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UNIDO GUIDE FOR INDUSTRIAL INVESTMENT AND PROJECT IDENTIFICATION AND PROMOTION IN THE ELECTRONICS SECTOR IN DEVELOPING COUNTRIES*

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INTRODUCTION

1. This Guide deals with the development of electronics applications and production in developing countries and has been prepared with a view to accelerating the flow of investments and technology, and to developing endogenous technological capability in these countries in this increasingly critical field. It is intended, through this Guide, to assist developing countries at various stages of economic and industrial development in identifying specific subsectors and products in the electronics sector where there is substantial potential for growth, together with the supportive policies, measures and institutional arrangements which may be necessary.

2. The rapid pace of technological developments in electronics, particularly microelectronics and informatics, which comprises computer applications, telecommunications, software and systems capability, is having a major impact on several production sectors. Innovative electronic processes and products are in a continuing stage of technological evolution, and developments in informatics, photonics, superconductivity and the like are increasingly multidimensional in their character and effects, which extend to a wide range of economic activities. These developments have taken place primarily in industrialized, developed economies and are resulting in significant socio-economic changes and in the way of life in these countries. At the same time, the pervasive and versatile nature of these developments is also having, and will increasingly have, considerable impact on the economies and production and trade patterns in various developing countries. This necessitates a comprehensive review of the implications of these developments and the policies and measures which should be considered and implemented at national and regional levels. Certain developing countries, particularly in South-East Asia, already have an extensive production of electronics, specially micro-electronics, and are exporting a wide range of electronics products, including microcomputers, peripheral equipment and components, besides a fast-expanding range of consumer electronics. In several other Asian and Latin American countries, the initial resistance to computers as aggravating unemployment has given way to increased acceptance and usage of various computer-aided functions, including design and manufacture. In other developing countries, where there has been a relatively limited growth of electronics production, there is growing recognition of the critical role of microelectronics and informatics and measures are being initiated for the development of technological infrastructure and local production capability in these fields.

3. The purpose of this Guide is to highlight the potential of, and the policies and programmes for sectoral expansion and development in electronics, as well as to facilitate the identification and promotion of investment projects for the benefit of developing countries. Accordingly, the Guide has been divided into four principal chapters. In Chapter I the characteristics, features and trends in electronics production, including the principal sub-sectors, are discussed. The experiences of certain developing countries are reported, including the prospects of, and the policies to be considered by developing countries. Chapter II contains a summary of the principal elements of a national policy and provides an annotated outline of a national policy statement on electronics development for consideration at the national level in developing countries. Chapter III deals with a questionnaire soliciting information about specific investment projects in the electronics sector for which foreign investment or technical assistance would be required. Chapter IV comprises a series of investment project profiles for the manufacture of

specific electronics products, ranging from consumer electronics to personal computers and peripheral equipment, which have considerable potential for local manufacture in a number of developing countries. Thus, while the Guide would be of interest to planners and policy-makers who could formulate appropriate national policies in the light of the experience of other countries, it would also be of particular value at the specific investment project level in various developing countries, where potential entrepreneurs could develop the investment project and product profiles contained in Chapter IV into viable projects and enterprises at the national level.

4. This Guide was prepared by the Industrial Investment Division (IID) of UNIDO. The role of IID is to assist developing countries in identifying and formulating industrial investment projects suitable for implementation in their countries, and to use promotional tools to bring about international business-oriented partnerships and collaboration between enterprises in countries at varying stages of industrial development. The identification of industrial investment projects has necessarily to be conducted through various stages. The initial stages in such analysis should be based both on global trends in production and technology in particular fields and on the policies, programmes and experience of selected developing countries where significant sectoral development has taken place. At the same time, certain basic information needs to be collected and collated on individual investment projects and products which may have potential for local manufacture in developing countries. This Guide is intended to assist developing countries during that initial phase.

5. Upon request, IID could undertake specific follow-up programmes for the development and implementation of investment projects in the electronics sector in particular countries and regions. While the project/product profiles contained in Chapter IV deal with the basic features of particular investment propositions, project sponsors at the national level will have to develop these profiles into viable techno-economic projects based on local conditions, including markets and demand, availability of raw materials and human resources, detailed investment and operating-cost requirements and other relevant factors. IID can provide the following assistance in formulating investment projects and in locating suitable partners and sources of technology:

(a) To improve the presentation of investment projects for promotion, technical assistance can be rendered through international experts and industrialists from countries with a relatively advanced electronics industry, with full participation of nationals from the developing country concerned;

(b) Promotional services for industrial investment projects are afforded through IID investment promotion offices in several countries. Country presentation meetings are arranged to enable representatives from industry and Government of developing countries to visit the investment promotion offices and to discuss investment opportunities with potential partners from the country where the office is located. The objective of these promotional services is to assist potential investors from developing countries in identifying potentially interested suppliers of the resources required to implement their investment projects. Such resources may include finance, technology, management, market access, etc. In order to provide these promotional services, IID requires the information collected by means of the questionnaire reproduced in Chapter III. Furthermore, the availability of a country paper for the developing country concerned would considerably facilitate such promotional activities;

(c) The services of the Investment Promotion Information System (INPRIS), which is a computerized data bank maintained by IID at UNIDO headquarters, Vienna, is available to project sponsors and potential investors;

(d) As part of its follow-up activities in particular industrial sectors, IID organizes Investment Project Promotion Forums, usually in developing countries, which provide an opportunity for project sponsors from developing countries and potential partners from industrially advanced countries to meet and discuss specific investment projects.

