries of West Africa indicates a similar state of affairs.

19. The situation in Ethiopia is much the same. Except for a radio receiver assembly plant in Addis Ababa, there are no manufacturers of specialized telecommunications equipment. The radio receiver assembly plant, which is staffed by one supervisor and four workers, has an output of 5,000 3-band receivers per annum and occupies an area of approximately 100 square metres. Even so, the import duty on complete radio receivers is 10 per cent less than on imported components as piece parts. Until a major revision of tax policy is put into effect, the plant will continue to operate uneconomically. Nevertheless, the market potential with a population of around 24 million is considerable.

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[1] At the end of 1970, the rate of exchange of the Pakistan rupee was 4.762 to $1.

[2] At the end of 1970, the rate of exchange of the Ceylonese rupee was 5.95 to $1.

20. There is, however, virtually no uniformity; each developing country represents a specific case. India presents an example where government strategy has encouraged the rapid and fruitful development of the telecommunications and electronics industries. At present, the entire range of telecommunications equipment, including switching gear, channelling equipment, microwave equipment and teleprinters is manufactured in government-owned factories. By 1973, the Government plans to have an installed capacity of 18,000 telex lines, with a total of 50 exchanges. Point-to-point telephone subscriber dialling has already been introduced over 17 routes, and integrated national dialling with automatic trunk exchanges of the crossbar type has been commissioned. India already has about 3.5 million kilometres of telegraph channels, linking almost every village. Message switching (TRX) is employed, and 8 more circuit-switching centres are proposed. Annual production of radio receivers is now 3 million and is expected to rise to about 7 million sets by 1973.

21. In the field of component manufacture, capacity is being expanded. Table 1 shows the projected output of some of the more important components in 1973.

TABLE 1. PROJECTED OUTPUT OF CERTAIN ELECTRONIC COMPONENTS IN INDIA IN 1973

Component	*Projected production (millions)*
Transistors (germanium and silicon)	120
Carbon resistors	400
Potentiometers	16
Thermistors and varistors	6
Plastic film and styroflex capacitors	140
Ceramic capacitors	160
Integrated circuits	6
Waveband switches	7
Trimmers	70

22. It is reasonable to suppose that, in a relatively short time, the Indian telecommunications and electronics industries will be in a good competitive position vis-à-vis the international market.

Negotiations with government authorities on incentive measures

23. Prior to the setting-up of new production facilities in a developing country, agreement will have to be reached with the host Government concerning the financial environment in which the guest firms will have to operate.

24. Factors such as tax exemption or concessions on investment, import concessions and restrictions, customs duties, and concessions on the repatriation of capital and profits will play a large part in influencing the decision of a manufacturer regarding the feasibility of such an enterprise. They will also influence decisively the pricing policy that will be adopted. The establishment of viable manufacturing facilities for telecommunications equipment thus hinges largely on governmental policy. There is, therefore, the need to appreciate, at the highest levels, the vital role this industry can play in the over-all economic and social development of a country.

25. Foreign investment in this sector should be seen as a valid means of attaining a desirable objective. Obviously, investment must be encouraged, and it is in this context that the need for prior and absolute definition of the whole structure of incentive measures exists. Each of the partners in the enterprise should have a clear picture of exactly what the others are deriving from the venture.

26. All too frequently, in the establishment of such enterprises, negotiations take place at an inappropriate level. There is much scope for Governments to improve their own machinery in this respect. Top-level negotiations are essential, and it may be advisable to plan for these negotiations to take place both in the developing countries and in the country of the potential investor.

27. There is also a need, in some instances, to create legislative machinery that would confer on industry some measure of immunity to drastic revisions of policy that might result from unexpected changes in the Government. Industry can thrive only in conditions of relative stability.

28. Incentive measures, however, must be precisely tailored to suit particular requirements. Indiscriminate allocation of benefits to foreign investors can do as great a disservice to a developing country as can the lack of a national incentive structure. An injudicious allocation of benefits may create an unwarranted future liability in the proliferation of uneconomic manufacturing units. Eagerness to attract investment should not be permitted to cloud good judgement.

29. The conventional system of incentives is the instrument whereby a Government discharges its responsibilities for a specific process of capital accumulation within the context of its national development plan. The basic principle of the theory is that only incentives that are strictly necessary to generate the required investments should be applied. In other words, the granting of incentives should avoid creating situations that generate excess profits. However, since every firm has its own peculiar cost structure, there is no system of incentives that will ensure the generation of all the required investments while avoiding the possibility of excess profits for some enterprises. The only way around this double problem would be to negotiate a system of incentives with each enterprise. For a variety of reasons, this approach is not practicable, although there is room for manoeuvre within the general framework.

30. The question of relations between Government and industry in what are, effectively, monopoly situations is one that needs careful consideration. There is no ready solution to the problem; and reliance on market forces provides no easy answer to the question of what rate of return on capital would encourage entrepreneurial risk and initiative.

31. Specifically, the kinds of incentive that industry requires are those related directly to profitability and repayment of the investment. In the initial operating period, which normally extends over the first five years, industry will look for:

Tax concession of five years of total or partial exemption.

Exemption from customs duties and related taxes on the importation of plant and equipment for the factory. This will absorb a considerable amount of the start-up costs.

Grants.

Protective tariffs that will allow the maintenance of a specific price level over an agreed period. This level will normally be in conformity with the Government's trade policy, but its application must be very clearly defined. In particular, the kinds and characteristics of the products to be protected should be specified. If protective tariffs are not considered carefully, their net result may well be the encouragement of a basically inefficient industry.

The ~~right to~~ repatriate capital and licence fees.

Repatriation of capital

32. As a general rule, most foreign companies do not aim to repatriate either their capital or their profits. However, the right to do so is regarded as essential to any agreement. The repatriation of licence, technical assistance and management fees is another matter and one that presents some difficulty. Where national ownership is coupled with foreign know-how, reasonable compensation must be ensured; otherwise, foreign investment will inevitably be discouraged. It should be remembered that the maximum input is obtained by first reaching an understanding on a satisfactory level of compensation and then setting up machinery to ensure that good value for the money is obtained. These arrangements should form specific parts of all technical assistance agreements.

33. The normal criterion applied by companies investing in the developing countries is a five-year period in which to generate earnings equal to the original investment. This, of course, does not imply that either earnings or investment will be withdrawn; it is merely a generally accepted means of assessing the viability and performance of a project.

Extended guarantees against risk

34. The time for return on investment also should be examined in the context of a system of guarantees. At present, United States Agency for International Development (US/AID) guarantees are applicable to some projects, but there is now the prospect of World Bank guarantees in the near future. These guarantees would naturally be based on stringent economic criteria, but it is evident that an extended guarantee against risks would be a very potent means of encouraging and accelerating investment in the developing countries.

Export-oriented industries

35. A further point to be considered in setting up a new industry in a developing country is the need to generate export earnings. It is necessary to determine the extent to which the new industry should be oriented towards exports. In most instances it would be very unusual for the domestically produced item to cost less than the complete item that is imported. Obviously, this will depend upon the amount of locally available material incorporated into the finished product and on the degree of vertical integration possible within the context of the economic potential of the country in question.

36. Government help will therefore be needed to create competitiveness by initiating exports to countries with which there are trade agreements. This help may take the form of a supply agreement similar to that which exists between the manufacturer and his domestic customer. The quantities supplied to a new country even at lower prices ex-factory than on the home market will ensure a better spreading of overheads and reduce the impact of depreciation on the equipment unit. This in turn will be reflected in the form of lower prices in the home market.

The regional basis for industry

37. Sound arguments can be advanced for the regional, as opposed to the purely national, allocation of industry. The availability of a very much larger market would permit production to be placed on an economically viable basis and would encourage the degree of vertical integration necessary for a really competitive product.

38. The example of the Latin American Free Trade Association (LAFTA) is of interest in this context. LAFTA is a grouping of eleven Latin American countries including the three most developed ones (Argentina, Brazil and Mexico). The group has six sectoral meetings each year to examine import duties and tariff barriers and to discuss products. Private industry is thus able to negotiate within the framework of regional policy. The object of the sectoral meetings is to formulate recommendations which individual Governments will be able to ratify subsequently. Experience thus far has been encouraging. At the most recent meeting, 65 products were negotiated to practically the zero tax level within the zone (Argentina at one time has a 300 per cent duty on imported equipment), and the establishment of uniform and equitable competitive conditions is proceeding well. Essentially, the aim is to increase the spread of technology by the relaxation of trading restrictions and to provide industry with a market of about 200 million people.

39. In the world today there are probably ten groupings like LAFTA in various stages of commitment and development. However, a regional basis for an industrialization programme relies on multinational political decisions, and these are none too easy to arrive at. Nevertheless, experience has shown that grouping according to availability of raw materials, labour potential etc. provides a more rational basis for operation in the area of telecommunications equipment manufacture than would be possible on a purely national scale; indeed, for some types of equipment it may provide the only basis for manufacture.

Bulk supply agreements

40. Where the manufacture of telecommunications equipment is concerned, the importance of bulk supply agreements must also be emphasized. The purpose of this kind of agreement is to guarantee the sales of manufactured equipment where the manufacturer is in the unique marketing position of having only one major customer (typically, the PTT Administration) and has no means of opening up other markets in the country. Such an agreement should be subject to review at predetermined intervals, normally of five years, and provide that:

The manufacturer will produce the types of equipment required by the Administration in line with a jointly agreed manufacturing programme.

The customer will, as far as possible, purchase all of his requirements from the manufacturer and will not place any orders elsewhere without prior consultation and agreement.

Commercial criteria and the developing countries

41. It is axiomatic that industry will look for a business basis for its operations. Responsibility to stockholders is of primary importance, and investments must conform to the normally accepted business criterion of profitability. Government, on the other hand, however else it may interpret its essential functions, must attempt to harmonize two different types of objective: the commercial and the humane. There is, in the present climate of world opinion, a general feeling that commercial criteria should be modified, as far as the developing countries are concerned, by a spirit more consistent with the avowed principles of the United Nations. If commercial criteria were to be applied rigidly, few developing countries would be able to provide the necessary preconditions for viable investment programmes, all the more so when the distortion of the normal commercial situation regarding foreign currency availability is taken into account. On the other hand, direct-grant aid is more the concern of Government than of industry. It seems clear, however, that what is required is a carefully planned and programmed policy of industrialization for the developing countries. This task might be undertaken by the industrially advanced countries as their particular contribution to the improvement of the general well-being in countries whose industrialization began later.

Basic criteria for the evaluation of industrial projects

42. The basic criteria used in the evaluation of industrial projects concerned with the manufacture of telecommunications equipment are:

The quality of the project in terms of the cost of manufacture when the cost is invariably high by international standards because of tariff barriers;

The efficiency of the project in terms of foreign exchange savings by the substitution of local production for imports and of foreign exchange earnings, which are essential for the increase of domestic industrial capacity;

The contribution made by the project in terms of value added to the gross national product (GNP) and the multiplier effect that this is likely to have in other sectors of the economy;

The social value of the project in terms of the provision of employment, the development and training of labour, the development of technologies and associated skills, its impact on the educational and cultural life of the people and the increased life expectancy consequent upon a raised standard of living.

43. From a purely economic point of view, choice will centre largely on:

Labour-intensive products, because of the desirability of relatively unsophisticated production techniques for low-volume products;

Projects that do not demand a high level of initial capitalization (ordinary radio receivers rather than those of professional quality);

Projects that offer the prospects of a sustained rate of growth.

44. It should be realized that the cost of manufacturing a product for which there is only a small demand may often eliminate or nullify the benefits that the project would normally confer, with a consequent waste of skilled management. Furthermore, local materials or components may be too scarce to allow their use in a competitive market.

45. Political considerations may have to be taken into account. For example, a Government may decide to initiate a project purely because of its prestige value. However, this in itself need not be a disadvantage because it could serve to attract more foreign investment.

46. It is suggested that:

Governments should not accept unsolicited manufacturing bids as part of a supply tender;

Governments do not request supply tenders with manufacturing commitments attached unless an extensive economic review of the place of the project in the general development strategy has been made;

Governments should realize the prime importance of regional industrial groupings, probably by product, and arrive at an equitable allocation of industry on this basis;

Intra-company allocation of manufacture of a particular product or component should be fully explored in order to promote specialization in the production of certain items of equipment to supply a wider market than a purely local one.

47. The decision to invest in a new manufacturing process is therefore governed to a large extent by considerations of financial viability and social desirability. Financial viability is determined by the existence of an adequate market demand for the product in question and on the technical feasibility of the operation. Extensive market surveys are not mandatory at the early stages of the operation, but investment is consequent upon the prospect of satisfactory market demand for the eventual product, and reasonably reliable data should be obtained.

48. In deciding whether to establish the manufacture of a new product, consideration must be given to the possibility of a long-term guarantee for the

product. 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 well-qualified technical staff, and modern equipment.

49. These factors are considered to be of approximately equal importance. An objective evaluation of production feasibility may be made by using the following equation

$$S_T = S_1 \cdot S_2 \cdot S_3 \cdot S_4$$

where

- S_T represents the over-all long-term guarantee on an area;
- S_1 is the ratio of the amount of cheap materials available to the amount of all special materials required;
- S_2 is the ratio of the number of economically attainable components to the total number of components needed;
- 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 have a significant influence on international markets);
- 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.

S_1, S_2, S_3, and S_4 are known, respectively, as the materials guarantee, the components-base guarantee, the labour coefficient and the equipment factor.

50. The results obtained by estimating S_1, S_2, S_3 and S_4 for several areas and by calculating the products S_T indicate the most suitable location for the manufacturing facilities. A similar process may be used to determine suitable groups of products. Even when $S_T = 0.05$, a sufficiently 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 production is possible. In this case, the area concerned must rely on imports to satisfy its production requirements.

The technical base

51. The term "technical base" denotes the research, development, design and technological capacities required in connexion with the preliminary assessment of technologies and technical services required for a new group of products. The following factors should be considered:

The complexity of the product;

The anticipated volume of production;

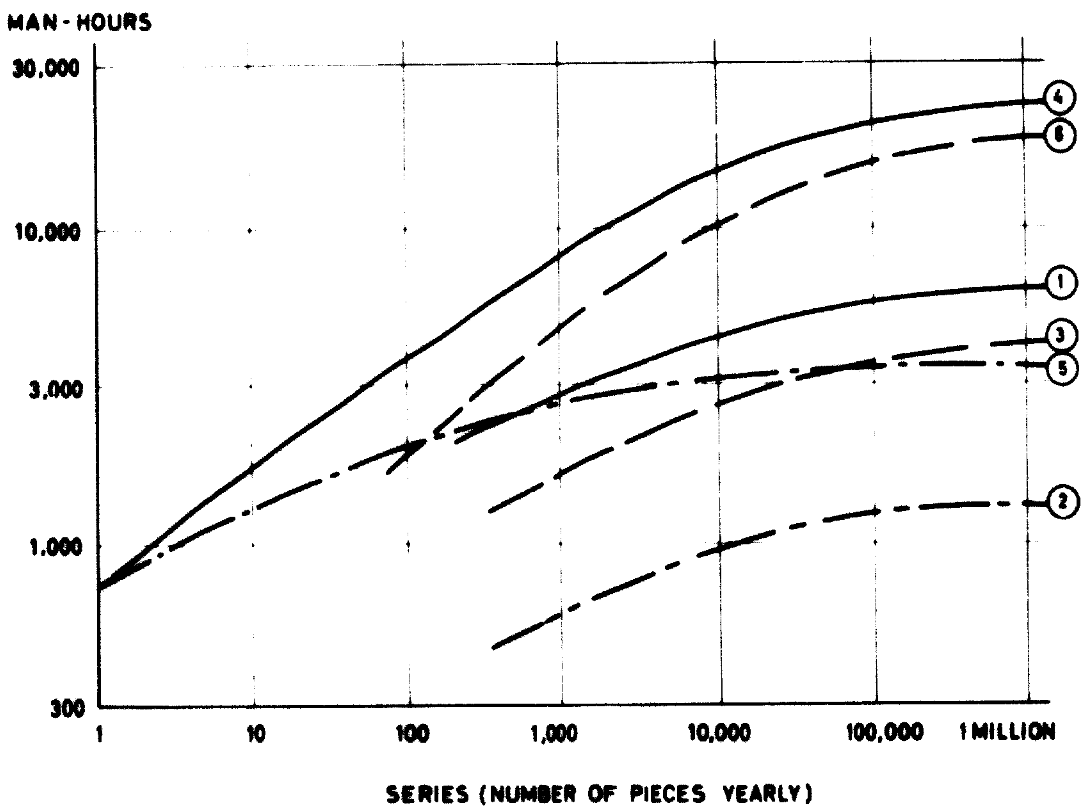
The technologies to be employed;

The scope of co-operation with producers;

The licences and technical assistance that will be required.

52. The complexity of the product and the volume of production influence the scale of the technical base, particularly in the electronics industries. Even a small series of products, produced in a simple way, will require a large staff for research and development; large-volume or mass production will obviously require more intensive technological research and development.

53. Figure 1 shows the required technical capacities, expressed in man-hours, plotted against the estimated production volume for an electronic product. Curve 1, which represents the total technical capacity, has been drawn for a product that is being manufactured under licence and that contains certain specialized devices. Some changes of the licensed design are found to be unavoidable; the additional technical capacities required by these changes are shown as curve 2; for example, performance modifications, other wavelengths, different finishing. Curve 3 represents the capacities required for such technological modifications as different starting materials, protection of products against specific climatic conditions or air-conditioning of working areas.



With a licensed design	Without a licensed design
Curve 1: total technical capacity	Curve 4: total technical capacity
Curve 2: additional technical capacity required for performance modifications	Curve 5: technical capacity required for design and development of the product
Curve 3: additional technical capacity required for production modifications	Curve 6: development of production technology and equipment

Figure 1. Technical capacities required to establish new production of an electronic device

54. An example would be a factory that previously had a licensed production of items using vacuum tubes. This factory now aims to establish a more complex final product in this instance a 7-transistor, single-band radio receiver. It is assumed that the factory obtains the necessary licence and imports special equipment. A further assumption is that an output of 100,000 units per year is attained. This means that curves 1, 2, and 3 will be used. For this number of units the results indicated are 5,000 hours by curve 1, which represents the total number of hours of technical work; 1,500 hours by curve 2, representing additional development work; and 3,500 hours by curve 3, representing the modification of technologies added to the licence.

55. These figures give an indication of the "value" of licensed know-how and can be of assistance in deciding whether to purchase a licence or develop the product locally.

56. Where new production has been established without the purchase of licences, the curves 4, 5, and 6 are applicable. Curve 4 represents the over-all capacity of technical work, curve 5 represents the design and development work involved in the product, and curve 6 represents the technological work and the development of technological equipment.

57. The law represented by 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 capacity may be found from statistical data concerning typical cases of establishing new production processes.

58. A minimum lapse of time between the start of research and the establishment of the new manufacturing process should be aimed for because of considerations of design life. A maximum lapse of time of three years may be allowed for the most complex articles.

59. There are certain limitations connected with licensed production. Experience has shown that a complexity of approximately 100 active electronic circuits is the maximum feasible where licensed production is remote from the licensor. It is therefore better for a developing country to build up its technical capacity gradually. This can be done by starting on the basis of limited licences and then establishing its own qualified technical base for additional and more complex items.

60. Table 2 shows the usual pattern of distribution of funds invested in a subscriber telephone system.

Inspection of this table will reveal that 35 per cent of the total investment in such a system (30 per cent for installation in elements 2, 3 and 4, plus the 5 per cent for buildings and land in element 5) is invariably of local origin and thus poses no problems as regards foreign exchange.

TABLE 2. PERCENTAGE OF TOTAL INVESTMENT OUTLAY REPRESENTED BY THE VARIOUS ELEMENTS OF A SUBSCRIBER TELEPHONE SYSTEM

Elements	*Per cent*	
1. Subscriber plant		5
PABX[a]	3	
Telephone handsets	2	
2. Outside plant for local network		35
Cables etc.	18	
Installation	17	
3. Telephone exchanges		25
Local	16	
Long distance	4	
Installation	5	
4. Long-distance network		30
Terminal equipment	9	
Line equipment	6	
Cables	7	
Installation	8	
5. Land and buildings		5
Total		100

[a]Private branch exchanges.

Estimating demand

61. There are two stages in the study of the market, namely, the collection of data and the establishment of empirical bases for their elaboration and analysis. The analysis and elaboration stage is required to answer the fundamental questions of this study: What will be the eventual market demand? At what price will the product be sold? Does the product present specific marketing problems?

62. In the field of telecommunications equipment, subscriber telephone equipment offers a market where the demand can be accurately calculated and where the growth in demand follows a pattern that permits good forward planning. The growth rate of demand in the developing countries varies between 7 per cent and 12 per cent per year. Taking as an example a country with an actual population growth rate of 3 per cent, and assuming a density of 2 subscriber lines per 100 inhabitants, with a goal of 5 subscriber lines per 100 inhabitants in 5 to 10 years time, it is easy to see that this will require approximately 1 million lines in 10 years, or an average of 100 000 lines per year.

63. A nominal figure of $1,000 per line would indicate an annual investment of about $100 million, and this does not take into account the sum necessary to replace worn-out equipment. These figures give some indication of the size of the problem for countries which, by and large, are characterized by a shortage of capital. However, the availability of relatively cheap labour must be considered an important incentive to local production and this, together with the growing availability of well-trained technicians, could go a long way towards compensating for shortage of funds for financing local production.

64. Two sectors where local production may be considered to be economically feasible are voice-frequency communications and carrier-frequency communications. There are, of course, items that should be included in one sector but that from a technical point of view are nevertheless classified under the other. Some examples are single-channel radio links to connect a remote subscriber directly to an exchange, subscriber carrier equipment to allow multi-subscriber operation over the same pair into one exchange, and voice-frequency connexions over multi-pair cables connecting a central exchange with satellite exchanges in the same area or town. However, for the purposes of evaluating the over-all requirements of a country, the basic operational division applies.

65. While the principal market outlet for these types of equipment will be basically the national PTT administration, the armed forces, the police, the gendarmerie, and private enterprises such as mining and oil companies should not be overlooked in this connexion, since their combined requirements can amount to a sizable proportion of the total PTT needs.

66. The basic information needed is the requirement for telephone lines. Once this is known, the demand for switching equipment can be easily derived. The basic data are:

The actual number of subscribers, in urban and rural categories, classified according to use (domestic or commercial);

The relation of these figures to the total population in the various points of concentration;

The investigation, where possible, of any anomalies found in the growth curve plotted over the past ten years;

The *per capita* income and, where applicable, divergences at the main concentration points of the population;

The growth rate of *per capita* income plotted over the last 5 - 10 years;

The projected growth rate of the *per capita* income in the framework of the national development plan;

An assessment of factors that could disturb the normally extrapolated requirements;

The waiting lists for subscriber equipment at the points of concentration and their development over a significant period.

67. With these data the future development of telephone density of a country can be predicted by means of a growth function whose determinant parameters can be

calculated. Furthermore, the general growth functions will apply to all countries uniformly, although they will not be synchronous.

68. It is of some interest, in this context, to note the findings of the ECAFE Subcommittee on Telecommunications (Bangkok January 1969). The subcommittee examined the relationship between the gross domestic product (GDP) and the number of telephone lines and developed what it termed the "utilization factor". If this factor is 8, the indications are that the economy is in a healthy state and its development is not hampered by deficiencies in the telecommunications system.

Carrier-frequency communications equipment

69. Carrier-frequency communications equipment must fulfil two basically different requirements, namely, the transmission of interurban telephone traffic and the transmission of broadcast programmes.