6. It is hoped that public and private agencies responsible for the development of the electronics industries in a specific country as well as existing and prospective enterprises will make use of this Guide in order to tailor their programmes and projects to the needs and potentialities of that country and to overcome total and sole reliance on external expertise from the United Nations or bilateral donors. The Guide should also be useful to regional and international financial institutions and to bilateral donors and investors in developing countries, who are seeking opportunities to attract investment, technology transfer, joint ventures and technical co-operation. It is further hoped that the Guide will assist developing countries in the formulation of a sectorial plan for the electronics industry together with a policy for its implementation; the translation of that plan into subsectorial and product-specific investment opportunities; the preparation of bankable investment projects for the manufacture of a single product or a group of products; the identification of financing, technology transfer and technical assistance needs; the conclusion of investment and co-operative arrangements; and the establishment and successful operation of manufacturing enterprises. UNIDO looks forward to a fruitful co-operation with developing countries in that comprehensive task.

Note: For UNIDO activities in the field of microelectronics, see "The UNIDO programme of technological advances: microelectronics" (IPCT.29/Rev.1(SPEC.)).

I. FEATURES AND TRENDS IN ELECTRONICS AND PROSPECTS FOR DEVELOPING COUNTRIES

A. Definitions

7. The pace of technological developments in the electronics sector has accelerated rapidly in recent years and a series of continuing technological innovations, particularly in microelectronics and informatics, are having major impact on several production and service sectors. Electronics production has emerged as the fastest-growing sector and is identified with a wide range of high-technology industries, processes and products. Though there was rapid growth in the electronics industry even prior to the 1970s, it is during the last decade that the massive and pervasive impact of technological developments in this field has been most felt in terms of new processes and products in various economic activities. These developments have taken place primarily in industrialized, developed economies and are resulting in significant techno-economic and social changes in those societies. The diffusion of these technological developments to developing countries has been slow and gradual and is still mainly confined to a few of these countries. The pervasive nature and impact of developments in electronics will, however, inevitably be applicable to all economies and it is necessary for every developing country and region to assess their situation in relation to these developments and to determine policies and programmes for production and technological absorption and adaptation in this field, so as to minimize the negative effects of such technological developments and enhance their positive impact as far as possible. 1/

8. The electronics sector comprises a wide range of technologies, processes and products, extending from hardware, components, software and systems to a large variety of technological applications in data processing, telecommunications, industrial production, instrumentation and control systems and other sectoral applications, and to a vast array of rapidly-changing consumer electronics products. Major technological innovations have been achieved through increased miniaturization of electronic components and application of digital technologies. This has not only resulted in substantial price reduction for products such as micro-computers, peripherals and other hardware, but has enabled radical improvements in their performance and services. There has also been a growing convergence in technological developments and applications between computers and telecommunications. Such convergence, which is often characterized as informatics, has led to a major new role for information services and capability, with the emergence of information as an increasingly essential and critical element for socio-economic development. 2/

9. Major innovative developments in information transmission, storage and instant retrieval have enabled information to be utilized for a wide range of techno-economic applications and are gradually leading to the development of an information society, where information would play the crucial role for decision-making in most fields. The convergence of computers and tools of communications has also led to the development of a series of automation technologies with wide-ranging applications. These technologies, some of which are still in the process of emergence, extend to photonics and lasers, and to robotics and artificial intelligence. The versatility and information-processing capability through micro-processors and other developments in electronics are also bringing about major transformation in equipment and processes, ranging from computers, wordprocessors and automated equipment in offices to numerically-controlled machine tools and robots, computer-aided designs and manufacture (CAD-CAM), computer-aided engineering (CAE) and

flexible manufacturing system (FMS) in the industrial sector, and to usage of new satellite technologies, fibre optics and other innovative developments in communications.

10. The use of electronics equipment and applications is also increasing rapidly in several other sectors such as in the medical field, particularly in diagnostic applications, in the agricultural sector, in macro-economic and energy planning, and a variety of other applications which would be of special interest to developing countries.

B. Characteristics of the electronics sector

11. The electronics industry has several features and characteristics which, taken together, make this sector unique and of special significance, particularly with respect to the range of technological innovations and applications and to their impact on other production and service sectors. 3/ Such innovations and applications continue to grow rapidly and there can be no doubt that the growth rate for global electronics production during the 1990s will continue to be very high and may even be higher than during the 1980s because of new processes, products and applications developed during this period.

12. Increasing range of applications: The range of application of electronics technologies extends, firstly, to specific electronic products, particularly micro-processors, and components, including semiconductors, and secondly, to the great diversity of their application in various fields such as data processing, communications, industrial applications, office automation and the like. 4/ As such applications get increasingly extended to new fields of economic activity, the nature of such activity itself tends to undergo major transformation. Thus, the utilization of CAD-CAM techniques, flexible manufacturing systems (FMS) and computer-integrated manufacture (CIM), is having major impact not only on production processes in several industrial sectors, particularly metal-transformation and engineering-goods industries, but on the machinery requirements for such industries. The machine-tool industry has, for example, undergone rapid transformation and there has been a major shift to numerically-controlled (NC) machine tools, which can be utilized for flexible production at machine-centres, comprising a cluster of such machines. The higher productivity, efficiency and precision achieved through flexible automated manufacture is inevitably having a major impact on costs, quality and competitive capability of resultant products, as against products manufactured through traditional machine-operation processes. Developments in flexible manufacture expand the scope of automation to a wide range of production processes and would undoubtedly have considerable effect on global industrial restructuring, particularly in the capital-goods sector, including automotive equipment. These would also affect developing countries such as Brazil and India, which have been exporting engineering-goods products and non-NC machine tools. In fact, the factor advantage of cheap labour in developing countries would be substantially reduced, because of developments in automation, based on electronics technologies. Innovations in telecommunications and data-handling have revolutionized the communications sector. Similarly, office automation including usage of desk-top computers, input-output devices, storage devices, calculators, duplicators and facsimile equipment have undoubtedly transformed office operations and management. These developments have already extended to several developing countries and would undoubtedly extend rapidly to others, as facilities become available in these countries. It is this pervasive and versatile feature of electronics applications that needs to be stressed in relation to the impact of this sector. It must also be emphasized that electronics is a continuing growth industry, with new technological developments being constantly evolved, including in electronics publishing, computer graphics, laptop computers and an enormous range of new products and applications, and

is very far from reaching a level of saturation, either in terms of technological developments or in the demand for its ever-widening range of products.

13. Low energy and material requirements and pollution-free operations: An important feature of electronics production is that it is neither energy-intensive nor material-intensive and is a "clean" industry from the viewpoint of environmental damage and pollution. Though uninterrupted electric power is an essential prerequisite, the power requirements are not particularly high. The requirements of raw materials are also not specially large, but the materials must be extremely pure as any impurities can result in lower production in terms of non-usable devices. The availability of components, particularly semiconductors, is undoubtedly an essential element and needs to be planned as a critical input for electronics production.

14. Knowledge-intensive industry: Electronics development is primarily knowledge-intensive. While research intensity is high, particularly at higher ends of the technological spectrum and for innovative developments, the principal feature lies in the innovative application of knowledge to various situations and requirements. A large proportion of technological developments in this field have been achieved through small research-intensive organizations and enterprises which have developed innovative products and applications in different fields. A large number of electronics companies, which have global operations today, had very small beginnings, often less than two decades ago. At the same time, overall research costs in this field are very high and major transnational corporations (TNCs) in this sector, such as IBM, AT&T, Hitachi and Siemens each spend $2-3 billion annually on research and development. Such expenditure is undoubtedly necessary to maintain technological leadership in this rapidly-changing sector. Research and development has generally been directed towards major innovations or proprietary products and designs, though incremental innovations built on imitation have also been very successful, particularly in Japan, and in other countries in South-East Asia in more recent years.

15. Rapid change and obsolescence: The nature of the electronics industry makes it susceptible to rapid technological changes and consequently to speedy obsolescence. It is, therefore, essential that a strong research base is maintained, either in the form of institutional linkages or enterprise-level research and development.

16. Global operations: Since electronics products, including most hardware, peripheral equipment, software and other electronics items are easily transportable, the electronics industry needs to be viewed on a global and international basis. 5/ Electronics has also often been characterised as a foot-loose industry, moving from one location to another to avail of particular factor advantages. The manufacture and assembly of electronic components in South-East Asia and other developing countries, was a typical example of the industry taking advantage of cheap labour in these countries, till such time as greater automation reduced such advantage. It would obviously be difficult and undesirable, particularly in this context, for individual countries to insulate themselves from global developments in this field. At the same time, countries need to ensure that their national growth pattern in terms of infrastructure and human resource development is adequate for local electronics production, both hardware and software.