70. For interurban telephone traffic, the nature and condition of the existing telephone network and its historical development must be known. In addition, there must be reliable data on the following points:

The initial bandwidth;

The initial number of channels;

The subsequent increase in bandwidth;

The increase in the number of channels;

The increase in telephone density at the linked points;

The limitation of the links in terms of hours of operation;

The utilization factors of the channels;

The average subscriber acquisition time (that is, the time required to make a telephone connexion) over the links.

71. Where the transmission of broadcast programmes is concerned, the data upon which estimates for future requirements will be based are:

The present volume (in hours and number of programmes) of radio and television programmes originating from existing studios;

The number and range (individual and combined) of existing radio and television transmitters;

The number of links between studios and transmitters.

The needed extrapolation from these data will be from the areas not yet covered by broadcast transmissions and the importance assigned by the Government to making good this deficiency. Valuable information on this subject is contained in the report of the Third Plenary Assembly of CCITT (Special Autonomous Working Party GAS 5) 1964 entitled "Economic Studies at the National Level in the Field of Telecommunications (1964–1968)".

72. Once the quantities of equipment required over a given period have been determined, it will be necessary to decide which types of equipment would best be suited to local manufacture. Consultation with ITU will be advisable to draw up specifications for the equipment to ensure its suitability to the environment and its conformity with certain special requirements such as compatibility with existing systems.

73. It is estimated that at present \$2 billion has been invested in telecommunications equipment over the world. A changeover to more advanced systems therefore cannot be envisaged until existing systems have been sufficiently depreciated. The useful service life of an exchange will normally not exceed 40 years. For private exchanges a service life of 20 years is more usual, while for telephone instruments and for transmission equipment the service life is 10 years and 15 years, respectively. These periods together with the service life of the relevant designs and the time interval between design changes, are set out in table 3.

TABLE 3. DURATION OF SERVICE LIFE AND INTERVALS BETWEEN DESIGN CHANGES OF TELECOMMUNICATIONS EQUIPMENT
(Years)

Type of equipment	*Operational service life*	*Service life of a design*	*Time between design changes*
Automatic exchanges			
Public	40	60	20
PABX	20	15	7
Telephone instruments	10	5	5
Transmission terminal equipment	15	7	7

74. Where public exchanges are concerned, the service life refers to the complete system as such. Components and parts, however, are subject to continuous replacement in accordance with the normal programme of rationalization and improvement that applies to such equipment.

Resource structure

75. The division of manufactures among various countries is an accurate reflection of the structure of their individual demands and resources. This division is smoothed, to a certain extent, by international trade, although this in turn is subject to various types of trading restrictions.

76. Availability of resources is of prime importance. It is therefore necessary to examine the resource structure of the various types of equipment required and to categorize them according to the demands they make on resources. To do so it is necessary to distinguish between what is essentially software and what is currently

termed hardware. In this instance software comprises the engineering skills involved in setting up the manufacturing process and in the equipment itself, and the capital required to finance the project until it begins to generate its own income.

77. Table 4 compares the costs of certain types of software. Three broad categories are employed light, medium and heavy and they refer in a purely qualitative manner to the cost of the software as a function of the total cost.

TABLE 4. COMPARATIVE COSTLINESS OF THREE TYPES OF COMMUNICATIONS SOFTWARE

Type of equipment	*Product development cost*	*Market adaptation cost*
Automatic exchanges		
Public	High	High
PABX	High	Medium
Telephone instruments	Medium	Low
Transmission terminal equipment	High	Low

78. Hardware, as distinguished from software, refers to the actual instrumentation. The figures shown in table 5 represent the approximate distribution of costs of imported and locally manufactured items and of their assembly and testing. These figures refer to a fully integrated telecommunications industry.

TABLE 5. APPROXIMATE DISTRIBUTION OF THE COST OF THE HARDWARE IN A FULLY INTEGRATED TELECOMMUNICATIONS INDUSTRY
(Per cent)

Type of equipment	*Purchased parts*	*Manufactured items*	*Assembly and testing*
Automatic exchanges			
Public	30	25	45
PABX	25	30	45
Telephone instruments	30	30	40
Terminal equipment	55	10	35

79. The two principal resources in production are personnel and capital. Table 6 and table 7 indicate, respectively, the distribution of these two factors in the sectors of manufacturing and of assembly and testing.

TABLE 6. APPROXIMATE DISTRIBUTION OF THE LABOUR INPUT IN THE MANUFACTURING AND THE ASSEMBLY AND TESTING SECTORS OF A FULLY INTEGRATED TELECOMMUNICATIONS INDUSTRY

(Per cent)

Type of equipment	*Manufacture*	*Assembly and testing*
Automatic exchanges	20	80
Telephone instruments	40	60
Terminal equipment	10	90

TABLE 7. APPROXIMATE DISTRIBUTION OF THE CAPITAL INPUT IN THE MANUFACTURING AND THE ASSEMBLY AND TESTING SECTORS OF A FULLY INTEGRATED TELECOMMUNICATIONS INDUSTRY

(Per cent)

Type of equipment	*Manufacture*	*Assembly and testing*
Automatic exchanges	70	30
Telephone instruments	90	10
Terminal equipment	40	60

80. The figures given in tables 6 and 7 are only approximate and are subject to local variations. However, they can serve as a general guide to the distribution of resources in a typical telecommunications industry.

81. The scale of demand and the resource structure of the product will be seen as the principal determinants in the choice of equipment for local manufacture. Automatic exchanges present a naturally strong case, since they represent the largest part of the hardware requirements of a system. Furthermore, the manufacture of automatic exchanges is highly labour intensive and can absorb large numbers of relatively unskilled personnel. The number of operations in the manufacturing sequence is limited; this circumstance permits training programmes to operate effectively in preparing personnel to perform a restricted series of well-defined tasks.

82. Today the choice of a telecommunications system lies basically between electromechanical and solid-state switching systems. In the former systems, the central functions are carried out by relays and fixed wiring; in the latter systems, storage by core-memory circuits, disc or tape is used, and all switching functions are programmed.

83. To increase the reliability of such a central programme-controlled system and to reduce repair time, it is important to have automatic testing and diagnostic programmes to identify failures. Electronic systems are therefore more expensive initially than crossbar systems, but their maintenance and running costs are appreciably lower. It is possible that this reduced cost of operation would compensate for the cost of interface equipment.

84. It is thus clear that, the more advanced the electronic system, the easier it is to interface it with older types of equipment. However, development costs of advanced technological projects are outstripping the resources, not only of most companies but also of some countries. The development of electronic switching has involved the Bell system (United States) in research and development (R&D) costs of about $200 million. In the United Kingdom, the costs are too great to be met by any one company, and a consortium of five companies is presently working on it. Some of this cost will naturally have to be recovered, and licensing fees are likely to be high.

85. Ultimately, the choice is likely to be decided by considerations of suitability for local manufacture. Of the systems currently available, the crossbar system probably offers both the best possibilities of economic interface with existing systems and the best possibilities for local manufacture. It is likely that these systems will still be in operation until the year 2000 at least; at all events, a number of European manufacturers are working on this assumption. Local manufacture of these systems would certainly offer considerable savings of foreign exchange even where production costs are higher than import costs.

86. One further question must be answered before a definite decision can be made, and this concerns the training problems involved. If these problems can be handled in a satisfactory manner, the decision to manufacture is reasonably straightforward.

Determination of capacity and location for starting or expanding production

87. Most manufacturing processes have a definite minimum industrial scale; in other words, a level exists below which production becomes economically unsound. This minimum scale may also have a decisive effect on the degree of precision required in the demand projection. It has been estimated, for example, that in the manufacture of transmission channel modulating/demodulating units (modems) a level of production of 2,000 to 3,000 units per year must be maintained. For switching equipment, this level is approximately 30,000 to 40,000 lines per year; with plastic capacitors, 10 to 12 million per year is the minimum level for economic production. If, when the manufacture of these items is contemplated, a minimum production at the level indicated cannot be envisaged, it will obviously be unwise to set up a factory, and no price estimates will be necessary in making a preliminary estimate of demand.

88. The plan of analysis for a specific project should envisage three fundamental situations:

Where the total demand is clearly less than the smallest production unit that may be installed;

Where the demand is the same as the capacity of the smallest production unit;

Where the demand is clearly greater than the largest production unit that may be installed.

89. The size of the project is usually taken to mean its productive capacity during a normal operating period. This capacity is expressed as a function of the number of

working days and the number of production hours required to attain a specific level of output. The optimum size and the best location will be those leading to the most favourable economic result. This result may be quantified by such coefficients as net return, minimum unit cost, sales-cost ratio and total profits.

90. The most important factor in determining the size of a project is clearly the volume of demand. All industries have characteristic curves of production costs as a function of size. Combining these cost curves with those of demand variation as a function of one or more of the factors previously mentioned will often reveal the possibility of achieving an output greater than that required by current demand.

Licensing fees and transfer of technology and know-how

91. Cost is the decisive factor in the transfer of technology. The new factory will require patent licences from the parent company to manufacture the proposed equipment. The determination of this fee will depend on international practice, licence fees already agreed with other manufacturers, and the regulations in the country of investment.

92. What is generally meant by a licence fee is a contract composed of several elements. These elements include the use of patents and of the manufacturing technology combined with technical assistance, the provision of sets of drawings and equipment, and agreement on the transfer of profits. There are no general rules for reaching such agreement; negotiation will determine the form of the final contract. Licence fees are normally calculated as a percentage of sales, and they usually include a percentage to cover R&D costs in the parent company. By this means the new factory is spared the cost of setting up its own R&D facility while ensuring that its practices will be able to keep pace with the latest technological advances.

93. Telecommunications enterprises present a rather special case. They deal with technically highly sophisticated products; the local market is likely to be very limited; and finally, they invariably operate at a serious disadvantage with regard to exports.

94. Careful consideration should be given to developing a system that would facilitate the transfer of technology and at the same time give fair compensation to patentees for their R&D costs. There is an urgent need for some sort of equitable formula to be worked out, since it is probable that the question of patents and the transfer of know-how is the critical one in setting up such technically advanced industries.

95. There is a vast reservoir of unused technical know-how in the form of patents. The cost of patent filing in developing countries is surprisingly low. However, it is interesting to note that of 80 developing countries in the world, only three or four grant more than 3,000 to 10 000 per year; most grant only between 200 and 300 per year. Morocco has two patent offices, yet for the Tangiers office the average number of applications per year is less than 20. The United Arab Republic exploits between 2 per cent and 5 per cent of the patents granted.

Joint Ventures

96. The laws governing foreign investment are always of a very general nature, since they must apply to the whole spectrum of industries and industrial requirements. Traditionally, the foreign investor has required 100 per cent ownership of new plants in developing countries to obtain the maximum benefit from the input of management and technical resources. Even today, United States investors or companies would require at least 51 per cent of the equity ownership because, without it, they would be unable to consolidate their earnings in the United States. However, it is clear that in developing countries the process is now moving the other way, and the importance of a strong local partnership with a strong minority interest is being realized as is also the necessity for the shift to full local management as quickly as possible. The strong local minority interest may in some cases be supplemented by contractual agreements and by the sale of stock to local investors after an agreed percentage of the capital has been returned. Where other factors are favourable, it may be desirable to have local majority ownership from the start. The question of debt/equity structure is also important. The desirable ratio is 50:50, although, with telecommunications industries, working-capital requirements represent a high proportion of the funding.

97. State participation may be necessary where there is no possibility of private investment and where a Government, for reasons of policy, judges that the operation of an industry is desirable. Such an enterprise can never be profitable, however, and only a Government can assume the financial responsibility for it.

98. Manufacturers interested in establishing production facilities in developing countries will, generally speaking, look for financial partners from the following sources:

Private, semi-private or governmental enterprises in the country of the manufacturer;

Private, semi-private or governmental enterprises in the country in which it is proposed to establish the new facility;

The PTT administration (as distinguished from those above), where the PTT is to be the major customer.

The term "financial partners" in this context is used to designate only these entities that participate in the profits of the company as shareholders; it does not include those who contribute to the financing of the operation in the form of fixed-interest loans.

99. There are few instances in which partners of the first category are involved. Governments normally invest in a developing country within the framework of bilateral technical co-operation agreements and in such an instance the investing Government would solicit bids from its own producers.

Cost areas in manufacturing

100. In a broad sense, the operating costs in manufacturing fall into the three following categories:

Production costs, including those of materials, direct labour, indirect labour, depreciation and utilities;

Related costs, including rejects and other manufacturing variances, inventory adjustments, packing and shipping costs;

Overheads, including administration and general costs, marketing and sales promotion, finance costs, interest repayments, royalties, management fees, transfer of know-how, taxes and net income.

101. In addition to the running costs of the operation there will be the start-up costs. These cover mainly:

The purchase of land;

Initial training of personnel;

The running-in of machinery;

Miscellaneous manufacturing start-up costs;

Marketing and sales-promotion costs.

102. The amortization of these costs will be spread over a certain number of years. All these factors influence the eventual selling price of the equipment, and although some are determined directly as a function of the general policy of the manufacturer and the regulations of the country of investment, others will have to be analysed in detail.

103. To make such an analysis, certain basic information covering the following points must be obtained from local sources:

The site of the proposed factory;

Government preferences regarding factory location;

The proposed incentive structure for the new enterprise;

Alternative locations and a comparison of the availability of utilities, transport, labour resources;

The cost of land;

The cost of building on the selected site;

The availability and cost of utilities (gas, water, power, drainage, telephone lines etc.);

The cost of security;

The cost of skilled, semi-skilled and unskilled male or female labour–includes availability of labour, transportation to and from the factory site, regulations governing employment in the country (canteen facilities, medical and first-aid facilities etc.) and social charges on wages;

Working hours, paid holidays, regulations regarding overtime;

Availability of middle and top management staff, salaries and social charges, educational ratings, experience in related industries;

Depreciation regulations for buildings and machinery;

Laws and regulations governing foreign investment (covering taxes, customs duties, repatriation of profits and capital, management fees, and royalty transfers).

104. Once the above background data have been collected and analysed, the next step is to work out the actual costs of manufacturing. These fall into the following seven categories: (1) production costs; (2) materials; (3) machinery and tools; (4) training costs; (5) utilities and related costs; (6) administrative costs and general costs; and (7) pre-operational expenses and start-up costs.

Production costs

105. To determine production costs, the production sequence of the equipment to be manufactured must first be determined. These costs will be classified according to the different steps of manufacture. Each manufacturing step will then be the subject of a separate cost analysis to determine the most economic method of production, which will be the most effective compromise between low foreign currency investment, low foreign currency recurrent expenditure, and maximum utilization of local resources.

Materials (raw materials, subassemblies and components)

106. In the manufacture of telecommunications equipment, certain special basic materials are essential. Their quality and variety determine the kind and level of technology employed, the degree of automation of their production and the performance characteristics and reliability of the final product. Although only small quantities of some materials are required, their quality must be very high.. Semiconductors provide an obvious example. Production of this type of component would be impossible without very pure materials. Magnetic, insulating and conducting materials, which are exceedingly sensitive to climatic conditions, also pose problems.

107. It is unlikely that any one country can obtain all these materials from its own resources. An accurate assessment of a country's resources is therefore important in deciding the types of equipment to manufacture. The problems of special materials can be solved, at least partially, through international co-operation and improved trade relations.

108. The following list contains some of the more important groups of materials used in the manufacture of telecommunications equipment.

Metallic materials

Copper and aluminium for conductors
High-purity metals and alloys for semi-conductors
Germanium, antimony, indium, tin, lead, gallium and gold-gallium alloys
Materials for electrical contacts
Tungsten and gold-nickel alloys

Alloys and other materials for vacuum purposes
Kovar,[3] tantalum and molybdenum
Magnetic alloys and other materials
Cobalt and gold-nickel alloys
Plating materials
Copper, gold, platinum and rhodium
Stainless steels

Chemicals

Nitric acid, acetic acid, hydrochloric acid, sulphuric acid, fluoroboric acid, trichlorosilane, silicon grease, photosensitive lacquers etc. for semiconductors.
Titanium oxide, aluminium oxide and zinc sulphate for ceramics and piezo-ceramics
Luminescent materials, materials for luminescent screens and fluorescent lamps, zinc oxide scintillation materials etc.

Plastics and moulding materials

Dielectric: Styroflex, polyethylene terephthalate, styrene, polyurethane, polytetrafluoroethylene (PTFE)
Structural: Silica resin printed board (SRPB), glass-reinforced synthetic resins, polyvinyl chloride, acrylonitrile-butadiene-styrene (ABS) copolymers

Glass materials and semi-products

Glass materials for light bulbs, ultraviolet glass etc.
Beading glass
Quartz glass

Varnishes

Insulating–for conductors
Impregnating–for windings and condensers

Cements and adhesives

Sealing compounds for light bulbs etc.
Silicon vacuum-sealing compounds
Cerasene, epoxies, polyesters etc.

Minerals and other materials

Talc, kaolin, quartz, magnesia, graphite, manganese dioxide

Gases

Nitrogen, hydrogen, oxygen, acetylene, helium, krypton, argon, xenon etc.

109. Table 8 compares the amount of raw materials required for the manufacture of equivalent telecommunications exchange of four types. In each case the average requirement for 1,000 lines is given.

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[3] Kovar is a low-expansion alloy of iron, nickel and manganese.

TABLE 8. RAW MATERIALS REQUIRED FOR THE MANUFACTURE OF FOUR TYPES OF TELECOMMUNICATIONS EXCHANGES[a]

Material	*Type A*	*Type B*	*Type C*	*Type D*
Soft magnetic steel (kg)	342	1,120	1,142	1,300
Iron materials (kg)	6,014	5,965	18,341	6,000
Non-ferrous metals (kg)	3,208	770	1,856	1,865
Precious metals (kg)	1,813	6,465	16,091	30,000
Wire for coils (kg)	407	508	810	850
Cable wire (kg)	302	1,867	1,333	270
Switch cables (m)	-	3,000	15,560	5,000
Plastics (kg)	403	217	180	160
Laminates (kg)	159	159	270	110
Transistors (units)		7,364	360	-
Diodes (units)	-	23,496	10,000	1,000

[a]A, step-by-step exchange; B, crossbar, with electronic control; C, crossbar, with electromechanical control (type 1); D, crossbar, with electromechanical control (type 2).

110. The materials required at each of the manufacturing steps can be acquired by local purchase from related industries already established in the country, through the production of the firm itself or, if need be, by importation. Even though purchase from established local industries is preferable, it should be carefully examined in terms of quality for the applications envisaged and in terms of price in relation to open-market procurement. It is advisable to have this assessment made in the presence of a representative of the Ministry of Industry or the governmental department concerned with these problems.

111. In the absence of a local supplier, supply from the firm's own production is envisaged as the next possibility. A cross-check of the investment in machinery required against the utilization factor of this machinery, as compared with the activity in the parent company, will determine whether this strategy is worth pursuing or whether it would be better to import. The basis of comparison will be the landed cost of the imported article (with its high content of foreign exchange expenditure) and imported raw material, with its high expenditure on manufacture.

112. If the utilization factors are of the right order of magnitude, and if the projected growth of production can bring it near to a reasonably economic figure the following alternatives can be evaluated: importation of the material until local production becomes viable; or local manufacture from the start. The latter possibility should be explored with a representative of the appropriate governmental authority to ensure that the requirements of the market can be met from this envisaged source. It will also be necessary to draw up a separate agreement with the Government for manufacture.

113. Obviously, as soon as the possibility of local manufacture of subassemblies is envisaged, this production will become the subject of a complete manufacturing planning exercise in itself. It will comprise the steps outlined above for production costs and related costs, as far as they are applicable.

114. The total cost of material will then be the sum of:

The cost of raw material and subassemblies bought locally;

Production and related costs of subassemblies of the firm's own local manufacture;

The landed cost of imports. (The charges for landing the material should be carefully evaluated and determined in terms of taxes, customs duties, customs-clearance costs and transport to factory site.)

115. One difficulty connected with the importation of materials for use in the manufacturing process arises from nomenclature.

116. Existing customs nomenclature involves many anomalies that hamper the flow of goods. Something in the nature of a universal approach is required to ease the situation and to rationalize a system that permits raw materials to have a higher duty imposed on them (as high as 70 per cent) than finished goods and that places a much higher duty on ceramic capacitors than on electronic components on the principle that what counts is the "ceramic" part of the title. Many countries now follow the Brussels Nomenclature of the Customs Co-operation Council. Approximately 60 countries already follow it, and both the United States and the United Kingdom are adopting it.

117. Obviously, customs authorities must interpret regulations as they find them, and much confusion arises because the regulations are not sufficiently explicit. There is, for example, the difficulty of having to distinguish between components used in manufacture (20 per cent duty) and components used for maintenance purposes (40 per cent duty). Many of these anomalies, delays and difficulties could be eliminated through a much closer co-ordination between customs authorities and industrial authorities.

118. There is a further possibility, namely, the complete removal of customs formalities and duties through the creation of a free port. Free port conditions are exceedingly attractive to export-oriented industries; the growth of industry in Hong Kong, in China (Taiwan) and, to a lesser extent, in the Shannon (Ireland) industrial estate is striking testimony to this fact. There are, of course, certain drawbacks, but the possibilities in today's shrinking labour market are vast. There is one objection, however; no matter how attractive free port facilities may be to foreign manufacturers, they will not solve the problem of providing low-cost radio receivers for the domestic market.

Machinery and tools

119. Once the availability of materials has been determined, the nature of the machinery and tools required to process them are readily defined. It can be assumed that all the machinery and tools will have to be imported. Normally, they will be

purchased through the parent (foreign) company, which can make all the necessary modifications of standard equipment. The Government will normally provide special conditions such as exemption from taxes and customs duties.

120. The depreciation of machinery as part of the manufacturing costs will be determined by the experience of the parent company and by existing local regulations. It should be kept in mind that the purchase of machinery and tools is a recurring item of foreign capital expenditure, and provision for obtaining convertible currency should be made when the manufacturing plan is negotiated with the Government.

Training costs

121. Training costs may be considered in two parts: the pre-operational preparatory training of supervisory personnel and of operatives; and the purely operational, on-going training designed to improve capacities and skills, with the aim of increasing productivity and efficiency. Both costs will appear in the total cost of labour as part of the manufacturing plan.

Utilities and related costs

122. Utilities will be included in the manufacturing plan in the usual form and at the costs derived from the basic information as outlined above. The continuity of utility supply and the impact of interruption on the manufacturing process will have to be determined in detail. The utilities required will be categorized according to their availability, as follows: those produced in the factory (compressed air, water etc.); those stored in the factory, (bottled gas, oil etc.); and those supplied continuously (electricity, telephone etc.).

123. For utilities that are to be produced in the factory, the design of the plant must ensure that sufficient space is allocated for their production and storage, and that the machinery needed for them will be included in the over-all calculation of depreciation. Water can be a critical requirement and may not be available through a piped supply. The costs for surveying the territory, finding the optimal location of a well and drilling it, and transporting and storing the water, can be negotiated with the appropriate governmental department concerned with industrial location and industrial development policy, and agreement can be reached regarding the financing and partial repayment of the cash outlay.

124. The only point to consider as regards utilities stored in the factory is continuous availability. This requirement will lead to an investigation of alternative sources of supply in case of emergencies and, where necessary, the provision of adequate bulk storage space on the factory floor, plus an adjustment for higher container costs.

125. The reliability of utilities continuously supplied will determine the solution to be applied. For example, it may seem advisable to provide floating batteries with alternators for certain processes, over-all generating sets or a combination of both with the necessary switchgear, stabilizing units and the like.

126. The related production costs will be determined primarily by the manufacturer's own experience in the parent plant as well as by company policy, which will have to be adapted to the local environment and to special customer requirements. The changes in manufacturing procedures will, for example, reflect the ability and skills of the labour supply as well as the efficacy of training. Labour cost may thus be high at the start of operations, decreasing to the standard practice level over an estimated length of time. Packing and shipping costs will depend largely on the location of the customer, the means of transport, the handling during transport and any special conditions arising from local climate and other influences. Such considerations may necessitate special kinds of packing and packing procedures.