C. Technology market in electronics

17. With the increasing internationalization of the electronics industry and the rapid pace of innovative developments, the technology market for this sector is becoming increasingly imperfect, with various alternative technologies and sources, but with a high level of product differentiation. The market for

electronics technology has undergone considerable change since the 1960s and early 1970s when some corporations, particularly IBM, had a predominant role in computers and related electronics development. IBM continues to be dominant in mainframe computers and an industry leader for several other products, but a number of other companies, specially from Japan, have become increasingly competitive in most fields, particularly micro-computers and semiconductors. 6/ Other major transnational corporations have played a dominant role in developing new technologies for communications, such as AT&T, Alcatel, Siemens and Ericsson, and for consumer and industrial electronics and other applications. Nevertheless, in recent years there has been considerable technological diffusion and a large number of new entrants have come into the field, particularly after the advent of micro-computers, and can provide technology and knowhow for a growing range of electronics products and components. This development has taken place largely because of extensive technology licensing, particularly by U.S. corporations to Japanese companies as also to certain corporations in Western Europe, during the 1960s and early 1970s, particularly in computers, semiconductors and communications technologies. New technological applications and products were also developed by a large number of enterprises which were often small but have grown rapidly in recent years. This is particularly true of software development in the United States. The capability to replicate and adapt existing products and to innovate new products and applications has also led to the development of a fairly extensive market for technology and knowhow, particularly in the USA and Japan, and in West European countries. Replication and packaging of "electronic kits" for assembly of various electronic products, including for desk-top, personal computers and peripheral equipment, has also developed fairly extensively in certain South-East Asian countries, particularly the Republic of Korea and the Province of Taiwan. At the same time, there is also a high degree of product differentiation and similar products may be substantially differentiated in value because of a particular brand name. An important aspect of technology transfer, particularly of advanced sophisticated electronics technologies from the United States, however, has been the considerable restriction placed on exports of both equipment and technologies falling in certain categories. These restrictions, which have been imposed for security reasons, are supervised by U.S. authorities, as also by a Co-ordinating Committee (COCOM) of 15 NATO members, including Japan.

18. The spectacular growth of electronics has resulted in problems relating to intellectual property rights, including copyrights on software. Intellectual property legislation in several countries has not taken adequate account of the rapid developments in the electronics sector. 7/ Considerable litigation is taking place, particularly in the United States, on the scope and coverage of patents and copyrights in the electronics sector. In several countries, copyrights on software are not recognized and the same software is available at much lower prices. There is considerable divergence of views between industrialized and developing countries on the nature and application of intellectual property legislation in this sector. These aspects can have an important effect on technology transfer negotiations and contracts in this field.

19. While electronics production is essentially research and knowledge intensive and subject to economies of scale for certain products such as 'chips', it is possible to undertake manufacture at various levels of production and local integration. The manufacture of silicon or gallium arsenide chips is, of course, highly expensive, but standard chips and integrated circuits have become relatively cheap and readily available. The assembly of several electronics products can be undertaken with relatively limited investments and with gradual backward integration. The production of software also involves very low investment, and joint ventures and technology licensing arrangements are extending in this subsector also.

20. While the rate of growth of various segments of electronics production will continue to be very high in the coming years, the degree of competition in the sector is also expected to increase rapidly. Investments have to be carefully assessed in terms of the segments to be concentrated on, recognizing that continuing research and adaptation alone would enable production enterprises to adjust to rapidly changing technologies and conditions of production in this field. At the same time, technology in most subsectors of electronics, particularly those in which most developing countries would be initially interested, can be acquired from alternative sources and joint ventures and licensing are becoming increasingly common in a number of developing countries. It is only with respect to advanced electronics technologies that restrictions would be faced, particularly from the USA, but also from other industrialized countries. The negotiation of technology agreements and contractual conditions for technology transfer may also be more difficult in the case of certain electronics technologies than in more traditional production. 5/

D. Production and trends

21. The production of electronics products and equipment has expanded enormously during the 1980s in the USA, Japan and Western Europe, which cover 80-90% of global production.

Table 1.

Electronics production in United States, Japan and Western Europe, 1980 and 1985
(In million US dollars)

	United States		Japan		Western Europe	
	1980	1985	1980	1985	1980	1985
1) Consumer electronics	6,066	5,970	18,704	32,652	13,338	10,399
2) Computers and components	51,700	85,500	24,447	62,804	26,397	33,100
3) Factory automation	13,619	20,570	3,430	5,195	10,331	9,885
4) Communications and telecommunications	25,983	43,780	9,1209	19,937	24,100	23,600
5) Automobile electronics	3,630	5,520	2,942	4,656	5,284	4,557
6) Medical electronics	2,709	5,130	931	1,269	2,922	3,086
TOTAL (Approx.)	103,826	167,450	59,653	126,413	82,450	84,720

Source: Battelle Institute, based on national statistics.