Administrative costs and general costs

127. The following functions are an integral part of the organization for control and management:

Production, such as production engineering and production control, industrial engineering, quality control, purchasing and shop accounting;

Operational functions such as marketing and sales, finance and labour relations;

Ancillary functions, such as communications (mail, telephone, transport) and safety and social (security, first-aid, canteen facilities);

Management.

Pre-operational expenses and start-up costs

128. Pre-operational expenses and start-up costs will be chiefly the costs of initial transfer of know-how and of the required technical assistance in the form of full documentation, drawings and designs, manufacturing flow-charts, the presence of specialized technicians from the parent factory for supervising the installation of machinery, the running-in of this machinery, trial production runs, adaptive engineering etc. Some of the marketing start-up costs may have to be considered as well, even though, for the typical purchasers of communications equipment, these may be quite low.

129. Finally, there will be the costs of the raw materials and components ordered for the production, as well as the work in process before the first sales are made. Minor items such as office furniture are not analysed in detail.

B. TECHNICAL MATTERS

130. Under the above item of the agenda, the meeting reviewed specifications for telecommunications equipment and for low-cost receivers for sound broadcasting and for television (TV). This item also included discussion of design requirements as regards reliability and maintainability of the equipment produced, a review of projected developments in the telecommunications field and in broadcasting, and the probable impact of these developments on equipment design.

Low-cost receivers for sound broadcasting

131. The most effective means of disseminating information, educating and instructing the vast majority of a population and promoting the kind of social dynamism judged to be necessary for rapid advancement is radio broadcasting. Thus, the supply and manufacture of suitable low-cast radio receivers is of extreme importance to most of the developing countries; so much so, indeed, that the whole question of providing them is one that should rank very high on a developing country's list of social priorities. The facilities accorded to a country's high-priority industries should also be accorded to the manufacture of low-cost radio receivers. Because of the large cost differential in both transmission and reception equipment, the question of TV, although it is grouped with sound broadcasting for the sake of convenience, is judged to be of lesser importance. There is, in effect, no such thing as a low-cost TV receiver. The provision of widespread radio reception facilities is the primary objective. The provision of TV receivers can be regarded as a second phase in a programme aimed at the education and information of the people.

The status of broadcasting in ten countries

132. To illustrate the practical problems encountered in setting up broadcasting systems in developing countries, the present status of broadcasting in ten of them, differing widely in size, geographical location and level of economic development, is described briefly below.

Argentina (population 21,247,420)

133. At present, there are about 12 million radio receivers in Argentina representing a ratio of 1 set to every 2 persons. The cost of these receivers ranges from $10 to $57 and all the major brands are available. Miniature radio receivers are available but are not manufactured domestically; they sell for $3 to $5. The type of receiver in greatest demand is a 2-band model, with one high-frequency (HF) band covering 6 to 18 megahertz (MHz) plus one medium-frequency (MF) band. There is still a need for low-cost receivers as well as for more sophisticated equipment. The low-cost type is required to have one MF band and one HF band covering 2.3 to 21.75 MHz.

134. There are 2.5 million television receivers in Argentina, that is, about 1 to every 10 persons. Their prices range from $130 to $260.

Ceylon (population 10,964,000)

135. The importation of radio receivers into Ceylon was banned in 1960. Local manufacturing facilities have been in operation for one or two years, assembling receivers from imported parts on which the duty is from 30 per cent to 60 per cent, depending on the country of origin. Production is severely restricted because of the lack of foreign exchange. Over 500,000 radio licences have been issued, and, according to the Broadcasting Commission, the present unsatisfied demand is estimated at about 300,000 sets. Receivers available on the market cost from Rs200 to Rs1,000. The price of the cheapest receiver represents nearly a quarter of the *per capita* annual income.

India (population 458,677,000)

136. Three million radio receivers were produced in 1969, and for 1973 a target has been set of 7 million per year, of which a sizable proportion will be low-cost, medium-wave receivers made according to CCIR standards. By this time India hopes to achieve the UNESCO minimum of one radio receiver for every 20 persons, or something approaching 25 million sets. (The present number is 10 million sets.) Of the 3 million sets produced in 1969, 2.5 million were transistorized, the rest being valve-type receivers. Prices range from about $8 for the low-cost transistor set, of which approximately 1 million were produced, to $100 for the larger valve-type receivers. There is a preponderance of 2-band receivers, but there is a considerable number of single-band sets. Receivers costing around $6 are in demand, and their output is expected to rise. The importation of radio receivers is banned, and there is a 60 per cent limit on the proportion of imported components in radio receivers. It is expected that all components will soon be manufactured locally. This output will represent a value of approximately $100 million by 1973.

137. At present, there is one television station at Delhi, and transmission is planned for another five stations in the near future. There are about 8,000 television receivers in the country, all of which have been imported. Four domestic manufacturers are now entering this field, with an anticipated capacity of 30,000 sets. By 1973, the demand of 200,000 sets will be met locally.

Kenya (population 9,365,000)

138. Kenya has one producer (ARMCO), which assembles radio receivers from kits imported from Japan. This assembly line was brought into operation in 1963, when it employed three workers on the assembly of single-band medium-wave receivers imported in SKD form.

139. By 1966, 4,600 sets, of six different models, were being produced. In 1968, 9,200 sets were being produced, and the range had been extended to 9 models. The cheapest model retails at about $14, while the most expensive retails at about $40. Since the *per capita* income is about $100 per annum, it will be seen that for the average Kenyan even the cheapest model is still expensive.

140. Assembly of TV receivers was to be begun in 1970. The production target is 100 sets per annum, rising to 200 per annum by 1972.

Nigeria (population 55,653,000)

141. In Nigeria, five companies are engaged in the assembly of radio receivers with imported parts and components. The customs duty on imported components is 20 per cent; that on complete receivers ranges from 66 per cent to 100 per cent. The present cost for a receiver is from $25 to $30, which represents one month's wage for the average person. Capacity is available for the assembly of about 100,000 radio and television receivers per year. The price levels of these sets have not yet been set. It is assumed that there are about 5 million receivers already in service in the country.

Pakistan (population 98,612,000)

142. Pakistan produces 200,000 radio receivers per year and has a production capacity of 500,000. About 22 units are engaged in manufacturing radio sets and 9 units in assembling television sets. The effective assembling capacity for TV sets is approximately 20,000 per annum. Three industrial units have been sanctioned for the manufacture of non-standard components, but, in general, manufacturers of radio and TV receivers are not utilizing fully the indigenous facilities available for the production of mechanical and electrical components.

143. At present, there are 1.5 million radio receivers available per 100 million people, which is well below the minimum figure set by UNESCO. By 1975, demand is expected to reach 2.5 million sets per year. Prices range from Rs45 to Rs50 for pocket receivers, Rs150 for 2-band sets and Rs180 for 3-band sets.

144. The capacity for TV receivers is 75,000 per year. Production at present is about 20,000 sets per year. The import of components amounts to 1.5 million per year. There is no duty on imported TV receivers.

Rwanda (population 2,971,000)

145. In 1965, there were 12,000 radio sets in Rwanda. About 1,400 sets were being imported annually, the duty on which was 30 per cent. Recently, the small MERA co-operative was formed to produce low-cost, single-band shortwave receivers: 6,500 were produced in 1967 and 6,200 in 1968. It is a simple, robust model operating on 4.5 to 12 MHz and designed to run for from 4 to 8 months on one battery. At present, the price is $16, which represents a high proportion of the *per capita* income. This price could be considerably reduced if the output of the factory were increased. The factory employs approximately 60 people, many of whom are physically handicapped. Rwanda is served by one HF transmitter plus one 100-MHz frequency modulation (FM) transmitter serving Kigali.

Sudan (population 12,650,000)

146. No radio receivers are manufactured in the Sudan. Approximately 100,000 sets, valued at about $1.2 million, are imported yearly, 90 per cent of which come from Japan. The duty on these sets is 100 per cent, and on the spare parts, 35 per cent.

Thailand (population 30,000,000)

147. In 1960, the Thai Electronics Industry (TEI), which is operated by the Royal Thai Army, was created for the purpose of assembling, from imported parts and components, low-cost transistor radios that could be made available to the majority of the population. Initially, 4-transistor sets were produced, but later 2-band receivers employing 8 transistors were also being assembled. The parts and components were imported from Japan, but the cabinets were manufactured locally.

148. Because of the demand, three additional firms for radio-receiver assembly were founded, and many companies began to import complete receivers. From 1960 to

1966, the output of TEI was 104,000 receivers, but in 1966, assembly was discontinued. The number of assembled and imported receivers is said to be sufficient to meet demand.

149. At present, there are three TV broadcasting stations in Thailand, and two more are planned for the near future. Three factories are engaged in the assembly of TV receivers. TEI also produces low-cost 19-inch sets at a rate of about 300 per month, and the price is about 20 per cent below the general market level.

Turkey (population 31,391,000)

150. There are about 5 million radio receivers in Turkey, representing nearly one receiver for every 6 persons a figure well above the UNESCO minimum. There are 4 manufacturing units, which have a combined output of 400,000 sets per year. The cheapest receiver produced costs approximately $25 and is a 2-band set. A 4-band receiver costs about $75. Customs duty on imported receivers is 100 per cent.

151. At present, the cost of imported parts represents about 40 per cent of the cost of manufacture of a radio set. For TV sets, the cost of imported parts amounts to about 60 per cent of the cost of manufacture. Annual production of TV receivers is about 2,000 units per year. This shows a rise of 100 per cent every year, while the production of radio receivers has remained constant. Because of the large capital investment necessary and the lack of specially trained personnel, no attempt has been made as yet to produce basic circuit elements.

Technical specifications

152. The specifications drawn up by CCIR for low-cost radio receivers provide for three basic types of equipment:

- Type AA low-sensitivity MF receiver with a range of 525 to 1,605 kHz;
- Type BA combined MF/HF receiver covering 525 to 1,605 kHz plus an HF range covering 2.3 to 16 MHz;
- Type B_2 As above, but with an HF range of 2.3 to 21.75 MHz;
- Type CA medium-sensitivity, very high-frequency (VHF) FM receiver covering the range 87.5 to 105 MHz.

153. General recommendations will not satisfy all developing countries; they may have to be modified to meet special requirements. One approach to the problem is to study the design objectives and then to manufacture the receiver in accordance with these objectives. A second approach is to decide on the specifications and go to the product sources to determine whether they can meet the specifications. This approach may lead to a lower price in a product already existing. For example, certain countries, notably Afghanistan, Hungary and Turkey, are interested in long-wave transmissions, and ITU Study Group XIc, documents 10275 and 11263, suggest the possible extension of the frequency range up to 26 MHz. However, any extension of the frequency range is inevitably attended by increased cost. A limit of 13.8 MHz might be an acceptable solution.

154. Physically, the design should have sufficient flexibility to accommodate changes in requirements for sensitivity, frequency coverage, audio-frequency output and power supplies. To allow for a greater range of choice, the three basic types of receivers can be further subdivided, as follows:

Type A	One-band MF 5.25 to 1,605 kHz (in some instances a long-wave band for 150 to 350 kHz would be required);
Type B_1	One-band 3 to 16 MHz (preferably with a timing ratio of 3.5);
Type $B_{1\cdot 1}$	3 to 10 MHz;
Type $B_{1\cdot 2}$	6 to 18 MHz;
Type $B_{1\cdot 3}$	11 to 26 MHz;
Type B_2	Two-band MF and HF receiver;
Type B_3	One MF and two HF bands from 3 to 26 MHz;
Type C	FM receiver;
Type C_1	MF and VHF (FM);
Type C_2	MF/HF plus VHF (FM).

155. In addition, some consideration might be given to increasing the recommended power output from not less than 100 mW to 350 mW and possibly 500 mW for high battery drainage, with 750 mW for special applications. This principle is capable of further extension. It is possible that a standard specification for one receiver with a frequency range of 200 kHz to 26 MHz would be preferable. This specification could then be divided into two types of receiver: a single-band receiver having a frequency ratio of 3.5 and a 2-band receiver, each of whose bands has a 3.5 ratio.

156. The sensitivity for Type A receivers is given in the CCIR specifications for 50 mW output 30 per cent modulation at 400 Hz as 5 mV/m. There is some doubt whether this sensitivity is sufficient, and the specification should be checked in this respect.

157. The general recommendations of CCIR state that the receiver should be robust and well protected against dust. The controls should also be robust and include a channel-selection switch, a fine-tuning control to facilitate accurate tuning and to compensate for any frequency drift during operation, and a volume control.

158. It might be feasible to employ a switched rather than a variable tuning system, but it is doubtful whether the elimination of the condenser would affect the cost of the receiver significantly. Humidity can also affect the switching seriously, and the cost of a frequency change is extremely high. There is, moreover, the question of the buyer's requirements. It is unlikely that a radio receiver that is limited to the reception of three or four stations will have a widespread appeal.

159. The draft specifications produced by ITU are, it should be remembered, desirable characteristics rather than performance specifications. Detailed equipment specifications do not exist, nor is it within the purview of ITU to produce them. However, detailed equipment specifications might well be taken up by UNIDO, for this is a field of activity in which it has already signified its desire to co-operate with

developing countries. Indeed, the establishment of a pilot scheme for the production of low-cost radio receivers is one in which ITU, IEC, UNIDO and UNESCO might well find ground for fruitful co-operation to the immediate benefit of the developing countries.

160. ITU already has the machinery necessary for the feedback of relevant information from the developing countries. IEC is in a position to produce recommendations on the standardization of the equipment and procedures used to measure the agreed-upon characteristics. UNIDO's responsibility would be to evolve adequate production techniques to produce the desired results. UNESCO, which has been trying to stimulate interest in low-cost radios since 1962 (the price mentioned then was $5 and the required quantity 400 million), has already acquired a large amount of data in the area of market surveys and research. These data would be of great use in choosing points of maximum effectiveness to locate pilot-plant projects. UNESCO has an important part to play in the promotion of communications. It interprets its role in this field essentially as that of dramatizing the necessity for the widespread introduction of radio receivers for educational and cultural purposes. Perhaps the most important prerequisite, however, is to convince the appropriate levels of government of the urgency, the necessity and the immediate and long-term benefits of such a project.

The low-cost concept

161. Although the low-cost element of the phrase "low-cost radio receivers" is a concept that everyone appears to understand, it is not particularly easy to define. There is general agreement that a low-cost radio receiver should be reliable, easy to operate and give a good performance. However, all these qualities are functions of good basic design, which often is expensive. It may be countered that initial design and development costs can be amortized over long production runs. Even so, there is a limit below which it is impossible to go, and this is the basic cost of the set. If this bears no relation to the purchasing power of the average person in a country, then the set, however cheap it may be, is not a "low-cost" receiver as far as that country is concerned.

162. It has been suggested that "low-cost" should be defined as a function of the *per capita* income of a country. What will constitute low cost will therefore vary from country to country. At first sight, this approach appears promising, but, as previously stated, the cost of producing any kind of commodity depends on several factors, of which not the least in importance is the size of the manufacturing series for a single model. Low cost may perhaps be defined as the price that allows the largest possible number of people to purchase the item in question, but this definition is also not entirely satisfactory. To summarize, low cost is a relative concept and will be closely related to *per capita* income in the country where the receivers are produced.

163. It is essential that low-cost design does not imply unreliability. The term is used to indicate that maximum value should be obtained for the cost of the system. Over-designing must be avoided. The most important consideration with respect to design is to provide sufficient latitude in the specifications. If this is neglected, manufacturing procedures may require a critical realignment involving extra work

and extra components, both of which are associated with higher costs. Low-cost receivers do not necessarily depend on simple circuit design; the success of the design will depend on matching the circuit with components that are satisfactory in performance, cost, reliability and availability.

164. The main factors that determine the cost of the product are the following:

Design including circuit design and external appearance;

Quantity and size of each production lot;

Purchase prices of materials and components;

Cost of labour;

Skill levels of labour;

Manufacturing facilities;

Quality control;

After-sales service guarantee.

165. The attitude of the Government would appear to be the most important factor in the realization of the low-cost concept. As long as the radio receiver is officially regarded more as a luxury item than as a necessary adjunct to modern living, it is not possible to envisage much progress or improvement in the present situation. In some developing countries the import duties on components necessary for local manufacture are taxed at a higher level than complete imported receivers. In such circumstances it is hardly likely that the local industry will be competitive. In general, the duties levied on imported components are too high. Similarly, the allocation of foreign exchange for the purchase of equipment and machinery necessary for local production is rarely extended to the radio-receiver industry. The industry itself rarely appears on the list of priority industries to which financial assistance is available from government-sponsored agencies and corporations.

166. The inconsistencies and anomalies that prevail in many of the developing countries require governmental action to eradicate them. The provision of low-cost radio to the population should be seen as an objective of prime national importance, which should be accorded a very high priority in view of the effect it can have on the national economy and on the orientation and mobilization of society.

Transistorization and integrated circuits

167. The question of integrated circuits (IC) is critical. While at present they are used almost entirely in high-quality audio equipment such as FM-stereo tuners and TV receivers (in the United States, the Radio Corporation of America uses about 15,000 ICs daily), their use is being rapidly extended to certain kinds of switching and transmission equipment. Furthermore, in spite of their high initial cost, they are being used increasingly even in more ordinary consumer products such as radio receivers. It is probable that ICs will supplant semiconductors entirely, but this transition is likely to be gradual. It can be assumed that semiconductors will continue to be used in low-priced radio receivers for several years to come. It is sometimes contended that the use of ICs in radio and TV receivers will solve the problems of

maintenance and servicing, but the most usual sources of trouble with these receivers are the volume control and the tuning condenser. At the present time, ICs are manufactured only in Europe, Japan and the United States. India intends to manufacture them as soon as an adequate demand has been built up, at the moment, requirements are met through imports.

168. The use of ICs confers vastly enhanced opportunities for miniaturization, but size reduction in radio is not particularly important. Reliability is high, but so also is the cost. Also, as far as performance is concerned, the qualitative difference between ICs and semiconductors is minimal. For developing countries it is doubtful whether there is any advantage, economic or otherwise, in their use at this time unless there are other applications such as in the manufacture of computers, as in India.

169. Much the same kind of reservation might be said to apply to the use of varicaps, which are electronic devices that vary in capacity with the application of a d.c. voltage. Such devices have been in use in the United States and Europe for several years in both TV receivers and FM tuners to provide accurate fine tuning and to compensate for any tendency for drift in local oscillator frequency. While circuit designs are improving in stability, it is anticipated that the varicap principle will continue to be used for many years in the manually tuned TV and FM receivers. The use of varicaps in medium-wave or shortwave tuners is not practical for reasons of cost. In its present state, local oscillator circuitry is sufficiently stable; automatic means of drift correction are not considered necessary.

170. Developing countries must concentrate on advancing their technologies without engaging in the manufacture of highly sophisticated components. Although it is suggested that the way to IC technology is along the semiconductor path, such considerations are rather remote from the essential purpose of providing about 400 million low-cost radio receivers at short notice, which is the actual problem with which the developing countries are faced.

171. It would seem that, for some developing countries, the best possibility at present is the community receiver described in Recommendation 416 of CCIR (1963). Its adoption could be used as an interim measure, pending the widespread introduction of individual or family receivers.

Cabinets

172. Basically, a radio receiver has two elements: (1) the actual chassis and circuitry, and (2) the envelope or cabinet. The circuitry will largely determine the performance of the equipment; the cabinet will determine the external appearance of the set and may influence the acoustic quality of the set. From a cost standpoint, the ratio of (1) to (2) varies widely, but, for comparatively simple receivers, it may be said to lie in the region of 60:40.

173. For the most part, cabinets are fabricated from plastic in industrially advanced countries. There are good reasons for this: the raw material is very cheap and, when moulded, it is strong, resilient and stain-resistant and has excellent insulating properties. Injection-moulding equipment, once set up, will continue to produce cabinets at an extremely rapid rate virtually unattended.

174. Against all these considerations must be set the cost of the injection-moulding equipment typically about $50,000 and the cost of the mould itself about $10,000 for the average radio cabinet. An extended production run is required to recover the investment, and a manufacturer would normally expect to produce about 250,000 per mould. Although moulds may be rented, it must be remembered that the rental period will include transit time, to the plant and back again, which is likely to be as long and as costly as the time during which the mould is in actual use.

175. From the standpoint of cost reduction, the cabinet offers interesting possibilities, for it is here that a substantial part of the production costs can be minimized. Developing countries with a plentiful supply of wood might do well to investigate the possibilities of using it, either in its natural form or in the form of resin-bonded laminates. Attention should be focused on the following points:

The cabinet should be designed with the use of easily procurable materials in view;

The design should be simple and should avoid excessive ornamentation;

The cabinet should be easy to assemble and not require the use of complicated equipment or processes.

176. It has been said that investment in new metalworking machinery should be avoided, but it is clear that cabinets fabricated from, for example, a light alloy or medium-grade aluminium and covered by a nylon coating, using the hot-dip process, could be offered far more cheaply and in a far greater range of colours and styles than could plastic or wooden cabinets. For countries where wood is lacking, this solution may offer an alternative to the use of costly injection-moulding equipment. Furthermore, nylon has excellent insulating properties and is extremely durable and very cheap. Another advantage is that, although the process lends itself to mechanization, it can also be made highly labour intensive.

177. Figure 2 shows the points at which it might be decided to stop buying and start manufacturing cabinets. No comparative information for cabinets fabricated from aluminium or light alloys is currently available.

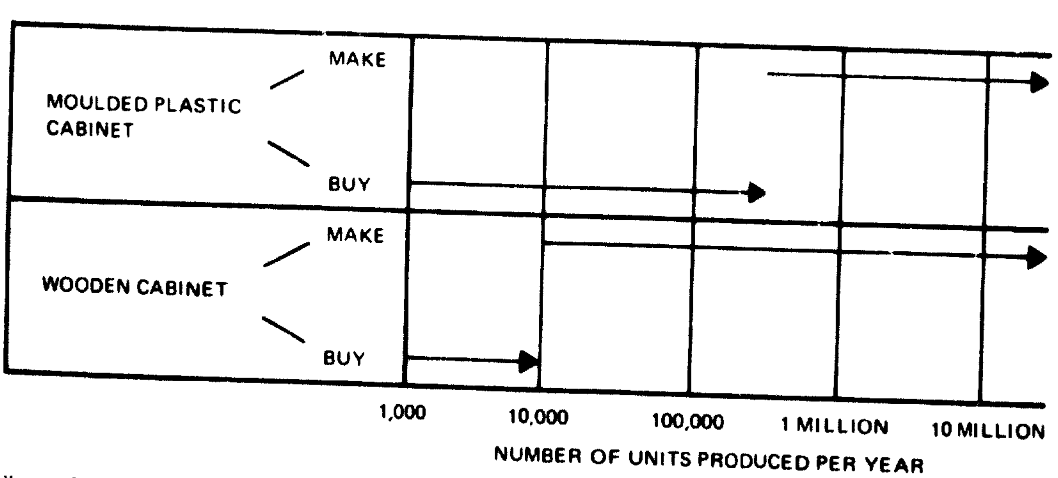

Figure 2. The relationship of the anticipated demand to the decision to make or buy radio cabinets built of wood or of moulded plastic

178. Perhaps as important as the technology and economics of producing radio cabinets is the matter of public acceptance. It is not economic to produce a consumer item that has little or no market appeal.

Circuit design

179. The age-old problem of balancing initial investment with producibility is one of the most basic and critical to be solved before a design can be considered. In Europe and the United States, a large initial investment in manufacturing facilities, tooling, and design is required because of the high cost of labour. In the United States, it is not uncommon to have an initial investment of as much as $200,000 in salaries, tools and equipment before the start of the production of a new AM radio receiver design; this is exclusive of the initial investment in the manufacturing and engineering facilities. This investment can be drastically reduced in the developing countries, where wages tend to be very much lower and more money can thus be spent on direct labour and less on equipment. This approach, however, must be taken with the full realization that it does not lead to long-term technological improvement, and the degree of design sophistication accepted should be considered in terms of the training and experience it involves.

180. Today most circuit components and materials are manufactured by mass-production techniques. Although there are indications that the component industry in the industrialized world is now operating seriously below capacity in some areas of production, this implies that most of the items required for the manufacture of radio and TV receivers are available on the market and at reasonable cost. The manufacture of these items requires a highly developed and sophisticated technology and production quantities far in excess of one country's requirements. In most cases, developing countries interested in the manufacture of low-cost receivers will be obliged to purchase the necessary components from industrially advanced countries, at least at first.

181. Information concerning the design of transistorized and vacuum-tube receivers is readily available. Receiver categories and specifications may be reviewed by referring to Recommendation 415 of CCIR (1963).

Components and technologies

182. Developing countries possessing comparatively unsophisticated machinery and tools may be able to produce from the start such items as AF and IF transformers, RF coils, film capacitors and simple switches. With delicate materials such as ferrites, it would be impractical to introduce domestic production until a substantial manufacturing base has been attained.

183. Very strict design disciplines are necessary to make extensive vertical integration economically feasible. A radio manufacturer who decides to attempt the production of loudspeakers, for example, places himself in competition with component vendors who have a volume base of millions of units a year. This will give an idea of the orders of magnitude involved in component production.

184. Domestic production of components also requires highly skilled mechanical, electrical and chemical engineers. The selection of appropriate techniques must also be considered. Once the product has been selected and the techniques for producing it have been decided upon, no change should be contemplated until the capital investment has been properly amortized. Typical components and the technology and equipment required to produce them are surveyed briefly below.

Magnetic circuits

185. Magnetic circuits are the basic components of a transformer. Starting materials consist of low-loss steel fabricated in sheets or rolls. Core-formers are made on sequence stamping presses. Single-operation concentric stamping tools are used in small-series production runs. The equipment required for the production of magnetic circuits for mains and output transformers includes:

Sequence presses;

Standard presses for pre-stamping;

Automatic presses for slotting;

Deburring grinders;

Tightening presses;

Lacquer-coating machines;

Coiling and uncoiling equipment for magnetic steel delivered in rolls;

Circular scissors;

Annealing ovens;

Waste-treating equipment for steel sheets and stamping tools.

186. Because of their delicacy, the magnetic circuits for loudspeakers pose special problems. Permanent magnets for these circuits are made from oriented ferrites or from special high nickel or cobalt steel alloys. The manufacture of these components is usually quite different from that of other magnetic circuits.

187. Magnetic conducting components are produced by standard mechanical engineering methods, that is, by stamping, heat pressing and the turning of cylindrical parts. Conductivity is increased by the use of annealing ovens, usually conveyorized, and the annealed parts are then insulated with metal. Special attention must be given to the metal insulation of the air gap and adjoining parts.

188. Basic equipment required for the manufacture of magnetic circuits is as follows:

Presses for flat parts;

Heated stamping presses;

Automatic machine tools for cylindrical parts;

Magnetizing and demagnetizing devices;

Turret or conveyor metal-moulding equipment.

Semiconductors

189. The basic starting material for the manufacture of semiconductors is semicrystalline silicon with controlled impurities of iridium, gallium etc. Homogeneous silicon monocrystals of high purity, 20 to 50 mm in diameter, are made from semicrystalline silicon by zone purification in induction ovens. Special devices are used to cut the monocrystals into wafers with thickness from 0.1 to 1 mm, according to intended use. These wafers are then accurately machined to the required thickness on automatic grinding machinery. The diffusion and epitaxial junctions are made in gas-filled, temperature-controlled ovens and then encapsulated after they have been provided with contact areas, soldered leads etc.

190. More complex components are made by planar-epitaxial methods. The system of leads, junctions etc. is deposited by metallic condensation on a photolithographically produced pattern. Programme-controlled optical systems of high accuracy are required for this purpose.

191. The production area for the manufacture of solid-state components needs a specially controlled environment with electrostatic air-filtration systems and constant humidity (5 per cent) and temperature control. The major items of equipment required for the manufacture of semiconductors are:

Zone-purification equipment;

Plate-cutting equipment;

Plate-grinding and plate-polishing equipment;

Checking and measuring devices to ensure that the plate conforms to the electrical and mechanical parameters;

Ovens for the diffusion processes;

Chambers for the epitaxial processes;

Checking equipment for intermediate controls;

Contact and soldering devices;

Encapsulation-process equipment;

Machines for attaching leads and applying glass or ceramic bushings;

Die-casting presses for cooling radiators;

Checking devices;

Photographic miniaturizing equipment for structural parts;

Programme-controlled stepping equipment for the manufacture of microstructures by planar technology;

Air-filtration and temperature-control equipment for all working areas.

Printed circuit boards

192. Printed circuit boards or cards are made from copper-clad, resin-bonded paper or glass-fibre laminates. Typically, the circuit pattern is printed on the copper cladding, using conventional screen-printing techniques. The inks used in this printing

process are designed to resist the mordants used to remove the surplus copper. Thus, after etching and cleaning, the entire circuit is presented in such a way that all that remains is to attach the components after a layer of 60:40 tin-lead alloy has been applied to the copper tracks by roller tinning machinery. Once the components have been loaded on the printed circuit board, the connexions are soldered, either manually or by the wave-soldering process.

Passive components

193. Included among the passive components are fixed capacitors and resistors for radio and TV receivers, electrolytic capacitors, power capacitors, potentiometers (for power-factor compensation, interference suppressors, amplifiers, transmitters etc.), soft and hard magnetic ferrites, switches, pushbuttons, variable capacitors and special components. They are required in developing countries for use in domestic production programmes and as spare parts for imported equipment.

194. The components that may be manufactured domestically at present include fixed capacitors and resistors for receivers, electrolytic capacitors, soft magnetic ferrites and variable capacitors. Because of the large quantities necessary to justify production, certain products should be manufactured in one plant serving the needs of several countries. Indeed, capacitors and resistors may be in such great demand that it would be feasible to manufacture a uniform type for several countries; this would be possible where the demand for one type exceeds 10 million pieces per year.

195. Some indication of the levels of output required for economic operation is given by the following:

Capacitors	12×10^6 units per year
Resistors	2×10^7 units per year
Semiconductors	20×10^6 units per year

Such levels can be achieved if the number of types produced is restricted. If it is not, production will not be economic.

Loudspeakers and other electroacoustical devices

196. Loudspeakers for receivers, power speakers for public-address systems, transmitter insets and receiver capsules for telecommunications equipment, headphones, high-fidelity (hi-fi) speakers and general-purpose microphones are included in this category. With the exception of power speakers and those intended for hi-fi applications, all these products are suitable for domestic manufacture. In particular, it would appear to be most profitable to manufacture loudspeakers for radio receivers when production is linked to that of low-cost receivers.

197. Ideally, the manufacture of most of these products should be concentrated in one plant serving the requirements of a group of countries. A plant producing magnetic circuits for loudspeakers should ideally be located in a country whose natural resources include nickel, cobalt, aluminium and ferrite materials. The manufacture of paper cones for loudspeakers is complicated and requires a paper material of high quality.

198. Efficient production of magnets and of standard magnetic circuits in a country with an adequate material base should offer interesting possibilities for export even to industrially advanced countries. Licences should be purchased for the manufacture of resistors, ferrite cores, switches and variable capacitors in order to promote good product quality and operational reliability. Licences and specialized production equipment are important for the production of high-quality oriented magnets made from alloys and ferrites and also for the production of paper cones for loudspeakers.

199. If the regional approach were adopted in the manufacture of components, it might be necessary to decide how many regional units should be established in each continent. If the figures previously quoted are strictly applicable, one such unit might suffice for the whole of Africa. Of course, it would be possible to have one factory for resistors located in one country and another for paper capacitors in another country, and so on. Each country, however, should possess its own assembly line.

200. Basic research aimed at introducing a local raw material content into an established design is needed, for this would entail deviation from the original manufacturing specifications. R&D facilities would thus be required. Figure 3 illustrates the decision points for the manufacture of certain components.

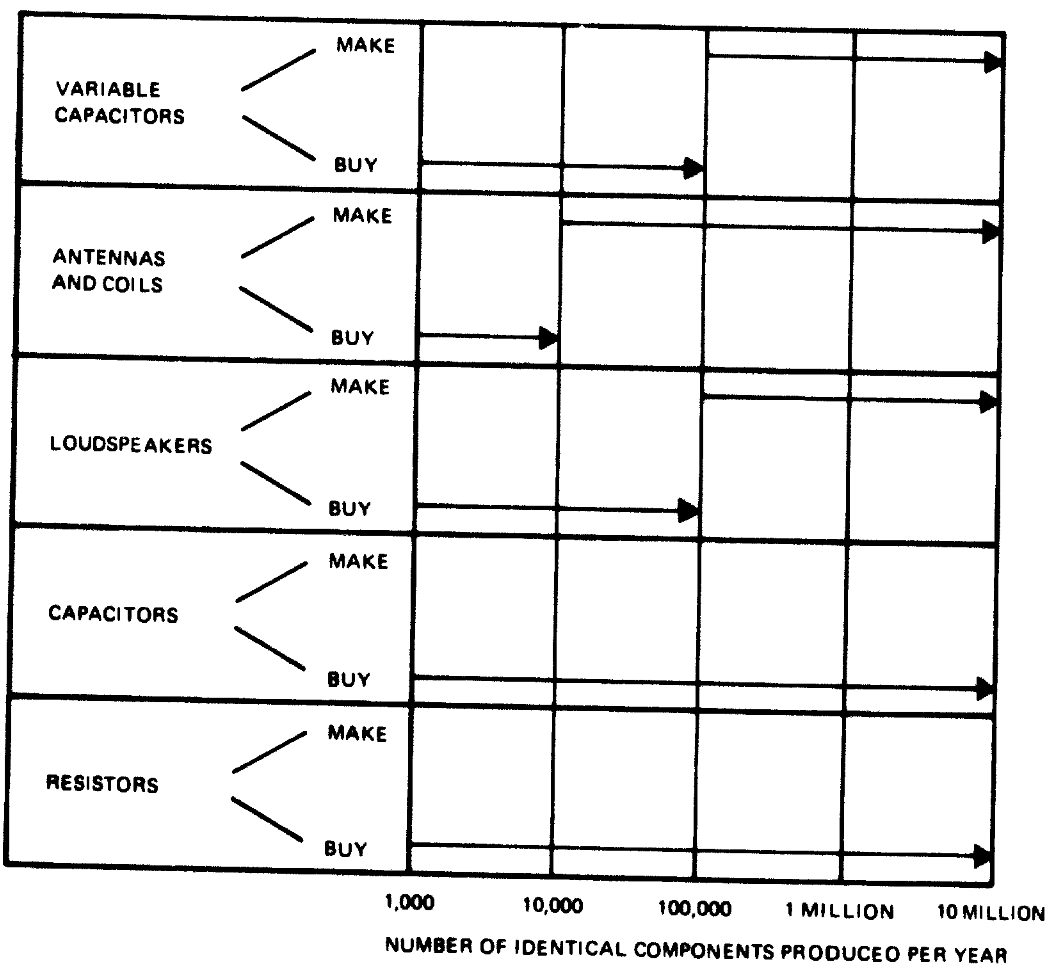

Figure 3. The relationship of the anticipated demand to the decision to make or buy certain components

C. MANUFACTURE

201. Under the agenda item on manufacture, the meeting surveyed a wide range of practical problems. Detailed consideration was given to plant layout and design, production techniques, materials handling, and labour requirements in three principal areas, namely, radio receivers, low-cost TV receivers and telecommunications equipment.

Radio receivers

202. Production costs are a function of the size of the series and of the daily volume of output. Where daily output is below 400 receivers, factory costs are likely to rise steeply. Indeed, the lower limit is probably in the region of 200 sets daily, and any lesser quantity would be quite uneconomic to produce.

203. When the production of radio receivers is begun, special training of factory personnel may be required. The ability to meet a production schedule depends primarily upon the appropriate factory facilities and upon suitably trained engineers, technicians and assembly workers. However, the training of assembly-line operators does not present much difficulty: the techniques can be satisfactorily mastered in as little as two weeks.

204. Thorough examination of trial products and careful pre-production runs are important preparatory steps in the mass-production system. Most malfunctions and production bottlenecks can be pinpointed at this stage and the necessary steps taken to eliminate them. Once the design work has been completed and the parts list, with specifications, has been drawn up, a small batch of 10 to 12 sets is manufactured. This is done in order to evaluate the product and to make a detailed production schedule based on an analysis of the processes involved. When necessary, the original design is modified in the light of this evaluation. The detailed production schedule is made by breaking down the assembly process into a series of discrete operations. Each assembly worker is then assigned a certain number of these operations, their number and type being closely matched to his ability and skill. As a general rule, it is considered that, initially, no more than five types of mounting or wiring operation should be performed by any one worker. Assigning a larger number is likely to lead to confusion and faulty workmanship.

205. Clearly, vertical integration is feasible only where a large production base justifies the additional investment in plant and machinery. The manufacture of components is a highly competitive field, and to reach a decision to manufacture rather than purchase them, it would be necessary to weigh carefully the advantages and costs of setting up production facilities against the immediate disadvantages of the loss of competitive bidding for these items on the world market.

206. Another factor must also be taken into account. Although, as shown in figure 3, the economic level of manufacture of resistors, for example, is approximately 10 million units of the same type, a case can certainly be made for a lower production level where savings in foreign exchange justify domestic manufacture.

207. Following the trial batch, several small pre-production runs are carried out so as to permit a uniform examination of the product performance and to check the accuracy of the manufacturing instructions. These pre-production runs are typically of batches of 10 to 12 sets and are carried out on the normal production line. Five or six batches may be necessary. Not only does this procedure provide a thorough testing of the product and of the production line, but it also serves as excellent on-the-job training for all the personnel concerned. Regular production is begun when the receivers produced in the pre-production runs have satisfactorily passed their tests and final inspection.

Plant layout

208. A dual-belt conveyor system probably provides the most economical and compact plant layout for a monthly output of 10,000 radio receivers. Such an arrangement will require about 2,400 square metres of factory floor space. In addition, space will be required for such auxiliary facilities as goods-inward and goods-outward stores, offices, a laboratory, a screened room, a toolroom and a compressed-air plant. Work stations are provided on either side of the belt, and wiring and compressed-air lines should be brought in from overhead so as to allow subsequent layout changes to be accomplished with a minimum of disruption.

209. Figure 4 illustrates a typical dual-belt conveyor plant. It comprises a series of 48 stations distributed over a dual run of 30 metres; the total effective length of the belt is thus 60 metres. The belt width is normally about 300 mm and it is driven by a 0.75-kW motor to give a speed which is continuously variable between 0.5 and 2.0 metres per minute. Workbenches are approximately 900 mm by 700 mm and are usually constructed with plywood tops. All working surfaces are about 750 mm above floor level.

210. The power supply to the work stations should, from the point of view of safety, be a.c. 100–120 V or a.c. 220–240 V. Electric current consumption is confined to soldering irons, test instruments and room lighting. Compressed air is also used to operate certain tools.

211. The screened room is required for precise performance tests and for the accurate alignment of the product. These processes must be carried out in an environment completely free from parasitical electrical disturbances. A Faraday cage with inner and outer mesh grounded at a common point and having an attenuation of 100 dB would be required for attenuating radio interference on frequencies from 400 kHz to 400 MHz. It may also be necessary to filter the main power supply to the screened room by means of a low-pass filter.

Flow-line operation by the conveyor-belt system

212. Flow-line operation, using the conveyor-belt system, is probably the most effective means of increasing productivity and of reducing the product cost. Typically, the layout of each process is made according to the assembly sequence in such a way that no work is delayed on the belt, no work can be moved backward, and all work

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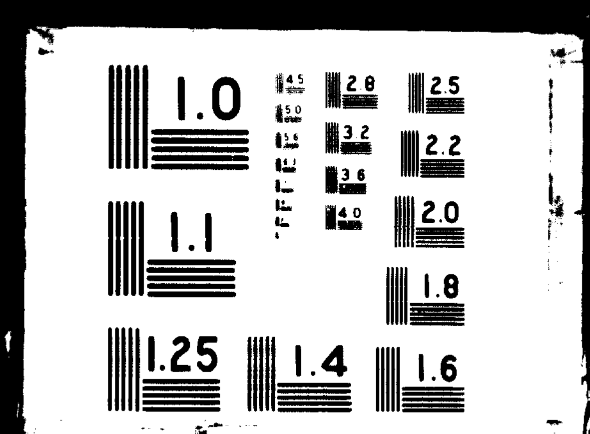


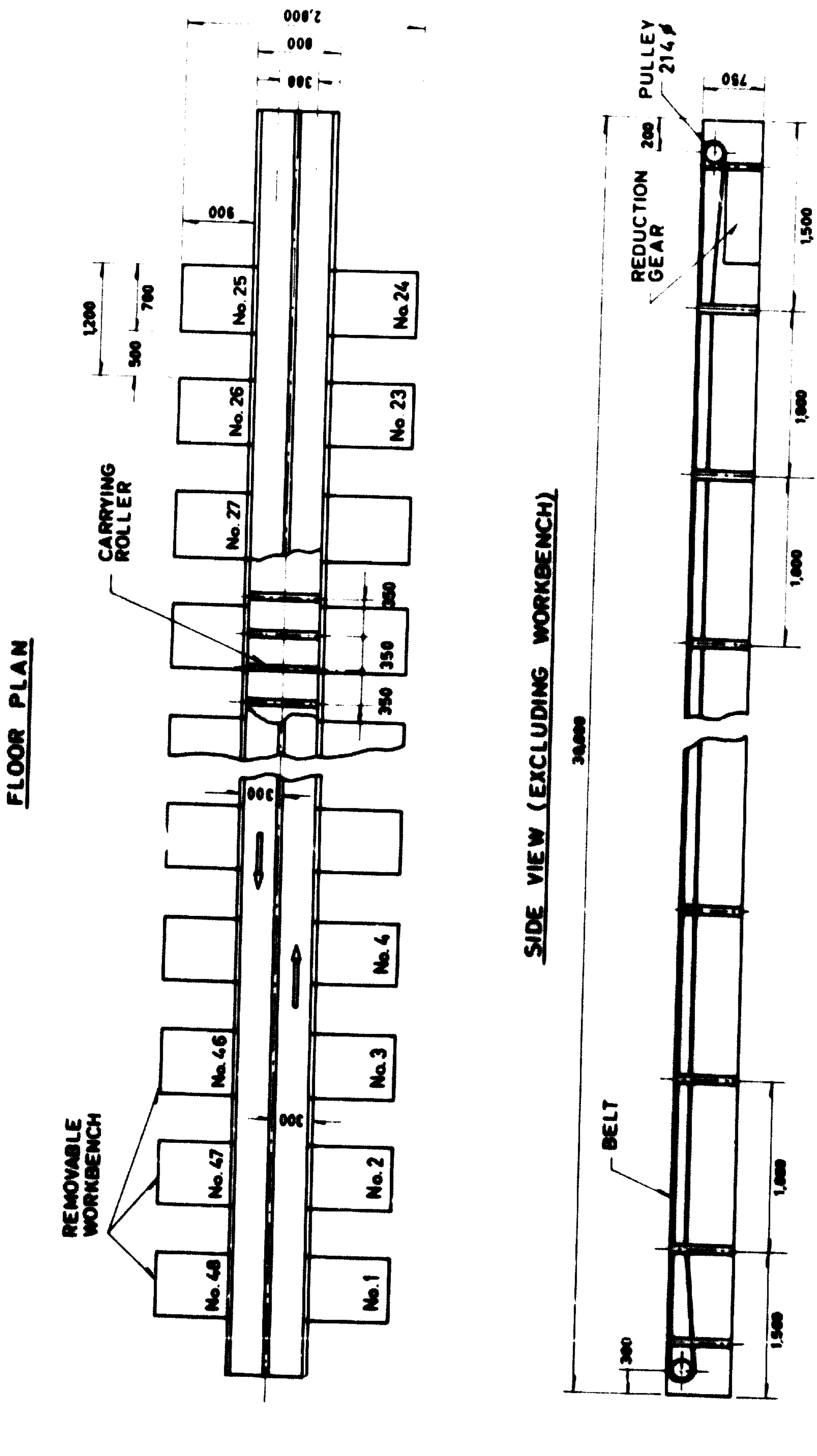


Figure 4. Floor plan (top) and side view (bottom) of a typical dual-belt conveyor assembly line (dimensions in mm)

passes through each assembly station. To fulfil these conditions, a uniform work time must be established for each operation. This time is arrived at by process analysis, which determines:

The appropriate assembly procedure;

The total number of processes involved;

The number of assembly workers required on the flow line;

The work content of each operation;

The most appropriate methods of using tools, jigs etc.

213. It is necessary to assume both a uniform level of skill on the part of the assembly workers on the flow line and that every assembly operation can be performed within a specified time unit, which is known as the standard work time. In order that each operation on the flow-line will be properly carried out, it is also necessary to institute a series of on-line checks. These checks are inserted into the line at critical points, and work that fails to pass them is removed from the belt and passed to an adjacent repair station. After rectification, the item is returned to the line at the correct point and allowed to continue down the line.

Operating instructions

214. Each assembly worker on the flow line works according to formal operating instructions. While in some cases it is possible to convey these instructions orally, it is always best to have them posted conspicuously at the appropriate work station. Illiteracy may raise some problems here, but with care a visual representation of the operating instructions can be made that will convey unambiguously the correct sequence and manner of working. Where no problems of illiteracy exist, the operating instructions should specify the process number, the operating sequence, the operational procedure, the standard work time, the number of parts used (with schematic diagrams to illustrate areas requiring particular attention), the tools used, the subsidiary materials that may be required and any information of a precautionary nature. A space should also be provided to record any defects.

215. Figure 5 illustrates the kind of feedback network required for the continuous monitoring of a flow-line operation.

216. While the worker at each station in the flow line performs an operation to turn out a predetermined work load according to an established operating procedure that is recorded on the operating instruction sheet, he may fail to perform the operation several times daily. Check sheets are attached to the work at each checkpoint on the line. The relationship between the checking system and process control is shown in the loop system illustrated in figure 5. It will be noted that both process-defect data and defect-repair data are required to institute the necessary countermeasures. Daily fractional defects are recorded on a control chart.