22. It will be seen from Table 1 that during this period, production of consumer electronics has tended to decline in the USA and Western Europe and has increased substantially in Japan. The production of computers and components has risen significantly both in the USA and Japan and, at a lesser pace, in Western Europe. During 1986-1987, similar trends have continued, with the added factor of substantially-increased production of consumer electronics and computers and components in certain South-East Asian economies, particularly the Republic of Korea, Hong Kong, Singapore and the Taiwan Province. While production of consumer electronics and computers and components has also risen substantially in certain other developing countries such as Argentina, Brazil, India and Mexico, the proportion of their production to global output in these subsectors continues to be relatively small. Exports of electronics products rose to about $124.8 billion

by 1985, of which major exports were from Japan ($36.2 billion) and USA ($26.4 billion). Exports from Taiwan Province, Republic of Korea, Hong Kong and Singapore, however, expanded rapidly by the mid-1980s and rose to $14.6 billion in 1985 constituting over 70% of exports of such products from developing countries. 9/

23. The pattern of growth in the electronics sector is likely to continue along the above lines during the early 1990s. With increasingly sophisticated applications, the proportion of electronics output in industrialized economies is likely to increase significantly in the areas of defence, industrial applications, communications and data processing. Demand for consumer electronics will continue to grow, with innovative developments in video and audio equipment, though the pace of growth in industrialized economies is likely to be slower than in the past. This will be in contrast to developing countries, where demand for consumer electronics will continue to increase rapidly in the next few years. Production of consumer electronics is also likely to expand considerably in a number of developing countries. It is, however, with respect to other electronics applications, particularly data processing, communications and industrial applications, besides applications in agriculture, macro-planning, energy planning and the like, that special attention may need to be given in developing countries.

24. With rapid expansion of the informatics sector and data processing, the various categories of computers, which comprised $150 billion of business in 1985-86, are expected to experience further rapid global growth in the coming years. 10/ In micro-computers, this may be as high as 40-60%, while the rate of growth for mainframes is likely to be much slower. Personal computers already account for 40% of the US market and 30% in Europe, and are finding versatile applications in office operations, particularly as "office-work-stations". Software packaging for computers has also become a very fast-growing industry and is expected to exceed $50 billion by 1989-1990. In communications, the growth rate is expected to be around 15.8% and value of production is expected to reach a level of $30 billion by 1989-1990. Of this, customer-premises equipment would account for around 14.5%, with telephone and data work stations registering fastest growth with a global market estimated at $[illegible] billion by 1987. Local area networks have also become important, in order to link micro-computers used in business. The other major items of growth include transmission equipment, data communication equipment, switching equipment, and cellular radio communications, which is rapidly becoming popular. The demand for testing and measurement equipment and for robotic equipment, used mostly for applications as spot welding, spray painting, material handling, etc., is also likely to grow fairly rapidly.

E. Subsectoral growth pattern

25. The electronics industry can be subdivided under several subsectors, though there is considerable interface and overlapping in use of equipment and interchangeable components. Nevertheless, a broad categorization would assist in defining the subsectors which could be of special interest to developing countries.

26. Consumer electronics: This subsector, which includes high-fidelity audio, FM radio, television receivers, video cassette recorders, and a growing list of products, is likely to be of most immediate interest to several developing countries in terms of growing demand and potential for local production. Technologically, the subsector ranges from the simple to the complex, particularly with recent developments in sound systems, video disks, laser disks, new forms of video games, and home control systems of varying degrees of sophistication.

27. The components and materials for consumer electronics include passive components such as inductors, resistors, coils, capacitors, etc., and those

which are active, such as tubes and transistors. Such components are also classified as discrete where the components are individual items and integrated for those items which are in packaged form. The level of integration is becoming increasingly large, the current rate being of the order of 10^6 on a single chip. Speed of operation and memory storage capacities are also increasing correspondingly. The production of high-quality components, which can be undertaken in a number of developing countries, is vital for the success of the consumer electronics industry. The production of semiconductors, which require expensive etching, bonding and packaging facilities may also need to be undertaken, though perhaps in a second phase, with a beginning being made with resistors and capacitors, either ceramic, plastic film, metal-film or electrolytic, which could be taken up for large-volume production. Simple types of printed circuit boards can also be produced in the initial stages. It must be recognised, however, that the ultimate quality and price of equipment would depend on that of the components which, in turn, would depend on the volume of production, and often the degree of automation. At a later stage, professional-grade items may be considered if the volume of demand justifies the large investments required for this purpose. This is particularly true with respect to processing basic materials like silicon, which needs to be purified to provide electronic-grade polysilicon. On a lesser scale, there is need for electrolytic grade aluminium, high quality ceramics, and various materials including beryllium. Fiscal policies will need to be formulated so that it is preferable to manufacture components locally rather than import. Technological developments in new materials may provide opportunities for developing countries to use their raw materials in a more productive manner. An example of such innovation is with respect to fine ceramics required for integrated-circuit packaging and ferrites. Ferrites are powdered, compressed and sintered ferric oxide mixed with other metals to develop special magnetic and resistive properties. The traditional ceramic industry has found new applications in such products as sub-strata for integrated circuits, ceramic capacitors, piezo-electric ceramics, thermistors/varistors used in industrial electronics, ferrites and translucent ceramics.