Electrical performance-measurement data

217. In addition to the production-control data discussed above, data on the electrical performance of the product will be required to ensure that performance

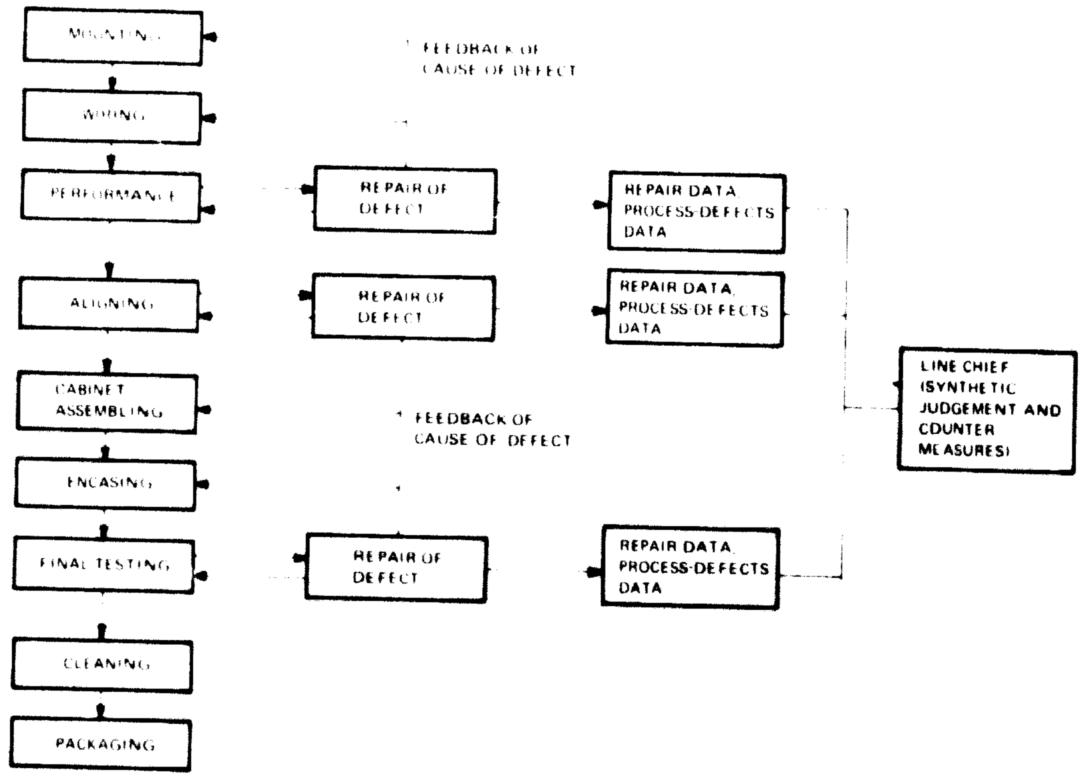


Figure 5. Typical feedback network required for the continuous monitoring of a flow-line assembly operation

specifications are being maintained. These tests are usually conducted on a random-sample basis. Any five to ten units are selected at random from the flow line and are checked for the following characteristics:

Sensitivity;

Signal-to-noise (S/N) ratio;

Tuning-scale error;

Image-frequency interference ratio;

Intermediate-frequency interference ratio;

Selectivity.

Production control

218. Production control exercises a co-ordinating function on the planning situation and on the control mechanism of the production setup. Thus, production planning, procurement planning and sales planning are brought together and harmonized over a set period of operation that will normally run to about six months but may extend to one year. The co-ordination takes place on what is usually known as the master schedule, which contains details of delivery and sales forecasts and the financing necessary for the operational period.

219. The basic data for the master schedule will be derived from the factory floor. It should be established in such a way as to provide a work load that is accurately matched to the capacity of the production line so that it will be able to function optimally, thus eliminating problems caused by excessive loading and idle time resulting from insufficient loading.

220. The working of the master schedule is supplemented by a monthly detailed planning schedule, which is designed to compensate for inaccuracies in the master schedule and to allow for discrepancies. These discrepancies may take the form of inaccurate estimates, delays in delivery of materials, manpower shortages etc. Efforts should be made to draw up the monthly detailed schedule in accordance with the master schedule as far as is possible. The estimated number of units to be produced daily and the standard number of man-hours should appear on the detailed schedule.

221. The number of units in the daily output is given by the following formula:

$$\frac{\text{Number of workers} \times \text{rate of attendance} \times \text{work time}}{\text{Standard number of man-hours}}$$

222. The number of days for completion of one production batch is calculated as follows:

$$\frac{\text{Standard number of man-hours} \times \text{number of units in the batch}}{\text{Actual man-hours}}$$

223. The number of workers required for a particular production level can be found by:

$$\frac{\text{Number of units of daily output} \times \text{standard number of man-hours}}{\text{Work time}}$$

224. The detailed schedule should also take into account the increase in efficiency that comes with familiarization. When a new item of equipment is put into production, a familiarization allowance should be made to take into account the period over which the individual workers become intimately acquainted with the new assembly process, which is usually from five to eight days.

Loading the production line

225. The production line must be loaded in accordance with the master schedule. Loading must take into account the required delivery date of a specific type of equipment and the number of units to be manufactured. Where adjustments with respect to additional labour are called for to meet a particular delivery date, the appropriate countermeasures must be initiated through the personnel department. Where sufficient labour cannot be obtained, other countermeasures, such as subcontracting, will have to be instituted.

Production control

226. Production control implies an accurate knowledge of the location and the amount of the finished goods, plus the exact status of all work in progress. As a control function, its purpose is to eliminate unnecessary work movement and to ensure that parts are neither omitted nor used for purposes other than those intended. Standard supervisory procedures and countermeasures are adequate for these purposes. The basic organization of production control is diagrammed in figure 6.

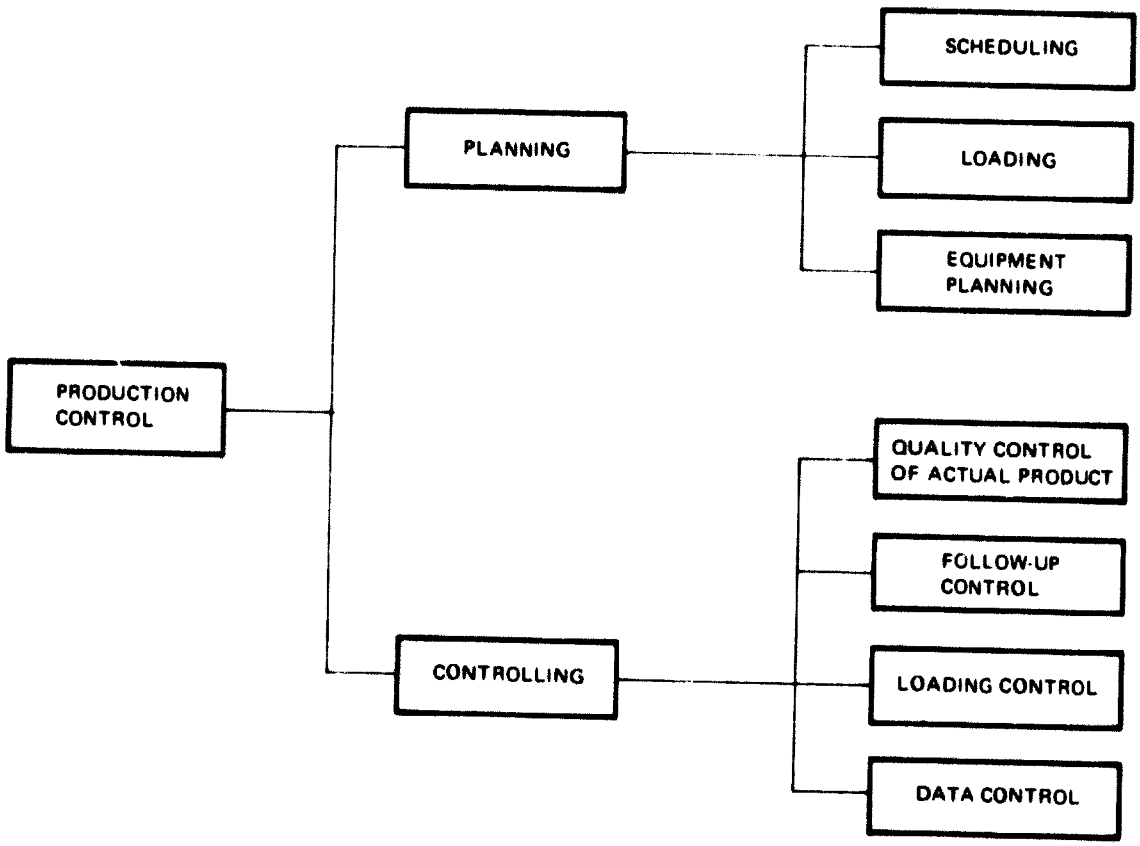


Figure 6. Block diagram of the basic organization of production control

227. Figure 7 presents the flow chart for a production line for the manufacture of a typical radio receiver, showing the general layout, the location of the various work stations, and the arrangement of the instruments needed. (These instruments are described in table 9.) In this setup, there are 44 production steps (work stations), and production is 480 sets per 8-hour workday. The pitch time (that is, the time to produce a complete set) is 60 seconds.

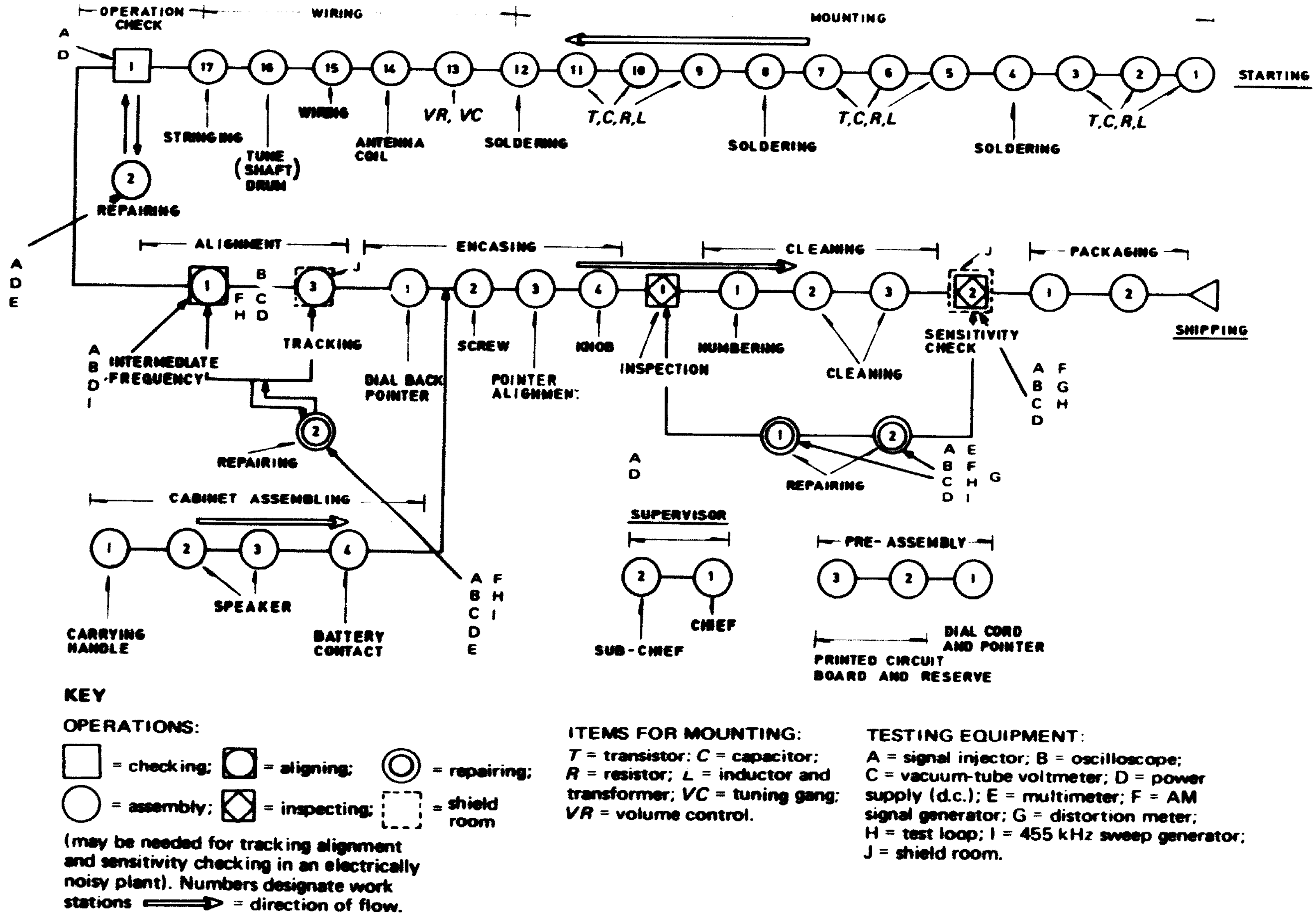


Figure 7. *Flow chart for the production of a typical radio receiver, including layout and arrangement of instruments*

TABLE 9. SPECIFICATIONS OF MEASURING INSTRUMENTS USED IN THE ASSEMBLY-LINE PRODUCTION OF A TYPICAL RADIO RECEIVER[1]

Item[a]	*Category*	*Specifications*
A	Signal injector (pulse generator)	Frequency: 200 Hz Output: 1V–2V peak Pulse width: 0.01–0.02 msec
B	Cathode-ray tube (CRT) oscilloscope	CRT (5-inch diameter) Sensitivity: Vertical–1 mV/cm Horizontal–10 mV/cm
C	Vacuum-tube voltmeter	Frequency range: 30 Hz–200 kHz Sensitivity: 0.01 mV–100 V at input impedance of 500 kΩ
D	Stabilized d.c. power supply	Output: 0–25 V, ± 2% 0–2 amp
E	Multimeter	Resistance range: up to 1 MΩ Voltage range: up to 100 V (100 kΩ/V) Amperage range: up to 1 Amp
F	AM signal generator	Frequency range: 100 kHz–30 MHz Output: 1μV–1V flat within ± 1 dB Modulation: 0–100% Modulation frequency: 400 Hz, 1,000 Hz Including test loop
G	Distortion meter	Frequency range: 20 Hz–200 kHz Distortion range: 0.1%–30% Level: 0.3 mV–10 V
H	Test loop	Frequency range: 400 kHz–30 MHz Loop diameter: 250 mm Cable length: 1.2 m
I	455 kHz Sweep generator	Centre frequency: 400–500 kHz Sweep: 0–± 50 kHz Marker: 445, 450, 460 and 465 kHz Sweep rate: ½ of line frequency Output control: 100μV–0.1 V
J	Shield room	Frequency: 400 kHz–200 MHz Attenuation: 60 dB Dimensions (cm): 180 depth, 180 width, 180 height

[1] See related flow chart, figure 7.

[a] The letters A, B, C etc. refer to the items as they are shown in figure 7, flow chart for the production of a typical radio receiver.

Degree of manufacture

228. Manufacturing can be organized in various ways, according to the complexity of the operations involved. The manufacture of radio and TV receivers is typically divided into the following four levels or stages:

Assembly from SKD condition;

Assembly from CKD condition;

Super-assembly, that is, assembly with the use of a proportion of locally made components (coils, variable capacitors, transformers, loudspeakers);

Real manufacture.

229. The first two stages are not particularly difficult and require good organization and management rather than large capital investment, but super-assembly requires more capital, more skilled personnel and a more complex organization. The degree of manufacture corresponds fairly closely to the amount of foreign-exchange savings involved. Assembly from SKD condition represents a very small foreign-exchange saving. Here, assembly consists of little more than putting together completed subunits and mounting them into a cabinet.

230. As the domestic component and labour content increase, the foreign-exchange savings also rise. As a point of interest, in one country it was noted that, whereas in 1954 the labour content of SKD assembly was 3½ to 4 hours, in 1969 this figure was less than 1 hour. The final stage, real manufacture, is the most demanding of all and requires great diversity and highly specialized personnel.

Level of production

231. According to Philips of Eindhoven, the Netherlands, the economic level of production (real manufacture) in 1959 was approximately 20,000 sets per year. This quantity would be quite uneconomic today because of the introduction of plastics and transistors and the reduction of the labour content.

232. However, while these levels may apply rigorously to the industrialized countries, they have little relevance to the developing countries. The example of the MERA co-operative of Kigali, Rwanda, might be cited. This co-operative, employing approximately 60 workers, without any fiscal or trade advantages whatsoever, and with no locally available basic materials, manages to produce 6,000 radio receivers yearly at a small profit. The output of this co-operative was expected to rise to 8,000 sets in 1970 and be stepped up progressively to a total of around 20,000 a year by 1979. This is an example of what can be done where the desire is strong enough. The taxes are high, the market small, the supply lines very extended and there is no tariff protection at all. Obviously, insufficient account is taken of the differences between European production techniques and those employed in the developing countries.

Exports

233. With export-oriented industries, the primary requirement is to meet delivery schedules, especially where components are concerned. Delays in a customer's production lines because of an exporter's inability to meet his delivery promises

cause a great deal of annoyance, loss of income and a resolve not to buy from the same source again. Reliability of supply is essential to generate the atmosphere of mutual confidence that industry requires.

234. Another problem that export industries in developing countries often face is that of paying import duties on raw materials. These duties are repayable upon exportation of the finished product, but a number of Governments make this refund only after a considerable amount of time has elapsed. This situation may be due to administrative inefficiency or to official policy, but in either case it makes the operation of industry difficult. There is room for improvement here.

Low-cost television receivers

235. Much of what has been written above with reference to the production of low-cost radio receivers also applies to the manufacture of monochrome TV receivers. Technically, one is dealing here with a much more sophisticated product; nevertheless, low-volume production of monochrome TV receivers does not require experienced or skilled labour for the actual assembly operations. Technical proficiency is required only in the finding and correction of defects at the production-line repair station and in quality control.

236. Figure 8 presents a schematic diagram of the organizational structure of a plant to produce 1,000 monochrome TV receivers monthly from the CKD condition. Obviously, staffing is a matter for local decision; the type of staff indicated in the diagram is offered only as a general guide. While the shown ratio of 7 nonproductive (supervisory) personnel to 43 direct-production personnel is not particularly favourable, it has been found to be suitable for an assembly plant of this size and kind. Also, as production volume increases, the ratio will change to permit a much higher proportion of productive to nonproductive personnel.

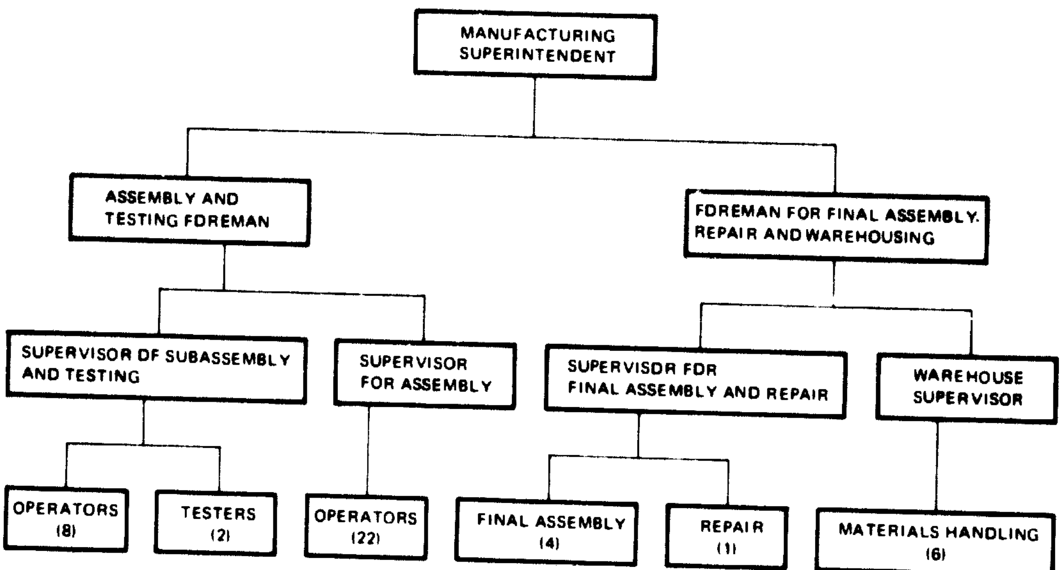


Figure 8. Block diagram of the organizational structure of an assembly plant that produces 1,000 monochrome TV receivers monthly from the CKD condition.

Production techniques

237. Most of the TV receivers manufactured today are produced on high-volume automated lines. Process information from such lines would be of little use to the small assembler even if it were made available to him. One technique that has proved successful for the small assembler is to purchase several complete instruments of the type to be purchased in SKD form. At least one sample is retained, without change, as a control, and at least one other sample is used for alignment training and technician training in defect-finding and troubleshooting. At least one sample is completely disassembled, step by step, with each step recorded, both in written form and photographically. The positions of the components and the wires are sketched, and each part is identified on the bill of materials and on the technical data sheets. This disassembly is carried to the point where all parts have been removed and the original receiver is now in the form of a complete kit of parts. The process is then reversed, and the assembly instructions can be written down. Additional advantages of this procedure are that the technicians who perform the disassembly become completely familiar with the layout of the receiver and with its construction, with the original factory wiring, and with the identification of the parts on the bill of materials. Furthermore, all wires are cut to the appropriate lengths and can be used to set up the cutting templates for the new assembly process.

Typical assembly process for monochrome TV sets

238. Since even the simplest TV receiver is a complex piece of equipment, its assembly is best considered, not as merely a single series of simple operations, but as three successive phases, centred respectively around *(a)* subassemblies, *(b)* chassis assembly and *(c)* final assembly, each phase consisting of several steps or subdivisions, as shown below. This phase includes, in addition to the subassemblies properly speaking, wire stripping and inspection.

239. *Tuner mounting assembly (TMA).* The tuner, sometimes called the RF unit, is purchased as a single, complete unit ready to be installed in the TMA. Because of the complex nature of the tuner and the delicacy of the adjustments to it, it is not wise to consider purchasing the tuner as a kit for local assembly. This caution applies even more particularly to UHF tuners, since their operating frequencies are much higher, making the tuning adjustments and the need for mechanical stability even more critical.

240. Stocks of TMA, with any associated brackets or controls and any connecting leads, may be built up ahead of production, and the inventory may be inspected and stored. When production begins, they can be fed into the chassis assembly position as required. As with any other item of subassembly or chassis assembly, it is important that they be adequately protected from dust when in storage.

241. *Printed circuit boards.* The printed circuit board, sometimes called the printed wiring card, is ideally suited to subassembly techniques. It may be assembled, soldered, inspected and, in some instances, electrically tested before being installed in the chassis. In most designs the printed circuit board (s) contains as much as 90 per cent of the receiver circuitry, a fact that serves to emphasize the need for care in its assembly. Its use also serves to reduce, both in quantity and complexity, the remaining chassis wiring.

242. During the start-up period of circuit-board assembly, it is especially important for the assembly operators to work with sample boards in front of them so that the assembly process may be continually self-monitored. In very low-volume production operations, one operator can handle the entire assembly requirement. All components should be arranged for maximum ease of assembly. Even when only one printed circuit board assembly operator is doing the work, the process should be laid out in its successive stages, each position having its own sample board and its own array of parts. Since a single misplaced, incorrect or missing component will later result in a great deal of lost time for repair, it is essential that each assembly operator have a simple means of checking the correctness of his work. This is easily accomplished by fabricating a flat mask of thin plastic or metal with holes accurately cut to indicate the precise position of each component to be installed in each assembly position. After the assembly operation, the mask is placed over the printed circuit board. Any missing or incorrectly mounted components will immediately be evident.

243. Simple wooden or metal jigs, which can be made locally, serve as loading jigs during the assembly process. On completion of component loading, the board is ready for soldering. This may be done by individual spot soldering or by making use of a simple dip-soldering technique. Immediately before soldering, a flux solution is applied to the side of the board to be soldered. This is best done with a small spray gun of the type used for paint spraying. The actual dip soldering may be accomplished by the use of a simple wooden jig to support the board by its edges. The board is then lowered to the surface of the solder pot. A 4-second "float" is usually sufficient when the solder temperature is maintained at 450°F (232°C). After cooling, a further half-second "float" will serve to remove any excess solder. The board is then cleaned, excess wire lengths are clipped off, solder bridges between copper tracks are removed, and both sides are carefully inspected. This inspection and any resultant corrections will greatly reduce the rejection rate at the final test position.