28. Computers: Perhaps no other branch of electronics has grown so rapidly in recent years as computers. The volume of information shared and retrieved is now so large that information systems have become indispensable. Apart from the hardware comprising the central processing unit (CPU) and peripherals, software packages have become of vital importance to extend and expand the application of computers in a wide variety of situations. CAD-CAM programmes and computer-integrated manufacture are now becoming fairly common to better organize utilization of material and human resources in industrial designing and manufacture.

29. Computers are generally categorized under mainframe computers, including super computers, mini-computers and micro-computers. Micro-computers constitute the fastest growth area in computers and the demand for microcomputers is expected to exceed $25 billion by 1989-90, with the market for mini-computers being around $28 billion. Storage capabilities are being raised to 100 million bits per square inch, using tiny magnetic devices called Josephson junctions. The micro-field is dominated by personal computers using 8 and 16 bits, together with small business computers with more bits and storage capability. The boom in personal computers has raised the problem of software compatability, since no one company can produce all the software needed for the diverse applications of varied customer requirements. A certain measure of standardisation is nevertheless taking place.

30. For developing countries, the growing demand for computers, peripheral equipment such as disk drives, magnetic disks, printers, keyboards, etc., together with software and systems, provide major potential for local production.

Software development provides special opportunity since, unlike the central processing unit and other hardware, software production is primarily labour intensive since it requires personnel to write programmes relevant to national needs and export requirements.

31. Communications: This includes both telecommunications, and other facilities for two-way communications including telephone, facsimile, telex, mobile radio, paging systems, etc., as well as broadcasting of both sound and video. Closed circuit and cable television systems are also expanding coverage of their services just as new techniques such as citizen band radio, cellular radio and local area networks are increasing the capabilities of communications systems. Fibre optics which provides new means of transmission, and wide bank communications, are increasingly being used to carry simultaneous single-voice circuits. Satellite communications technology has also developed into a powerful medium with considerable potential for flexibility, processing, switching and growth. By the mid-1980s, Intelsat IV was able to provide 25,000 circuits at a cost of $5,000 per year per circuit and the system included 12 satellites, and 300 earth satellites in 125 countries. In addition, many countries, such as Canada, India, Indonesia, Japan, USSR, and the USA and others operate domestic satellite systems for communications and TV services.

32. New developments in communications capability such as videotex, electronic mart, tele-conferencing and CATV are leading to automated offices and even home office facilities, where a great deal of information can be generated, processed and used for business operations and for recreation. Electronic publishing and video data are likely to replace, to a significant extent, the conventional media of books, journals and newspapers with customers obtaining information on demand from central data sources. Viewdata public service is now available in several industrial economies, while agricultural information systems have been widely extended in the USA and several other countries. While transmission equipment required for these services is fairly complex, auxiliary equipment and components can be assembled and made locally. New applications in communications will also undoubtedly be extended in a large number of developing countries, including to rural regions in the near future. It is important that facilities for local production are also expanded to cover a wide range of communications equipment and components.

33. Industrial applications: This is a vast and growing field because of the immense potential of electronics to control and monitor complex systems and to prepare designs and conduct integrated production operations through automated equipment in various sectors. These can range from textiles and clothing, where CAD-CAM has already been introduced in several developing countries, to the manufacture of automated equipment, specially NC machine tools, which has been undertaken in certain countries, such as Argentina, Brazil and India. In this subsector, an important challenge is to tailor systems to suit specific requirements of user enterprises. The demand for such systems is likely to be small, at least in the initial stages, and since much of the system would comprise assembly operations, investment costs and infrastructure needs would not be unduly high. Apart from numerically-controlled machine tools and work stations, industrial control systems and instrumentation comprise critical equipment for such applications. Industrial control systems can be variously categorised and include industrial drives (both AC and DC), convertors/and rectifiers for various control systems, programmable logic controllers for process control, flexible manufacturing systems (including numerical control machine tools), road traffic signalling, weighing, measuring and packaging systems, and miscellaneous items, such as solar power panels, industrial lasers, industrial ultrasonic equipment, security systems, special tools, jigs and fixtures, etc. Most of such equipment and systems have varying degrees of application in developing countries and local production and developments have to be planned in relation to national factor endowments and industrial and technological capability.