244. *Wire stripping.* In the process of subassembly and chassis assembly, many connecting wires are used. These wires are usually of varying lengths and colours. The colour coding of wiring is useful during the assembly process and in troubleshooting. The exact length of wire required in assembly may be determined either from the wire-cutting list provided by the SKD kit supplier or from the list made during the disassembly process of one of the original receivers. All wires in the receiver should be precut, stripped and stored in bundles for use on the assembly line.

245. *Miscellaneous subassemblies.* The most important of these, the high-voltage cage, is sometimes called the extra-high tension (EHT) box. It contains several components and the high voltage (EHT) rectifier tube. This section can be subassembled for later installation in the chassis. Also included here are the control subassemblies. In many designs, some of the operating controls are remote from the main chassis. The lead wires and brackets associated with these controls can be subassembled for later connexion to the chassis.

246. *Inspection.* All subassemblies should be inspected before being set aside for installation in the chassis.

CHASSIS ASSEMBLY

247. In addition to actual assembly operations, the chassis-assembly phase also includes some testing and inspection procedures.

248. *Riveting.* Before the chassis is ready to receive any electrical components, all needed mechanical brackets, sockets, terminals and the like must be attached to it. This is usually done by riveting, although screwing and bolting are also used in some designs. Since the average chassis will require several sizes of rivets and the number of riveting machines is usually limited, all operations using the same size of rivet can be performed at the same time on a large group of chassis. The setup of the riveting machine can then be altered to suit another size of rivet, and all operations requiring that size can then be carried out.

249. *Component mounting.* This part of the assembly process covers the mechanical mounting to the chassis of components that are mounted directly to the chassis. These will include the power transformer, electrolytic capacitors, filter choke, power connectors etc. These components are normally screwed or bolted to the chassis to facilitate their removal should service be required at a later date.

250. *Printed circuit board mounting.* The printed circuit board, having been completely subassembled and inspected, is now mounted to the chassis, and the connecting wires are installed and soldered. Printed circuit boards are normally mounted by eyelets. Eyeleting can be done by a riveter on a machine set up for this purpose.

251. *Chassis wiring.* At this stage the rest of the chassis components are mounted or installed. All connecting leads are added and all connexions soldered by hand. During this operation a sample chassis should be used for guidance, or drawings may be prepared illustrating each part and each wire and its connexion. Because of the ease with which wiring errors can occur during chassis wiring, the process should be divided among several operators; as many as 6 chassis-wiring operators may be needed to wire 50 chassis per day correctly. The soldering is particularly important, and careful instruction in soldering technique is required. After this stage in the assembly process, the chassis is complete, and all subassemblies should have been installed and connected.

252. *Inspection.* The most critical inspection occurs at this point. The entire chassis must be inspected for missing parts, wrong parts, wiring, tightness of components and soldering. It may be of interest to note that most in-plant quality problems are the result of improper soldering.

253. *Testing and alignment.* The exact steps in routine testing and alignment will vary with the individual set design. Generally, the operation will be as follows:

Resistance test for power-supply short circuits;

Application of power and measurement of power-supply voltages;

Power is disconnected and the chassis is connected to an oscilloscope and deflection yoke, a speaker, and the test-alignment equipment specified by the set manufacturer;

Power is reapplied, and the circuits are checked for operation of video and deflection circuits and for noise from the speaker;

The specified alignment process is performed to cover the following circuits: tuner/IF link; picture IF; over-all response; and sound IF.

At the completion of the testing and alignment, the chassis is complete and in operating condition. It is now ready for installation in the cabinet. It is at this stage that operational defects first occur, and for this reason the repair bench is usually adjacent to the testing and alignment positions.

FINAL ASSEMBLY

254. During the phase of final assembly the TV receiver takes the form in which the customer will receive and use it. Consequently, all work must be performed accurately, and inspection and testing must be thorough. The various steps are presented below.

255. *Installation of the mask and the picture tube in the cabinet.* In most receivers, the mask that frames the picture tube also forms the front panel of the set. The speaker is also installed at this point.

256. *Installation of the chassis in the cabinet.* The completed chassis, with the TMA, auxiliary controls and antenna terminals, is installed and secured to the cabinet. The front panel trim and knobs are attached, and the picture-tube neck components such as the deflection yoke are placed in position.

257. *Final setup and adjustment.* At this point the receiver is given an over-all operational check of all functions. The adjustments that must be carried out require a test pattern or a linearity pattern generator, plus a sound signal, in order to perform the following checks:

Tuner operation	Centring
Control operation	Height
Focus	Width
Automatic gain control (AGC) setup	Linearity
Picture tilt	

258. *Inspection.* This is the final inspection before the instrument is packed and therefore covers all items of appearance and operation.

259. *Operational test.* It is highly recommended that an operational test be conducted for at least four hours on every receiver produced. This is particularly important in the early months of production and until enough experience has been acquired to show whether this operational period should be increased or decreased. Timing devices can be used to turn the receivers on and off at predetermined intervals to stimulate operation in the home. A typical cycle used in performing life tests is 1¾ hours on, ¼ hour off, with one cooling period of 4 hours each day. Such extensive life testing is not normally employed by firms that assemble from the SKD or CKD condition.

Quality control

260. It is much better and easier to create an initial image of good quality in a consumer market than it is to correct an image of poor quality. Similarly, on the production line it is better and easier (and also less costly) to assemble the product correctly than to assemble it carelessly and have to repair it. The personnel responsible for inspection and testing have a very important task, which usually demands a greater degree of intelligence than many other tasks and could carry an incentive in the form of higher wage rates.

261. Quality control can take many forms. Major companies spend large sums of money to assure the best possible performance and durability of their products. Television assembly in developing countries is generally started with SKD kits representing a quality product of proven design. Such products will, when assembled, tested and properly aligned, be of good quality and perform well, since a certain amount of quality control will be built into them. This does not, however, relieve the assembler from any of his responsibilities for product quality.

262. Quality control begins when the first parts arrive at the factory. Goods-in inspection should be instituted to check quantities and correctness of parts against the bills of materials or parts lists. In some instances drawings will be supplied by the vendor. Simple electrical tests can be performed, where applicable, as a means of indentifying defective components before they arrive on the production line.

263. Production inspection can be set up as follows:

One inspector for all subassemblies. Inspection routines will cover soldering, correctness of parts, missing parts and the length of the leads.

One or two inspectors for printed circuit boards. They may also be responsible for cleaning and repairing soldering defects as part of the inspection routine. They will inspect for poor soldering, missing solder, incorrect parts, loose parts and broken parts.

One inspector for chassis assembly. Here the inspection routine will cover wiring, poor soldering, loose parts, missing parts and incorrect parts.

One inspector for final assembly. The inspection routine at this stage must cover all items of appearance and operation.

264. After each of the above inspection operations, the inspector should initial or stamp a part of the chassis in a predetermined spot with an indentification to indicate that the inspection has been carried out, by whom, and the date, which may be taken from the normal calendar or from the factory calendar.

265. For guidance, the following specific checks should be performed:

Visual checks:

Check that all parts and valves have been properly installed.

Check speaker wiring and mounting.

Check all wiring, tube leads, leads near hot valves, ground wires, tuner leads, auxiliary control leads etc.

Check all screws for tightness, stripped threads etc.

Check for loose material inside the cabinet.

Check over-all appearance and condition of the mask, knobs, decorative trim and cabinet.

Check the face of the tube for marks or foreign material.

Electrical and performance tests:

Check picture on received test signal for brightness, focus, definition, contrast, synchronization stability, noise, arcing, smear, oscillations, beat interference, tilt, centring, height, linearity, width, and picture flashing when tapped (FWT).

Check sound performance for picture/sound tracking, noise, hum, output and noise when tapped (NWT).

Make sure all controls have been checked for proper operation. This will include channel selector and fine-tuning controls.

Packing spot check:

At least twice each day, check a completely packed set for adequacy of packing, security of taping, foreign material in carton, presence of serial number and any other necessary markings, presence of customer instruction book etc.

Check over-all appearance.

Check back cover installation for security of screws, antenna or antenna terminals, power cable etc.

266. Any cause for rejection should be discussed with the supervisor of the area responsible for the error. Rejects must be corrected and reinspected.

Final note on production techniques

267. The point has already been made that production techniques used in the developing countries need not be based on current practice in the industrialized countries. The technique best suited to a particular circumstance is closely related to the underlying industrial philosophy of the country. Like "style" in management, it is a function of a number of basic assumptions about the nature of people and their place in specific industrial environments.

268. For example, the conveyor-belt technique is not only an efficient means of producing items in series, it is also the product of a particular attitude towards people engaged in certain kinds of work. In Europe, where the questions of job satisfaction and work style are becoming increasingly important in the process of what can only be called the democratization of industry, new techniques are having to be introduced to give the individual workers a greater share of responsibility for the finished product. A case in point is the technique known as the "cell system", whereby small groups of workers are responsible for the assembly of the complete article, from start to finish. Instead of using the conveyor-belt system to organize and monitor production, the work force of a particular factory is divided into a number of discrete groups or production cells. Even the critical problems of alignment are handled by assemblers rather than by technical staff, and in many instances this has proved to be a distinct advantage.

269. By and large, however, most radio and TV assembly is carried out on the conveyorized assembly-line principle. In Argentina, for example, it has been found that the most economic unit for the series production of TV receivers is based on a 4-minute cycle. Parallel working has been introduced as the most effective means of compensating for absences and of ensuring better quality control.

270. In Hungary, TV receiver production is based on an 8-hour total assembly time, using a 4-minute cycle. In the United States, cycle time, defined as the length of time each operator spends on his particular assignment, has been reduced to 40 seconds. In effect the chassis never stops moving along the belt; the belt speed is used to dictate the length of the cycle time where adjustments are called for. In the Federal Republic of Germany, the cycle time used in the production of TV receivers is nominally 35 seconds. Needless to say, with such reduced cycle times the system must be capable of dealing adequately with all exigencies.

Telecommunications equipment

271. With most kinds of telecommunications equipment, the sequence of the basic steps of manufacture is as follows:

1. Rack testing;
2. Rack assembly;
3. Sub-rack testing;
4. Sub-rack assembly;
5. Cabling;
6. Printed-circuit testing;
7. Printed-circuit assembly;
8. Incoming inspection: electrical and mechanical;
9. Manufacture of printed-circuit boards;
10. Framework manufacture;
11. Coil assembly and testing;
12. Coil winding;
13. Production of metal piece parts;
14. Plating;
15. Moulding plastic parts;
16. Manufacture of jacks and plugs;
17. Tool manufacture;
18. Manufacture of components.

(Step No. 18 may be considered a separate industry.)

272. Following the above sequence, the degree of manufacturing can be roughly graded into five different levels, ranging from stage I (complete assembly from purchased parts) through stage V (complete production from manufactured

elements). The degree of manufacture, as shown below, would depend upon the number of the steps of manufacture listed above that it includes. Thus:

Steps included	*Degree of manufacture*	
1 . . . 5	I	(pure assembly)
1 . . . 8	II	
1 . . . 12	III	
1 . . . 15	IV	
1 . . . 17	V	(complete manufacture)

273. These groupings will differ according to the type of equipment manufactured and according to the philosophy of the manufacturer, who may further subdivide each of the basic operations, but the principle remains the same.

274. Obviously, the ultimate aim of an enterprise and of the administration concerned will be to produce locally as much of the equipment as possible, with the highest degree of manufacture that is economic. Many of the manufacturing steps for producing quite different elements are similar and can be performed by the same operators, using the same equipment, even though the tools may differ. This concept leads automatically to the acceptance of a sequential plan of manufacture in which the producer starts with manufacturing degree I of the most promising type of equipment as defined by his market research, and gradually raises the degree of manufacture. Other products may be added as soon as the volume of demand indicates the feasibility of economic production.

The limits of economic production

275. Experience has shown that, where switching equipment is concerned, an output of 30,000 to 40,000 lines per year is the lower limit for economic production. This volume can be handled in a single workshop. Where an output of 100,000 to 200,000 is contemplated, some of the subassembly work, relays and machines will require separate facilities.

276. As shown in table 10, the labour input per 1,000 telephone lines will vary widely, both as regards the individual items and as regards the totals, according to the type of exchange concerned.

Production strategy

277. In the developing countries, investment in metalworking equipment will be required unless fairly extensive facilities are already available. In countries where telecommunications industries have been set up in recent years, it has usually been found necessary to build up a mechanical workshop of considerable size, with capacities for repair work and toolmaking.

278. In any event, the setting up of a telecommunications industry does not involve heavy capital investment. The industry, as a whole, is now labour intensive, although in the industrialized countries the tendency is to change this situation as rapidly as possible.

TABLE 10. AVERAGE LABOUR INPUT PER 1,000 LINES FOR COMPONENT PRODUCTION, ASSEMBLY AND INSPECTION IN FOUR TYPES OF TELEPHONE EXCHANGES

(Man-hours)

	Types of telephone exchange			
			Crossbar with electromechanical control	
	Rotary	*Crossbar with electronic control*	*Type 1*	*Type 2*
Component production				
Pressing	1,200	1,000	1,600	800
Milling	400	200	200	100
Automatic tools	1,000	600	1,600	1,000
Turret lathe work	700	200	400	200
Drilling	700	300	700	400
Toolmaking	400	100	400	200
Fitting	1,400	2,300	2,600	1,400
Casting	100	–	100	–
Plastics	800	1,500	2,500	1,500
Mechanical work	500	10,000	1,000	700
Assembly				
Switches		4,000	3,700	2,300
Relays	4,700	4,200	5,400	3,300
Other devices	3,800	600	12,000	7,800
Cabling	1,100	2,800	7,100	4,500
Final assembly	11,000	100	11,000	7,000
Control				
Electrical tests	20	16,000	500	300
Total	27,820	43,900	50,800	31,500

279. While large factory units are not needed to manufacture the required range of equipment, there must be sufficient flexibility in the setup to allow for the gradual introduction of new items, the predicted expansion of capacity and the eventual rationalization of the product mix.

280. Initially, for example, the manufacture of subscriber instruments and equipment for improved manual switching might be undertaken, followed by the manufacture of automatic switching equipment, open-wire and cable carrier systems, coaxial cable carrier equipment and microwave radio equipment. These items would be introduced progressively as traffic increases and as the replacement of step-by-step switching by crossbar switching becomes necessary. Although at first a whole variety of items may be manufactured in the same unit with appreciable economies in terms of common services, it will gradually become necessary to set up separate units.

281. A telecommunications-equipment plant of optimum size would employ about 2,000 workers. A plant of maximum size would employ about 5,000 workers. From the standpoint of efficient management any greater number would present administrative problems. Where larger numbers of workers are required, it is advisable to subdivide the operation.

Plant location

282. The location of the prospective plant is important. The site should be in an area in which the usual services (transportation, utilities etc.) are available. In addition, the site should be unaffected by sea breezes, which can cause problems of corrosion associated with a saline atmosphere; it should be unaffected by atmospheric pollution from chemical plants; and it should be relatively free of dust.

283. Proximity to other industries can be a distinct advantage because of the resulting availability of a pool of skilled and semi-skilled labour and a range of other facilities and equipment. At the same time, the industrial environment should be chosen with care, especially with regard to future development. The best climate is an equable one.

Collaboration with foreign partners

284. When a country must create its telecommunications industry almost or entirely from the beginning, it may find it advantageous to work in close collaboration with a large foreign firm that has wide experience in this field. Pakistan provides a classic example of good planning in this respect.

285. When Pakistan came into existence in 1947, only a very inadequate telecommunications network existed. It was based on the requirements of a former province and could not meet the needs of a sovereign country. In 1952, the Pakistan Government made a contract with Siemens und Halske A.G. (Federal Republic of Germany) providing for the erection of a factory capable of producing 7,000 telephone receivers yearly and the exchange equipment for 7,000 subscribers. This contract, which was of the turn-key type, provided for the entire planning, installation, personnel training, and operation until an agreed-upon level of profitability had been reached.

286. The first 400 telephone receivers, assembled from imported parts, were made by the summer of 1954. In 1955/1956, the manufacture of manual and automatic switching equipment was begun, and the manufacture of trunk exchanges, and carrier-frequency equipment was undertaken subsequently. The manufacture of paper capacitors, Styroflex capacitors, wire-wound resistors and the like was also introduced, as the quantities required made local production feasible.

287. Fifteen years later, the factory had expanded to a capacity of about 55,000 telephone receivers and 45,000 line units yearly, and manufactured a large volume of special equipment as well. Indeed, this plant now exports parts to the parent company in the Federal Republic of Germany, as well as to other countries, and the idea of multinational manufacture has been brought a step nearer to realization. This idea is of prime importance and reflects much credit on its originators. It could well form the basis of a new philosophy of co-operation between the industrialized and the developing countries.

Staffing problems

288. Job functions and areas of responsibility should be clearly defined in the organizational chart that is drawn up at the inception of a project. The Financial Controller, the Personnel Manager and the Project Officer should have been appointed and be functioning for at least six months before the factory comes into operation. A Board of Directors, supported by a sufficient number of people with good knowledge of industry, should also have been appointed before the start of the project.

289. Highly qualified administrators are essential to the success of any telecommunications industry. Management personnel of this calibre is scarce in most developing countries, and provision will have to be made, in the early stages of the project, to find and train managers. In any project financed by the UNDP Special Fund, this is a requirement to which the highest importance is attached. Ideally, both higher and middle management should be trained before the factory goes into production.

290. As far as labour is concerned, most developing countries have long been involved in training programmes of various kinds. As a result, there is a considerable pool of well-trained labour in many of these countries, notably in African countries. To avoid the drain of skilled labour from developing to developed countries, developing countries must provide talented and able individuals with opportunities for self-development.

Plant layout

291. A suitable layout for the plant is of the utmost importance in ensuring the smooth and economical flow of raw materials, manufactured components, subassemblies and the final product through the manufacturing system. Experience has shown that a poor or inappropriate layout is responsible for more undetected wastage of time, effort and money than any other single factor. Thus, the correct layout of the factory is of prime importance and its elaboration should be entrusted only to well-qualified persons.

292. The plant layout is determined on the basis of data regarding the products to be made and the processes through which they must pass before they are completed. The object of the flow layout is to keep materials-handling costs to a minimum and to determine correct placement of machinery. A process-cum-product layout is probably the best for grouping work centres to obtain minimum materials-handling costs, maximum utilization of machinery and effective supervision.

293. The completed flow layout is used to determine the plant layout, and from this the form of the building can be extrapolated. Care must be taken to see that the conduits for cables, compressed-air lines, water supply, exhaust and cooling systems are planned correctly. Provision must also be made for dust-collection systems in moulding shops and for efficient fume extraction from electroplating shops. The effluent from electroplating shops must also be treated. The custom of dumping such wastes into the nearest river has turned much of the industrial landscape of Europe and the United States into festering sores about which the public conscience is only just beginning to be aroused. In the developing countries, river pollution by industrial wastes could be a very much more serious problem; for example, only a few parts per million of copper contamination in a river can wipe out an entire fish population downstream from the point of entry. In Europe and the United States, this would be serious enough, but in some developing countries it could result in the loss of livelihood for fishing peoples downstream and of an essential item of diet for the population.

294. Because assembly work with telecommunications equipment does not involve moving very heavy items, it can readily be accommodated in a multi-storey building. The floor-loading is light, and a much more compact building can result.

295. The design must also take into account the projected expansion of the industry over a period of 20 to 25 years. This requirement entails making a layout plan that is as universal as possible and readily adaptable to changing circumstances.

Materials handling

296. In view of the large number of items (1,500–2,000) and the large variety of materials used in the production of telecommunications equipment, the materials store must be well organized. The issue system may be either production-guided or consumption-guided. With a production-guided system, issue and ordering are integrated with production requirements; with a consumption-guided system, materials flow is guided by actual consumption and the maintenance of minimum stock balances.

297. In general, mass and series production are consumption-guided; with small-series runs, the production-guided system is usually employed; these principles apply to the manufacture of telecommunications equipment. With radio receiver assembly it is necessary, because of the very extended lead times involved in obtaining requirements, to maintain minimum stock levels. The importance of this aspect of organization cannot be overemphasized; entire plants have had to close down because of the lack of some small brass screws.

298. The control system should aim for the best utilization and turnover of the available inventory. This consideration is very important in developing countries, where the working capital available is likely to be limited.

299. An efficient flow of the materials to the production area is necessary for uninterrupted production. The stocking of components at each assembly operator's position minimizes time and effort wasted in locating and inserting parts. This handling and location of components deserves careful study in the layout of the goods-inwards warehouse, the production area, and at each work position. An effective system is to arrange for the incoming-materials warehouse to release to the production area each day a supply of components and materials calculated to complete one full day's production. If possible, these materials should be moved to the immediate work area where they are to be used. Movement can be accomplished most effectively with small hand-trucks for small parts and larger flat dollies for large parts such as panels and cabinets. From storage bins or shelves at the work area, the parts may be transferred to the work positions as required during the day. In some instances it can be arranged to stock the assembly area after normal working hours so that all will be ready for the next day's production.

300. The importance of careful materials inventory control cannot be overemphasized. It is tempting to overlook the clerical drudgery of keeping accurate inventory records, but there is no other way of keeping track of use of materials and possible pilferage and materials location. A simple and effective system uses a card-index file. Quantities, date received, and stores location are entered in a card file, which is referenced for each item. The cards are then used to record the precise movement of each part and will instantly indicate the stock level of that particular item. As each movement of parts to the production area takes place, the quantity, date and inventory balance are recorded on the appropriate card. Similarly, each receipt of a part is entered and a new inventory balance established on a continually updated basis. Accurate inventory control is also necessary in assessing the total performance of an industry and is as important as the accurate assessment of work in progress.

301. There is much room for improvement in the existing system of materials handling when materials and equipment are shipped by sea. The percentage of goods arriving in a damaged condition is exceedingly high. Pilferage en route is also extremely high, and goods can often be blocked at ports of arrival for two or three months for customs clearance, and this after two or three months in transit. Valuable capital is needlessly tied up for long periods. Goods that have to be paid for in foreign exchange often can be insured only in the domestic currency, and the return for damage and loss is minimal. It is noteworthy also that damage occurs even with the most careful packing. Some of this damage must be wanton; much of it is difficult to account for in any other way.

302. Obviously, a certain percentage of losses in transit must be accepted as one of the hazards of doing business, but it is important that the authorities handling goods at seaports and airfields take the utmost care with materials and equipment. Some improvements have been made over the last few years, but many more are needed. The immediate effects of bad handling are plain to see; the effects of such damage on the economy are harder to assess, but they can be very serious indeed.

Some special problems

303. In addition to the more general telecommunications problems considered above, several particular problem areas deserve mention. These include *(a)* rural telecommunications networks, *(b)* power supplies and *(c)* reliability and maintainability of equipment.

RURAL TELECOMMUNICATIONS NETWORKS

304. It is to be expected that a high proportion of the national budget for telecommunications will be absorbed by the urban areas. Nevertheless, the acute problem of providing rural telecommunications over extensive, sparsely populated areas is one that is of great concern to some developing countries. The cost of providing physical lines would be prohibitive, yet effective rural telecommunications systems would bring considerable and immediate economic benefits to countries such as Argentina, where the rural areas play an important part in the national economy.

305. At present, equipment for rural telecommunications is produced in very few of the industrially advanced countries, and not many manufacturers are making serious efforts to cope with this problem. Some, however, have been working on small VHF and UHF transceivers. Small transistorized carrier equipment is also available, as are small automatic exchange equipment of 20 to 30 lines that run unattended for long periods (for example, 5 years in the Philippines). South Africa has designed rural carrier equipment (60 to 350 kHz, with up to 12 channels), and France has installed a low-capacity tropospheric-scatter system in Algeria.