34. Instrumentation are the building blocks of the control systems and range from simple measuring and test instruments, such as multi-meters, to highly-complex instrumentation to determine and control various parameters in industrial operations. Such instrumentation can be utilized in various industrial applications, including oil prospecting and drilling, steel, cement, fertilizer and chemicals, paper, sugar, etc., besides mining and agriculture. The current trend is to use sensors and transducers using new developments in the fields of micro-electronics and fibre optics. Distributed systems with several micro-computers can be physically spread over and handled through cables which may be either coaxial or fibre-optic.

35. Testing and measuring instruments constitute an important sub-sector and are essential for increased production and greater productivity. These are of varying degrees of sophistication, from simple oscilloscope to frequency control equipment, signal generators, and logic analyzers and to automated test equipment. Various types of instruments are in considerable demand for measuring different parameters of industrial investigation and control.

36. Medical electronics: An area of growing interest is that of medical electronic equipment which are now being increasingly utilized for diagnosis, therapy, patient monitoring and clinical analysis. The range of such equipment is fairly wide, from relatively simple instrumentation to highly complex systems. New techniques include the use of lasers for opthalmology, plastic surgery, cancer treatment, etc. Ultrasound is utilized widely for diagnostic areas such as blood flow measurements, ultra sound imaging of heart valves and various other applications, including in electro-encephalography and diagnosis. Nuclear magnetic resonance scanning is a newly emerging area, and is utilized in CAT-scan studies of brain and body tissues etc. Microwaves are utilized in diathermy as well as for location of cancer. Modelling and signal processing constitutes an important tool for thorough understanding of physiological phenomena. The extent to which medical electronics equipment can be manufactured in developing countries would vary with the level of electronics development and technological capability but the range of applications would undoubtedly increase rapidly in coming years.

37. Defence and aerospace: The defence sector requires very specialised electronics items including radar, navigational aids, communications for defence, marine and underwater electronics and specialised military equipment for aerospace, land and naval operations. Defence electronics has been a major source of technological developments in electronics in the USA, and to a lesser extent, in several West European countries, because of the massive fund allocations provided for defence-oriented research. Most countries have defence programmes which are increasingly dependent on electronically controlled equipment. Not many developing countries may need to design such equipment, but several of these countries will need to develop maintenance and repair capabilities to keep such equipment in operational order and to make simple spares. Civil aviation is also an important field since many developing countries operate fleets of passenger aircraft. These require constant inputs in the shape of maintenance crew and equipment and availability of spares. While initial equipment and training would be provided by aircraft manufacturers, it is necessary to develop basic maintenance and repair capabilities at national level, as also to develop design skills for the simpler equipment used in civil aircraft.

38. Other subsectoral applications: The above account only exemplifies some of the varied applications of electronics in certain selected sectors. Such applications, however, are increasing every day. Whether it is photocopiers or cameras, fish finders or forecasting the future, electronics seems to enter increasingly into every-day life in various production and service sectors. For developing countries, electronics applications in the agricultural sector,

including irrigation, forestry, animal husbandry and the like, would also be of special interest. Combined with developments in biotechnology, the impact on agriculture and related sectors is likely to increase substantially in coming years and would provide considerable potential for technology "blending" through the use of microprocessors and the like in traditional processes and operations in agriculture. 11/

39. Table 2 lists certain sub-sectors and the range of principal equipment and components under each sub-sector. The list is, however, only illustrative, since new applications are being constantly developed and extended.

Table 2.

Sub-sectors in electronics: types of equipment and devices

Sl. No.	Sub-sector	Equipment and devices
1.	Consumer electronics	Radios (AM, FM, car), TV receivers, (colour and black and white), hearing aids, amplifiers (stereos, Hi-Fi), PA systems, TV games/toys, watches, tape recorders (two in one) VCR and TVR, record players, pocket calculators.
2.	Components and materials	Active: Transistors, ICs, micro-chips Passive: Resistors (wire-wound, carbon, metal/film). Capacitors (ceramic, paper, mica, plastic film, electrolytic). Others: Ferrites (soft, hard), printed circuit boards, tape decks, micro-motors, loudspeakers, microphones, TV picture tubes, crystals, connectors, relays, switches, TV deflection components.
3.	Communications & broadcasting	Telecommunications: Equipment for transmission and switching, PAX and PABX, telephone head sets, paging and mobile communication systems, facsimile, telex, teleprinter, fibre optic systems. Broadcasting: LP transmitters, studio equipment, microwave antenna, industrial drives (AC and DC), converters and inverters, traction and loco control systems, process control systems for textiles, sugar, oil, cement, refineries, etc., traffic signalling systems, rectifiers (SCR, thyristors), furnace control systems, weighing, measuring and packaging systems, industrial lasers, security systems, pollution detection and control systems.
4.	Instrumentation (Testing and control)	Signal generators, oscilloscopes, digital counters, multi-meters, analytical instruments, spectro-photo meters, nuclear and geo-scientific instruments, echo sounders and fish finders, pulse function generators, logic analysers, LCR bridges.
5.	Medical electronics	Audio meters, sound level meters, pace makers, X-rays and diagnostic equipment, defibrillators, patient monitoring systems, electro-cardiogram (ECG), nuclear magnetic resonance (NMR) scanning, laser for surgery, CAT (Computerized Axial Tomography) scanner.