306. Something in the nature of the South African farm-line system is perhaps indicated, and probably much of value might be gained from Australian experience with transceivers powered by pedal-operated generators. However, generally speaking, development of rural telecommunications has been carried out unsystematically and in isolation. Now is perhaps the time for a thorough survey of this entire problem, for it would seem to be of relevance to most developing countries. The survey would need to include an analysis of equipment needs, and particular attention should be paid to the types of environment in which the equipment would have to operate.

307. The idea that the PTT administrations of developing countries should hold joint meetings to discuss and define mutual problems in the area of equipment requirements has much to recommend it. Considerable benefit could accrue from the pooling of these requirements, since group orders are probably the only economic method of interesting equipment manufacturers.

POWER SUPPLIES

308. There is a need for low-cost and reliable power supplies for rural telecommunication networks in remote areas not served by national power-distribution systems. This matter has been given particular attention by ITU and larger manufacturers. However, further development work is called for.

RELIABILITY AND MAINTAINABILITY OF EQUIPMENT

309. Particular attention should also be paid to equipment reliability and maintainability. The ability to function for extended periods in conditions of widely varying humidity and diurnal fluctuations of temperature with little or no maintenance is essential. This ability would also imply a high degree of imperviousness to dust impairment and to fungus attack. It has been suggested that this might be an area in which UNIDO might organize research and development to produce specifications and design parameters for the industry, bearing in mind the desirability of eventual local manufacture.

310. It was pointed out that UNIDO has mounted a major programme in this area (Symposium on Maintenance and Repair in Developing Countries, held in Duisburg, Federal Republic of Germany in November 1970). Both consultative committees of ITU are at present studying these problems. The International Telegraph and Telephone Consultative Committee (CCITT) Working Party on Data Transmission Systems, for example, is carrying out studies to establish precise definitions of reliability, maintainability and availability (that is, the percentage of time a piece of equipment may be relied on to function correctly) and to establish numerical values for these functions. IEC has also published data on environmental testing.

311. The diversity of the problems of routine maintenance of telecommunications equipment in the developing countries is extreme. The Democratic Republic of the Congo, for example, has an extensive telecommunications network. This country, although for the most part rather level, is covered by vast areas of forest and is traversed by many rivers, and road building on any scale is virtually impossible. The waiting period for repair when remote telecommunications stations go out of action is frequently very long. The Sudan represents another case. Here the terrain is mostly desert, and road building is consequently impracticable. Again, the waiting time for equipment repairs and maintenance is very extended. Ethiopia is very mountainous, roads are few, and road building is extremely difficult. Maintenance and repair at remote equipment sites is therefore arduous and very expensive.

312. Ideally, maintainability and reliability should be designed and built into equipment. This point is of particular relevance to developing countries that manufacture telecommunications equipment or intend to do so. However, equipment designers in general show little awareness of the causes of failure of the components they specify and of the effect that environmental differences can have on them. The typical reaction to equipment breakdown resulting from component failure is to write stricter specifications for the item in question. This is a dangerous procedure, however; without an understanding of the underlying cause of the failure, tighter specifications may be pointless; they will almost certainly be expensive.

313. In equipment manufacture the problem is to select the best components from those currently available. "Best", in this context, does not necessarily mean the most expensive. For this selection, some kind of testing facility is indicated where detailed evaluation, failure analysis and screening can be carried out. Contrary to what might be expected, an expensively equipped laboratory is not required to produce substantial cost savings and to increase equipment reliability. Much good work can be done with instruments as simple as a hammer and a magnifying glass. The cost of

testing liquid solder fluxes and cleaning solution periodically by using litmus and silver chromate papers is negligible, yet the use of unauthorized fluxes in equipment assembly, for example, if undetected, can cause faults that may take many thousands of dollars to rectify.

Some conclusions

314. It is clear that in several important aspects the problems of the telecommunications systems in developing countries differ widely from those in the industrialized countries, and these differences are carried over into the area of manufacture. No universally acceptable telecommunications system yet exists. Much equipment is available on the international market at prices that might well interest developing countries, but it will not interface with other networks. There must, however, be means of interconnexion between the networks of different countries, and translation equipment is expensive. It is possible to install equipment that does not conform to the CCITT/CCIR recommendations and is on the periphery of the national/international networks, but only for a relatively short period. Eventually these peripheral systems will have to be replaced by standardized systems, since traffic creates traffic, and the pressure towards standardization will increase as the volume of traffic that must be handled grows.

315. The main requirement for local industry is to produce serviceable but not necessarily the most modern equipment. Parenthetically, it should be noted that the most modern telecommunications systems are, for a variety of reasons, unsuitable for local manufacture. Equipment should conform with the CCITT and CCIR recommendations, especially where long-distance connexions are involved and where interface with international circuits is necessary. The users' interests are best served and protected by adherence to the standards outlined in these specifications.

316. Of the three currently available switching systems—step-by-step, crossbar and electronic—the first is rapidly becoming obsolete; the second is in very wide use and is ideal for large urban areas; and the third is still largely in the development stage. PTT administrations are faced with the dilemma of choosing a basic design that provides for complete compatibility with other systems, meets their own particular needs and will respond to the long-term development of the country in terms of its communications requirements. A similar dilemma faces them in the choice of long-distance equipment—whether to opt for open-wire carrier, coaxial or microwave systems. Obviously, the nature of probable future demand will have a decisive influence on the choice, as will the ultimate objective of administrations everywhere, that is to say, complete world-wide accessibility in conformity with international standards.

317. Equipment with built-in safety factors is recommended in order to increase reliability and to reduce repair time and the necessity for carrying heavy inventories of spare parts. Obviously, a certain percentage of equipment failure results from nothing more than human error in the assembly processes. Continuous education and surveillance are required to minimize this type of problem. Total elimination of component damage in assembly would appear to be impossible as long as human beings are involved in the process.

318. Information on the state of production capacity in industrialized countries, on how much is produced and by how much world-wide capacity is below present demand would also be useful.

319. As regards reliability, availability and maintainability, ITU is at present engaged in the following studies:

In CCITT:

Special Joint Study Group C (CCITT/CCIR) (Circuit Noise):

Question 12/C–Definitions and general studies relating to reliability.

Study Group IV (Maintenance):

Question	15/IV	Application of quality control to maintenance methods.
	17/IV	Effect on maintenance of the introduction of new components and modern types of equipment.
	22/IV	Measurement of the reliability of leased international circuits.
	23/IV	Influence of human factors on reliability.

In CCIR:

Special Joint Study Group C (see CCITT above).

Study Group IX (Radio-relay Systems):

Draft Question F.4.L. (IX)–Radio-relay systems for telephony. System reliability.

Study Group XIV (Vocabulary).

In IEC:

Technical Committee 1–Vocabulary:

Publication 271	Preliminary list of basic terms and definitions applicable to reliability of electronic equipment and their components (or replacement parts).
Publication 272	Preliminary consideration of reliability.

By all three:

Joint Working Group on Terminology (CCITT, CCIR, IEC).

320. Since documentation on design requirements for telecommunications equipment is scanty, machinery for the collection and exchange of information would be invaluable both to developing countries and to actual and potential manufacturers. It would appear that there is considerable scope here for joint action by UNIDO and ITU. Some sort of clearinghouse is needed for information on:

The special maintenance problems encountered in developing countries;

Design requirements for reliability and maintainability;

The characteristics and relative advantages of various switching systems;

Programmed control equipment;

The analysis of equipment failures;

Specifications for the minimization of equipment failures;

Evaluation data on components currently available;

The application of the diode noise analyser and other simple equipment to the problem of effective, non-destructive screening of components.

D. DISTRIBUTION AND SERVICING

321. This item of the agenda was concerned specifically with low-cost radio and TV receivers. The problems of marketing, shipping, packing and packaging, storage, distribution, installation and after-sales servicing of such equipment in developing countries were all considered. These matters are grouped below under the three broad headings of distribution, after-sales service, and packing and shipping.

Distribution

322. Distribution has been defined simply as the bringing together of the product and its user. However, the mere fact of bringing them together does not in itself guarantee the acceptance of the product by the user; before this can occur the manufacturer will be obliged to determine what section of the market he is aiming at and how the product he is manufacturing will best appeal to it. This is the purpose of market surveys and product engineering.

323. How far these considerations apply to the distribution of low-cost radio receivers in the developing countries is a matter of conjecture. In the industrialized countries, mistakes in the field of marketing and distribution have caused more industries to fail than any other factor. Thus, great importance is attached to marketing in a consumer-oriented society.

324. Obviously, in a developing country, much depends on the structure of the manufacturing organization. If it is owned and operated entirely by private enterprise, it will have to maintain its own distribution channels via the normal trade outlets, where they exist or try to establish them where they do not. More effective coverage of the market can be arranged where the Government is actively interested in the project. Where the Government is involved, as a result of policy regarding the use of radio and TV, direct distribution from centralized distribution points can be arranged, with a significant reduction in cost.

325. It is a rule, however, that the more sophisticated the product, the more important and the more expensive the distribution channels become. The distribution channels required for radio and TV receivers are a great deal more elaborate than those required for the sale of ordinary consumer products. It is

general practice for these receivers to be sold with a written or implied guarantee for a period varying from two months to one year. (Hungarian firms are currently offering a two-year guarantee on their products.) Furthermore, with TV receivers, there is also the question of installation and the fitting of a suitable antenna. With both radio and TV, the replacement of defective components and general servicing and repair present problems.

326. In industrialized countries the labour and the capital requirements of distribution are roughly five times higher than those of manufacturing. The reasons are quite clear: the movement of supplies ties down a great deal of capital, even more than the amounts invested in shops and factories. Also, installation and servicing demand more time than manufacture. It is inevitable, therefore, that more labour will be drawn into the distribution channels.

After-sales service

327. The costs generated in the distribution channels, including proper after-sales service, must be incorporated into the selling price of the product. It is in the interest of all concerned to see that these costs be kept to an absolute minimum. All too often, a low price is related to poor servicing, but the satisfaction of the customer is related directly to the manner in which the equipment functions in his own home. Unless proper functioning can be assured from the start, consumer resistance is likely to be encountered and sales will be disappointingly low.

328. In Hungary, a profit margin on radio and TV receivers of 26 per cent is normal when there is no after-sales service. When service is included, a margin ranging between 34 and 36 per cent is normal. In the developing countries this margin can rise to 50 per cent because of the very much more severe problems encountered in the installation and after-sales servicing. This high a margin can apply with some justice to TV receivers but is difficult to countenance where radio receivers are concerned.

329. Probably the best solution for enterprises embarking on the manufacture of low-cost radio and TV receivers in developing countries would be to arrange for servicing to be carried out at the factory. This procedure would have the dual advantage of making the factory technical staff aware of field failure problems and of providing in-plant training for service technicians. However, reliability and maintainability are basically functions of good design, and good design for a developing country must take into account inadequate servicing facilities. The cost of after-sales servicing can be significantly reduced by facing the problems at the design stage. Plug-in disposable or returnable circuit modules for TV receivers would virtually eliminate the need for trained service technicians in the field, and it is not at all difficult to build radio receivers capable of functioning for many years without failure. There are, for example, numerous valve receivers still in operation that have been functioning daily for more than 20 years. By this time, of course, the valves will have aged seriously, with a consequent deterioration in performance. The point is that they still function. Transistors are said to be more reliable than valves, although they have not been in use long enough for an accurate assessment of their ultimate reliability.

Packing and shipping

330. Packing and shipping involve considerations of shape, size, weight, vulnerability to transit shocks, vibration, humidity and heat. For radio and TV receivers, an excellent form of packing consists of:

A polyethylene inner wrapper, containing a desiccant such as silica gel, which seals the equipment from humidity and dust;

Expanded polystyrene formers or spacers to insulate the equipment from impact shocks occasioned in transit;

An outer envelope or carton, which ensures, to some extent, the integrity of the two inner packings and standardizes the form of the package.

In the case of radio receivers, individually moulded, expanded polystyrene formers become economic for series in excess of 50,000.

331. In addition to the usual trade marks and publicity, the outer carton should also carry some indication of the manner in which the package should be handled. Attempts have been made to work out a series of universally comprehensible symbols, but with limited success. The difficulty is that symbols having a readily perceptible meaning in one culture may be enigmatic or even meaningless when transferred to another. It is difficult to foresee any solution to this problem.

332. Telecommunications equipment does not require "packaging" in the accepted sense of the term. Packing, however, is very important when equipment must be transported and has been the cause of much concern to manufacturers when sending equipment to the developing countries. In the effort to ensure that equipment arrives intact, almost as much may be spent on the packing as on producing the equipment contained in the package—and often to no purpose. The incidence of damage in transit between ports of entry and destination remains very high. Where strength and solidity of packing have been unable to withstand the handling to which the goods have been subjected, some manufacturers have resorted to flimsy packing, which allows the handlers to see the delicate nature of the equipment contained within it. Handlers in general have remained singularly unimpressed by such ruses.

E. TRAINING

333. Since training is central to industrialization, a separate agenda item was devoted to this topic. Training requirements and policies for administrative and technical personnel and workers were surveyed. Although training requirements differ according to the degree of industrial development of the countries concerned, training itself remains both an essential element of the infrastructure of industry and an integral part of the entire industrial fabric.

334. In general terms, training for industry is performed by three distinct but, ideally, not separate institutions, namely, the universities, the technical institutes and

industry itself. Each institution has an individual role, but there is, and should be, some overlapping of function. The universities will be largely concerned with the training of engineers and upper management; the technical institutes will be concerned with the training of technicians, and industry will deal with the very important on-the-job training for personnel from the universities and technical institutes and with the adaption to its own specific needs of semi-skilled and unskilled personnel.

335. It is axiomatic that training should be appropriate to the needs of the individual and to the situation in which he is to work. In this respect, teaching institutions (that is, universities and technical institutes) in many of the developing countries are rather deficient, largely because their structures; syllabi and teaching methods follow patterns set by industrially advanced countries. All too often developing countries have inherited, lock, stock and barrel, educational systems that are replicas of ones that formerly existed in France or the United Kingdom and that are singularly inappropriate to their real needs, except as conceived in specifically European terms.

336. The main criticism is that most academic courses are too theoretical in their approach. Too little emphasis is placed on the actual physical nature and content of the work. Students are not trained to tackle the day-to-day physical problems they are likely to encounter in their careers. Such a consciously practical orientation is less important when training is carried out against a background of high industrial density such as would be encountered in Europe and North America, but in the developing countries it is exceptionally important.

337. A primary requirement is, therefore, that curricula be biased heavily towards the practical situation. Ideally, the trainee should be taught how to evaluate the general economic climate of his country. He should be given an understanding of the immediate and long-term objectives of any programme of industrial development and be able to relate his individual contribution to that of the industry in which he is employed. It is essential to avoid stereotypes. The approach of the trainee to problem-solving should be empirical, and his attitude constructive and flexible. He must be prepared to adapt, to substitute and to modify according to prevailing conditions or the exigencies of the moment. Engineers especially should be given a keen awareness of the problems of construction and production.

338. It should also be recognized, from the outset that, practically everywhere, the educational system is itself probably the most technologically backward of all the systems by which society seeks to perpetuate or improve its physical conditions. There are a number of reasons for this, but the most crucial are possibly the innate conservatism of educational systems and the notorious lack of consistency among the various philosophies of education that have been proposed from time to time. However, recent work, notably in behavioural psychology, has given a much firmer foundation to learning theory than it has had in the past and offers a basis for a coherent and demonstrably effective system. The benefits of this research should not be ignored when new technical institutes are established to provide training for industry.

339. The specialized agencies of the United Nations can offer extensive assistance to the developing countries in the sector of human resources engineering. This assistance may take the form of training institutes, consultancy services or fellowships for selected candidates.

340. UNIDO offers three types of training programmes tailored to suit specific needs. The first type, where the emphasis is on general training, is designed for countries with a low level of industrial development. Here a multisectoral approach is favoured, with in-plant group training, management analysis, and consultancy services. The second type is for countries that already have a more developed industrial structure. The emphasis here is on training for management. The third type of programme is for countries with already well-developed industrial structures and concentrates on the improvement of management.

341. UNIDO also offers a three-level programme of in-plant training for graduate engineers. This programme is carefully adapted to suit the special conditions of the country where the engineer is employed. The first level of the programme is designed to prepare recently graduated engineers for specific jobs in industry. The aim is to bridge the gap between what is supplied by the educational system and the actual knowledge and skills required by the job. The second level, which is the most developed programme offered by UNIDO, is devoted to upgrading the skills of middle-level personnel; it is designed for engineers who have already acquired a certain amount of practical experience in industry. Training is on a purely sectoral basis and is divided between theoretical work (about 80 per cent) in the form of lectures on recent developments and techniques and about 20 per cent to practical in-plant training. The third level is for engineers who have fairly extensive experience in industry. It is designed to prepare them for greater managerial responsibility. The programme is of 4 to 6 weeks' duration for groups of 15 to 20 engineers and is conducted in an industrially advanced country.

342. Eight such programmes were conducted in 1969, and it was the intention of UNIDO to extend this number to 15 for 1970. More co-operation from the industrially advanced countries in the operation of these programmes would be welcomed.

343. In addition, individual fellowships are offered to meet special needs that cannot be met through other programmes. However, from the viewpoint of effectiveness, a few objections to fellowships may be raised. Candidates must be selected extremely carefully, for there is always the risk that, without direct supervision, they will spend too much of the available time in mere observation. Furthermore, it has been observed that an extended period abroad can have a deleterious effect on individuals, alienating them from their own cultures and investing work in an industrially advanced country with a certain spurious glamour that makes them reluctant to return to their own countries. Candidates for fellowships abroad should be regarded as investments and be selected accordingly. Courses, where possible, should be kept short enough to prevent alienation. The award of diplomas and titles on completion of courses should be avoided, and lectures on the latest developments in highly technical subjects should not be included, in order to prevent dissatisfaction with conditions in the home countries of the trainees.

344. Exaggerated notions of status can modify the whole concept of hierarchical structure and cause severe problems in management, notably in such critical areas as the delegation of responsibilities. National institutions should be established to rectify the imbalance in pay and status between the student who does graduate study abroad and his colleague who, with no further education, goes directly into industry in the home country.

345. ILO has also been active in the field of training for a long time, and particular mention should be made of the ILO Centre for Advanced Technical and Vocational Training at Turin, Italy. The Turin Centre offers, among others, courses in electrical engineering, electronics and management. The orientation of these courses, as with those provided by UNIDO, is towards training those who will be engaged in training activities. Indeed, 40 per cent of each of the Turin courses is devoted to this aspect, because of the important multiplier effect training can have on the industry of a developing economy. Obviously, to get maximum effect facilities must already exist in the developing countries to make use of the training given, and the active support of industry will be required for subsequent in-plant training by those who have been trained.

346. ITU has to date set up in the developing countries a total of 27 telecommunications training establishments financed by the UNDP Special Fund. These projects are, by their very nature, both self-liquidating and self-sustaining in that an essential feature of each is the gradual replacement of expatriate staff by fully trained local counterparts.

347. The contribution made by UNESCO is too well known to need elaboration here, but it will be seen that UNIDO, UNESCO, ILO and ITU, each within its own special sphere of competence, together provide a very wide spectrum of training, both within the developing countries and in special institutes abroad. ITU provides operational training and complements national university programmes; ILO provides basic and specialized technical and vocational training; UNIDO provides training with a more specific industrial orientation; UNESCO is active at the university level in the training of electronics engineers, and UNDP acts as the co-ordinating authority to ensure maximum inter-agency co-operation at the level of field operations.

348. Apart from these international programmes, industry in the industrially advanced countries is willing to provide certain training facilities for the developing countries. In the United States, for example, the Radio Corporation of America has correspondence courses that are available on a world-wide basis. It is also willing to set up technical institutes in the developing countries. In the Netherlands, Philips of Eindhoven, in conjunction with UNIDO, is providing an in-plant training scheme specially designed to meet the requirements of developing countries. Certain professional bodies also are willing to provide fellowships for study abroad.

Part II RECOMMENDATIONS

349. The Development Meeting on the Manufacture of Telecommunications Equipment (including low-cost receivers for sound broadcasting and television) adopted the following recommendations:

A. GENERAL

CONSIDERING:

The importance of establishing a strategy of development in the field of electronics and telecommunications, taking into account the increasing market requirements in the developing countries;

The importance of these industries in stimulating economic development, through savings or generation of foreign exchange, development of industrial technology and creation of employment opportunities;

The part played by this industry, and more particularly in the development of radio and television receivers, in aiding social development and international co-operation:

The high cost involved in carrying out basic research and development of more sophisticated electronic and telecommunications equipment but the relatively lower costs in applied research;

That in many cases developing countries have complicated customs and import tax structures that differ from those already existing in more industrialized countries;

That in many cases, when merchandise is cleared through customs, confusion arises as regards the correct nomenclature of the products under consideration as well as the application of the relevant duties and taxes;

SUGGESTS that:

1. Developing countries give highest priority within their national economic and industrial plans to the telecommunications and electronics industries, particularly those involved in the production of low-cost radio and television receivers.

2. Developing countries give serious consideration to starting up local assembly and/or manufacture of telecommunications and electronic equipment even when quantities are initially below minimum requirements for economic

assembly and/or manufacture. In this regard, consideration should be given to savings or generation of foreign exchange, the development of technology, the setting up of an industrial base and the possibilities of creating employment for nationals.

3. Developing countries encourage and support local production and sale of equipment through such incentives as tax holidays, customs exemptions, assistance in financing and adequate protective tariffs. Particular attention is drawn to one such aspect: namely, to the need to allocate sufficient amounts of foreign exchange annually for importing components for the product to be manufactured and, at appropriate intervals, for importing factory equipment and machinery needed for expansion or replacement of existing equipment and machinery.

4. Developing countries do not discourage, but rather allow, where necessary, the importation of technology through licensing and payment of royalties, as it stimulates the development of technology and of these industries. However, local design and development facilities should be built up at the same time with a view to exploiting locally available raw materials and gradually reducing imported technology.

5. Developing countries give serious consideration to regional or subregional development of these industries on a co-operative basis through pooling of requirements, resources and production capabilities to attain the following:

   (a) Increase in output to reach more economic production level;

   (b) A freer exchange of technology and training within the region;

   (c) Lower costs and increased market potential through exports;

   (d) An equitable distribution of industries throughout a region.

6. Developing countries take appropriate steps:

   (a) To ensure co-ordination among the various government branches involved and to promote the earliest application of universally accepted nomenclature such as that laid down by the Customs Co-operation Council in Brussels;

   (b) To rationalize as far as possible the national procedures when reclaiming import duties and taxes wherever such problems exist.

RECOMMENDS that, upon request of countries or groups of countries:

7. UNIDO, in collaboration with the regional economic commissions, tabulate and analyse all factors leading to problems associated with and benefits accruing from the establishment of both local and regional telecommunications and electronics industries in developing countries and disseminate this information to all countries and organizations interested in these industries.

8. UNIDO be prepared to render technical assistance and aid in the financing of telecommunications and electronics industries in developing countries. In particular, UNIDO should collaborate with UNDP in setting up small model industrial plants for the manufacture of modern telecommunications and electronic equipment.

9. UNIDO study means of encouraging the establishment of export-oriented industries in developing countries.

10. UNIDO also co-operate with major professional and manufacturing associations in the gathering and dissemination of up-to-date information on the manufacture of telecommunications and electronic equipment, modern small-scale production techniques and marketing.

B. LOW-COST RECEIVERS

RECOGNIZING:

The importance of mass communications in the developing areas for cultural and educational development, for the dissemination of information and news and for entertainment;

That radio is a basic means of mass communications that does not require literacy on the part of the listener;

That the benefits to national and regional co-operation derived from the wide reception of radio programmes are attained only when radio receivers are available to the entire population;

The work carried out by ITU, through CCIR, in the field of recommended specifications for low-cost radio and television receivers;

CONSIDERING that:

The major impediments to wider use of radio are the relatively high cost and/or non-availability of suitable radio receivers;

The extent of the importation of radio receivers is restricted by the need for the strict control of foreign currency expenditure;

Developing countries, particularly those with significant local markets, can benefit widely from telecommunications and electronics industries;

The manufacture of radio receivers can begin with small-scale assembly, using parts obtained from the larger manufacturers;

Technological personnel and facilities can be developed without direct government financing through the development of the telecommunications and electronics industries;

SUGGESTS that:

1. Developing countries consider establishing or supporting radio receiver assembly/manufacture, for which joint-venture agreements and technical assistance might be sought, if required.

2. Developing countries consider the extension of radio receiver manufacture to include television receiver manufacture to meet the country, subregional and regional needs.

3. Developing countries, in fostering radio and television receiver manufacture, could begin with a simple, robust, low-cost unit with a minimum number of models, based on the performance specifications and design characteristics set forth in the appendix (radio and television receiver specifications) to this recommendation.

4. Developing countries plan and initiate afterwards (or, when possible, concurrently) the manufacture of the component parts, in co-operation with other countries if desired. For this, the advantages of large-scale production are very important, and the manufacture and distribution of components on at least a regional or subregional basis should be encouraged.

5. Developing countries give serious consideration to the incentives mentioned above in the General Recommendations, together with special arrangements for eliminating or reducing listeners' licence fees.

RECOMMENDS that, upon request of a country or groups of countries:

6. UNIDO provide technical assistance in surveys, studies and the setting up of small industrial plants as outlined previously, particularly for radio and television receivers and their component parts.

Notes on radio and television receiver specifications

The performance specifications and design of low-cost radio and television receivers are given in the ITU, CCIR Recommendations 415, 416 and Study Group Doc. XI/246 of 12 September 1969. The frequencies for the broadcast transmission are in the low frequency (LF), medium frequency (MF), high frequency (HF), very high frequency (VHF-FM), together with television emissions in the VHF and ultra-high frequency (UHF) bands. These are assigned by Governments in accordance with the ITU Radio Regulations; radio receiver reception bands range from 150 kHz to 26 MHz (this limit is still under study by ITU) for amplitude modulation (AM) and from 87.5 to 108 MHz for frequency modulation (FM).

Radio receivers

Radio receivers best meeting the requirements of the developing countries (estimated by UNESCO to be 400 million sets at $5 each) must be simple, robust, transportable, have ease of tuning, reasonably good sensitivity, selectivity and electrical qualities and operate with low battery drain from standard dry-cell batteries. As a guide, it is suggested production be initiated with radio receivers of one or more proven designs as follows:

1. One-band set MF–525 to 1,605 kHz;
2. One-band set HF;
3. Two-band set LF and MF, MF and HF, or 2HF;[4]

The output power should be at least 350 mW.

[4] The HF bands could be chosen between 3 and 26 MHz, the range of frequencies not to cover more than 3.5 times the lower frequency.

Television receivers

The CCIR specifications for type B or better, as presently available, are recommended for first consideration. However, the need is to produce these television receivers at minimum cost, and therefore the initial production should be restricted to VHF receivers.

In view of the differing television standards and conditions in various countries, a low-cost television receiver may not be further defined; this must be left to the countries to determine according to their national interests, but otherwise in accordance with the CCIR guideline performance specifications.

C. RELIABILITY

CONSIDERING:

> The growing importance of the reliability of equipment used in telecommunications in developing countries, especially in sparsely populated areas where access to equipment sites is often difficult and time-consuming and where there is often a lack of skilled personnel;
>
> The importance of reducing the incidence of equipment failure and the simple localization and repair of such failures;
>
> That ITU and IEC, the regional economic commissions and other organizations are already actively studying these problems;

RECOMMENDS that UNIDO and ITU, in their respective domains:

1. In consultation with telecommunications administrations and in co-operation with the organizations mentioned above, foster the study of the causes of faults and equipment failures and propose methods whereby their incidence may be eliminated or reduced.

2. Disseminate this information in the form of guidelines for the benefit of developing countries; to manufacturers and users of telecommunications equipment.

3. Examine the desirability and feasibility of establishing design and test centres for component failure analysis and associated investigations concerning reliability.

FURTHER RECOMMENDS that manufacturers:

4. Continue their work in this field and particularly in simplifying defect-finding through improvements in both design and equipment and in the preparation of instruction manuals.

D. RURAL TELECOMMUNICATIONS EQUIPMENT

CONSIDERING:

The importance and special needs of rural telecommunications in the more sparsely populated areas of the developing world;

RECOMMENDS that:

UNIDO collaborate with ITU and IEC in preparing a study for rural telecommunications systems and foster the design, development and manufacture of suitable equipment. Particular attention is drawn to the requirements of rural networks (e.g. reliable power supplies at low cost that can withstand tropical conditions).

E. SERVICE

CONSIDERING:

The necessity for delivering to users sets in perfect working condition;

The necessity for organizing installation, maintenance and after-sales services efficiently to ensure the correct operation of the equipment;

RECOMMENDS that:

1. Local manufacturers devote particular attention to the packaging, storage and delivery of radio and television receivers to ensure that they reach the user in good condition.
2. Manufacturers, wholesalers and retailers realize the basic importance of organizing installation, maintenance and after-sales services and of providing them with technically competent staff, measuring instruments and the facilities necessary to ensure good service to users.

F. TRAINING

CONSIDERING that:

Industrial activities can be developed only if personnel with the appropriate qualifications are available;

Successful and competitive production of electronic equipment requires an awareness of the many factors that influence the economic and technical choices made by engineers and technicians;

SUGGESTS that:

1. Countries strive to arrive at an appropriate balance of skilled labour, technicians and engineers, in relation to their present industrial situation and their development plans, thus allowing for adequate staffing of their industries while fostering their technological progress. Particular attention should be given to training at the lower levels and to in-plant training of graduate engineers.

2. Countries favour development of local institutions to train people at the necessary levels, thus rendering it possible to have a better correspondence between study and actual practice under local conditions.

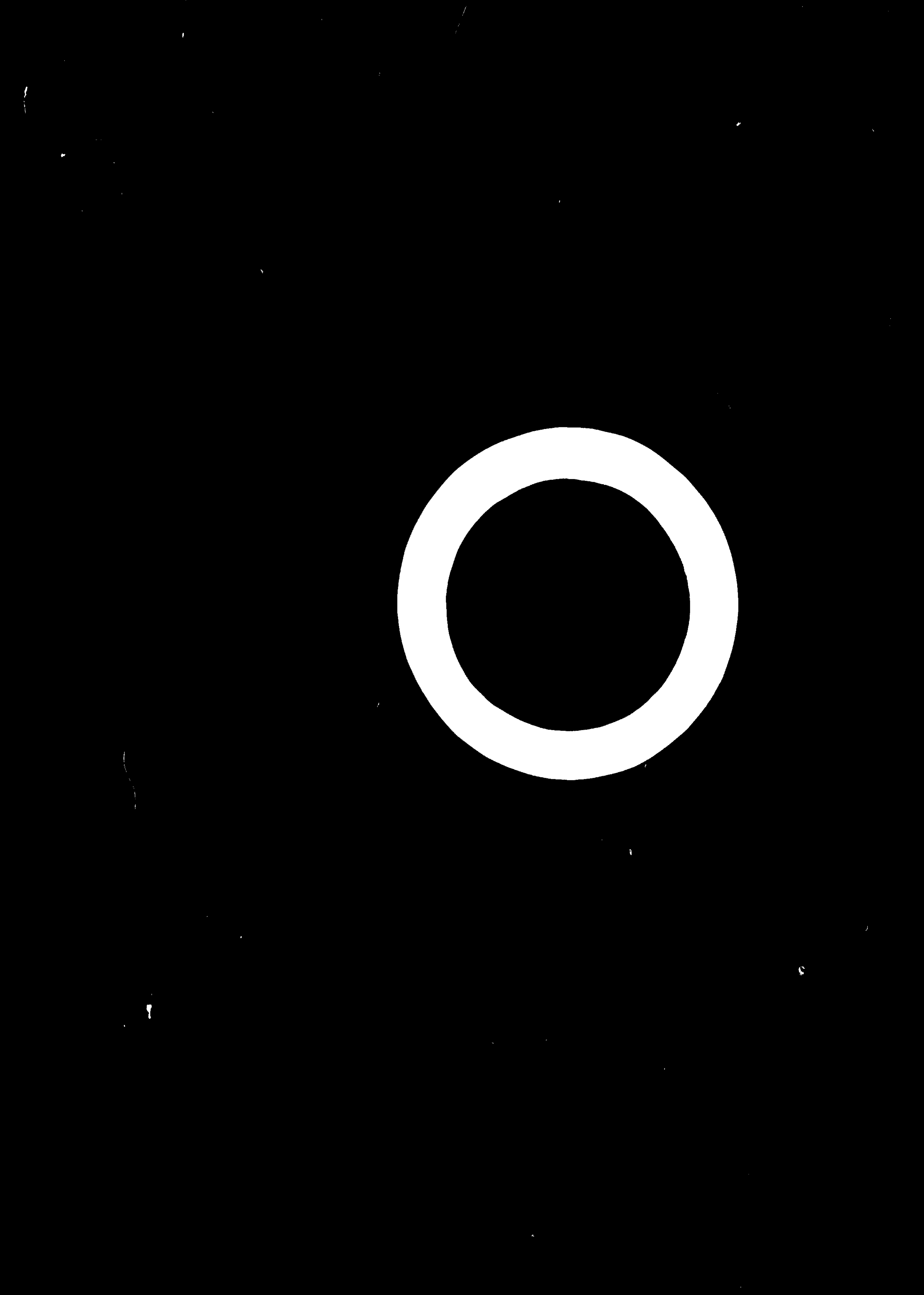
3. In the training of engineers and technicians, particular attention be given to the development of technical discernment applicable within the economic, social and material conditions prevailing in the countries.

4. Industry play a more important part in the training process, not only during schooling but also after technicians and engineers start their work in industry, through in-service training schemes, seminars etc.

5. Governments and industry alike note that organizations of the United Nations family, such as UNIDO, ILO, UNESCO, ICAO, ITU and WMO, operate technical assistance programmes within their own terms of reference, in the fields of electronics, telecommunications and mass communications; and that the inter-agency activities of the International Centre for Advanced Technical and Vocational Training (Turin Centre) include courses in technical subjects, methodology and management, especially designed to train teachers and for the conditions prevailing in the developing countries.

RECOMMENDS that, upon request of countries or groups of countries:

6. UNIDO expand its activities in the field of in-plant training at the graduate level.



ANNEX 1

LIST OF PARTICIPANTS

Country representatives

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Director General
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ARGENTINA

J. R. LARREA
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Argentine Chamber of Electronic Industries
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S. RAJANAYAGAN
President
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Private consultant
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	G. MAHLER AEG- Telefunken Ulm
HUNGARY	S. LEDERER Director Videoton Wireless and TV Factory Budapest
	P. S. MOLNAR Chief Designer BHG Telecommunications Factory Budapest
	D. SELLO General Manager BHG Telecommunications Factory Budapest
INDIA	S. M. AGARWAL Joint Secretary Dept. of Defence Supplies & Electronics Ministry of Defence New Delhi
IRAN	K. MALEK Technical Director Microwave Communications Company Tehran
ITALY	F. ANGELI Deputy Director Laboratorio Richerche RAI Radiotelevisione Italiana Turin

ITALY (cont'd)	L. BENCINI Division Director Instituto Superiore P. T. Rome
	I. MOCCI Marketing Manager Product Planning & Systems Engineering Telecommunications Division Rome
JAPAN	C. ANAZAWA Manager Radio Engineering Association Tokyo
KENYA	C. M. AMIRA Chief Engineer Television Voice of Kenya Nairobi
MOROCCO	H. EL GHALI Radiodiffusion Télévision Marocaine Rabat
NETHERLANDS	J. J. KALDENBACH Regional Manager Far East N. V. Philips Telecommunicatie Industrie Hilversum
	W. A. Van WAASDIJK Head of Design Group N. V. Philips Telecommunicatie Industrie Hilversum
	J. FABER N. V. Philips Telecommunicatie Industrie Hilversum
NIGERIA	E. A. OGUNTAYO Assistant Chief Engineer Nigerian Broadcasting Corporation Broadcasting House Lagos
PAKISTAN	Lt. Col. M. R. KHAN Production Manager Mohammad Ebrahim and Co. Karachi
PERU	A. PEREYRA Director of Telecommunications Ministry of Transport & Communications Lima
ROMANIA	G. ZAMFIR Uz. Electronica Bucharest

RWANDA	R. G. CHOME Directeur de la Coopérative MERA Ministère d'Etat à la Fonction Publique Kigali
SUDAN	M. A. ALLAM Deputy Director General PTT Department Khartoum
SWEDEN	E. H. LEDIN L. G. MJOEBERG Telefonaktiebolaget L. M. Ericsson Stockholm
THAILAND	C. KRUNYAWATH Chief, RTA Factory Signal Department Royal Thai Army Bangkok
TURKEY	Y. KAHAHAN Senior Telecommunications Engineer PTT Arestirma Laboratuari Istanbul
	T. SAYRAG Chief Engineer Turkish Radio Ankara
UGANDA	M. B. S. MANGEN Engineer in Charge Radio Uganda Kampala
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UNITED STATES OF AMERICA	G. H. EBEL Conrac Corporation West Caldwell, New Jersey
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	C. E. WALTER RCA International Division Consumer Products Marketing Department Clark, New Jersey

International organizations

United Nations and Specialized Agencies

UNIDO	R. LINE Vienna F. NORMAN Vienna O. SOSKUTY Vienna
ILO	F. F. PAPA BLANCO Chief, Research Section International Centre for Advanced Technical and Vocational Training Turin
UNESCO	F. L. GOODSHIP Division of the Development of Mass Media Paris
ITU	W. PIERCE Jr. Union Internationale des Télécommunications R. FROOM CCIR (UIT) Geneva
WMO	G. WEISS Chief Networks and Telecommunications Division World Meteorological Organization Geneva

Other

IEC	J. J. BLANC International Electrotechnical Commission Geneva
EBU	R. R. BLACH Österreichische Rundfunk GMBH Vienna

ANNEX 2

STATEMENTS TO THE MEETING

Introductory statement by Mr. I. H. Abdel-Rahman, Executive Director of UNIDO

UNIDO, with your help through this meeting and through a number of other programmes, is trying to accomplish its task of helping the industrialization of the developing countries. Our main objective is to look at the situation of industry in the developing countries and to see how assistance may be given. This meeting typifies but one of the many activities which UNIDO pursues in its attempt to fulfil its objective. We hope, as a result of your meeting and discussions, and with the collaboration of the representatives of other international organizations as well as with the collaboration and co-operation of industry in the industrialized countries, that a series of activities can be established by UNIDO with the developing countries, to help them in the manufacture of telecommunications equipment, which is one of the most important aspects of industry in the developing countries.

What kind of conclusions could come out of this meeting, and which of these conclusions could later be taken up by UNIDO? These are two main questions which I would like you to help to answer and advise us on in collaboration with the representatives of UNIDO, who will be taking part with you in these discussions. Your final conclusions, I am sure, will be addressed first of all to the developing countries themselves, because they are the primary agents in this type of work; second, to international organizations such as UNIDO, UNESCO, ITU and others who have particular interest in the various aspects of this important subject; and third, I hope your observations and recommendations will contain technical, economic and administrative guidance at all levels.

Telecommunications and electronics, even in the most advanced countries, are developing very rapidly, and I am sure in the next few years there will be still greater acceleration of these developments. What the developing countries can then do with this fast-developing subject, where everything is new every day, where there is necessity for an international comparability and quality in work, and where difficulties of manufacture are certainly taking a particular form because of this quickly developing base and increasing complexity of the subject is a question which we must deal with.

It cannot be said simply that the developing countries must sit quietly and obtain everything from the advanced countries without taking part themselves in the production and development process. No doubt their share in production and development will be much smaller than that of the advanced countries, but certainly they will have a definite share, and it is up to you and to this meeting to indicate to the developing countries and to us in UNIDO what would be their proper share and what would be the best procedures for developing the manufacture of telecommunications equipment in the developing countries.

Various aspects of the subject have been of particular interest to one organization or the other; the question of low-cost radio receivers has particular importance because of its mass media and educational and cultural implications. Questions of telecommunications in general, using the most modern systems, are also significant because telecommunications must cover the whole globe; the question of the manufacture or partial manufacture of some of the basic and recurrent equipment is quite important, and I am sure that your discussions will refer to many other aspects of this development.

In collaboration with the Government of the Netherlands, UNIDO will soon begin a training course in electronics and telecommunications for representatives from the developing countries. It is to be an in-plant training course centred both in the Philips Company in Eindhoven and at the Technical University of Delft. This is one of the training courses that UNIDO is trying to develop regularly over the next three years. We hope, with the collaboration of the Dutch Government and the Philips Company, to have three successive courses, each one of which could be considered, in effect, a follow-up to your meeting. The participants to be invited will be senior engineers and managers who have actual experience in the manufacture of some kinds of telecommunications equipment in their countries or who are likely to be interested in establishing such an industry in their own countries, and we hope that, in three successive years, your recommendations and observations will be examined, among other things, in the Eindhoven/Delft training courses.

This course is only one part of UNIDO's work. Our main concern is to bring the benefit of your conclusions directly to the countries concerned, through the programme of technical assistance. We have now in the field in the developing countries a large number of technical advisers giving advice and help to the developing countries in various areas. In the area under discussion now our efforts are still at a very early phase, but we hope in the next few years that they will be further developed so that a relatively large number of advisers from the advanced countries could be sent by UNIDO to assist the developing countries in some aspects of the development of their industries as you will be discussing it. This programme of technical assistance and the programme of training, as well as the other programmes which will be discussed and mentioned in your deliberations in the next few days, gives you the image of the instruments with which we work in UNIDO, and we would appreciate it very much if your recommendations would be designed so that we could use the instruments and the programmes which we have, to carry your recommendations to practical application. Of course, we shall value all the advice you give, but we will try in UNIDO to implement it and to see that it will actually reach the areas it should reach in the developing countries.

Closing remarks by the Chairman, Lt. Col. M. R. Khan (Pakistan)

My army career has taught me many things. I would relate two of them to you now which appear pertinent. First, never volunteer for any job. You know that I did not volunteer for this one! Second, once you have been assigned a job and have agreed to do it, then do it with zeal, efficiency, speed, accuracy and to the best of your ability. However, what really prompted me to accept the honour of being the chairman of this meeting was a motto given in the preface of a book on mathematics which I read about fifteen years ago. The motto was, "What one fool can do, another can".

I have had some experience of taking part in the international conferences of the Commonwealth countries and even of presiding over some of the sessions, but I have never before been assigned the heavy duty of not only conducting day-to-day business, but also getting suitable recommendations discussed, formulated, reviewed and adopted, and all in one session.

I feel that we went through all the subjects quite thoroughly, perhaps deeper in some subjects than was necessary. I also feel that we arrived at appropriate recommendations which, if fully implemented, should bring the desired results. There thus appears to be no need for me to review any aspect of the work that we did during these sessions. We cannot be the judges of our own deeds or misdeeds; let others judge us. Nevertheless, before I finally declare this meeting formally closed, I wish to highlight four points which I think are extremely important:

First, we, the developing countries, must analyse our own problems and decide ourselves what we wish to do in the field of electronics and telecommunications. We may seek assistance from the advanced countries to help us in surveys and feasibility reports, but we must encourage our own specialists to take part in these activities and to determine our real requirements; we must not depend solely on imported talents. Our requirements may be enormous, but our plans must be feasible and economically viable. Any decisions reached must be our own; they should not be from abroad.

Second, after deciding what our requirements are, we must fit them into the over-all plan of our national industrial strategies, with the highest possible priority. Only then should we ask for technical assistance or aid from the developed countries, from the industrialists of those countries or from international agencies.

Third, we should, at governmental levels, assist our own industries in the production of cheaper radio and TV receivers by removing or reducing customs duties on imported components and by providing tariff protection against similar imported goods.

Fourth, while providing any other incentives that may be required, Governments must also persuade their industries to produce the cheapest possible radio set, which may be rightly called the "people's set". If it is then found that private industry cannot cope with this important task, the Governments of the developing countries must have such a people's set designed and should subsidize its production so that the recommendations of UNESCO pertaining to mass communications will be met within the specified time.

ANNEX 3

LIST OF DOCUMENTS PRESENTED TO THE MEETING[1]

ID/WG.15/1	Plan of Meeting
ID/WG.15/2/Rev. 1	Provisional agenda and work schedule
ID/WG.15/3	The sharing of manufacturing facilities in the electrical and electronics industries among developing countries *by J. Pohanka and V. Vokalik*
ID/WG.15/4	Radio design and manufacturing considerations for developing countries *by F. Banovic*
ID/WG.15/5	The manufacturing of low-cost television receivers in developing countries *by C. E. Walter*
ID/WG.15/6	Manufacture of telecommunications equipment in developing countries *by K. C. Berger*
ID/WG.15/7	Some telephone problems in developing countries *by H. K. Ebenberger*
ID/WG.15/8 Add.1	Possibilities of establishing telecommunications industry and planning of the same with special reference to developing countries *by Imre Varadi*
ID/WG.15/9	Maintenance and repair of radio communication equipment *by A. Dobrokhotov*
ID/WG.15/10 and Corr.1	Designing and manufacturing low-cost receivers of radio broadcasts in developing countries *by D. Hara*
Add.1	An example of process control for production of radio receivers by belt conveyor system
Add.2 and Corr.1	Examples of specifications and design of low-cost radio receivers
ID/WG.15/11 and Add.1	Promotion of the manufacture of low-cost sound and television receivers in developing countries *by C. Anazava*
ID/WG.15/12	Training for design and production of electronic equipment *by the International Labour Organisation*
ID/WG.15/13	State of manufacture of telecommunications equipment in Pakistan *by M. R. Khan*

[1] A limited number of copies are available upon request.

ID/WG.15/14	The status of telecommunications equipment in Iran *by K. Malek*
ID/WG.15/15	An outline of the actual state of plans for the establishment or expansion of telecommunication industries in Kenya *by C. M. Amira, Kenya*
ID/WG.15/16	Report on the telecommunications industry in Turkey *by Y. Karahan*
ID/WG.15/17	Programme
ID/WG.15/18/Rev.1	Provisional list of participants and Add. 1
ID/WG.15/19 and Add.1	Provisional list of documents
ID/WG.15/20	Status of manufacture of telecommunications equipment in Thailand *by C. Krinyawath*
ID/WG.15/21	Draft report
ID/WG.15/22	The status of manufacture of telecommunications equipment in Nigeria *by F. A. Oguntayo*
ID/WG.15/23	State of and plans for telecommunications industries in Ceylon *by S. Rajanayagan*
ID/WG.15/24	Report of the problems involved in providing for community reception of television in non-electrified areas of developing countries, and an examination of possible solutions *by UNESCO*
ID/WG.15/25	Status of the manufacture of telecommunications equipment in Ethiopia *by G. Tedros*
ID/WG.15/26	The stage of manufacture of telecommunications equipment in India *by S. M. Argarwal*
ID/WG.15/27	Production transmission and receiving requirements for the application of mass communication to development and education *by UNESCO*
ID/WG.15/28	L'état de l'industrie des télécommunications au Congo *by A. Kumba*
ID/WG.15/29	Broadcasting in Uganda *by M. B. S. Mangen*
ID/WG.15/30	Final recommendations
ID/WG.15/31	Status of manufacture of telecommunications equipment in Argentina *by J. R. Larrea*
ID/WG.15/32	La maintenance et le service après-vente des récepteurs de radio et téléviseurs en noir et blanc et en couleurs dans les pays en voie de développement *by R. Besson*

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