Table 2. (Continued)

Sl. No.	Sub-sector	Equipment and devices
6.	Computers	Hardware: Main frames, mini and micro (including personal) computers. Software: Packages for different end uses. Peripherals: Line printers, teletype terminals, tape recorder, card reader, tape and disc drives, floppy disc.
7.	Defence and aerospace	Radar, sonar, underwater electronics, weapon control and missile tracking systems, HF, VHF and UHF communications equipment for ground, air navigational purposes.
8.	Miscellaneous	Agri-electronics, mining electronics, solar power panels, NC machines, photo copiers, computerized forecasts.

F. Electronics Development in Developing Countries

40. While most developments in electronics technologies and applications have taken place in industrialized countries, there have been certain significant developments in a number of developing countries. The initial pattern of growth in the latter countries has primarily been in consumer electronics where increased demand and usage has been accompanied by the development of local production capability, often through subsidiaries of transnational corporations, in several countries. In the last decade, however, there has also been rapid growth in the usage of computers, particularly micro-computers, for a variety of applications, together with the use of communications satellites and other electronic equipment of varying degrees of sophistication. The initial resistance to the use of computers and data-processing equipment as aggravating local employment, which was a feature in several developing countries, has gradually given way to recognition and acceptance that computers and related equipment can be utilized as vital tools for socio-economic growth and the development of international competitive capability in the present era of technological change.

41. Country classification: A broad classification can be made of developing countries in terms of usage and application of electronics and development of electronics production and technological capability. The first group comprises certain countries in South-East Asia, in particular the Republic of Korea, Hong Kong, Singapore and the Taiwan Province of China and, to a lesser extent, Malaysia, Philippines and Thailand. These countries, which have had considerable initial inflow of foreign direct investment and technology, mainly in offshore electronics assembly and production of components, have developed considerable capability in usage and production of electronics products and equipment. Not only are electronics products extensively utilized in homes and offices, but increasingly in computer-aided designs and production operations in several fields. The Republic of Korea and the Taiwan Province have, in particular, emerged as major exporters of micro-computers, peripheral equipment and components, besides a wide range of consumer electronics products. The second group comprises some of the larger developing countries, including Argentina, Brazil, China, India, Indonesia, Mexico and Pakistan, in which there has also been considerable increase in usage of computers and other electronic equipment and varying levels of growth in indigenous electronics production. Among these countries, the development of micro-electronics and informatics has been the

highest in Brazil. In some countries, particularly India, special emphasis has been given to software development, especially for exports. Local production has been established in these countries not only for a wide range of consumer electronics products, but for assembly of personal computers and peripheral equipment and for manufacture of various components. These developments have taken place through varying policies on foreign investment and technology, ranging from relatively unregulated inflow to varying degrees of regulatory control. Despite considerable technological absorption in certain subsectors of electronics, the overall pace of development in electronics production and applications has, however, been relatively slow, except in Brazil, where local production has expanded very rapidly.

42. The third group comprises several middle-size developing countries in Latin America, Asia and North Africa, including oil-producing countries. The level of technological development differs from country to country but there has been rapid increase in usage of computers and other electronics equipment. Considerable research has been taken up in certain of these countries, such as Kuwait, particularly in micro-electronics and informatics. The fourth group comprises a large number of developing countries, including several African countries, 12/ in which there has been relatively little development of electronics, particularly in terms of local production and technological absorption. Finally, the least developed countries, and several island economies, have not experienced much impact from developments in electronics, except where production or assembly facilities for electronics components have been set up.

43. The above classification is, by its nature, only indicative. The range of new applications has undoubtedly become fairly extensive. Apart from rapid increase of computers, wordprocessors and facsimile equipment in offices, electronics technologies are increasingly being utilized in finance, banking and trading operations, as also in factory management and in design and manufacture of garments, footwear and several other industrial products. Micro-electronic applications have also been tested and applied in some developing countries for demographic surveys, energy planning, public health, agricultural operations, including surveys and remote sensing, forestry, irrigation, food storage, animal husbandry and animal feed, weather forecasting and meteorology, and other activities linked to agriculture. 13/ At the same time, it would appear that, with the exception of certain countries in South-East Asia, and some of the large developing countries, the growth of local production and technological capability in electronics has been fairly limited. There have been major constraints in usage and local development of computers and micros and related software. These arise both from infrastructure constraints such as inadequate and irregular power supply and inadequate communications facilities and from severe shortage of trained personnel, particularly programmers, limited availability of hardware, including repair and maintenance facilities, little software capability and scarcity of packaged sector-specific software of direct relevance in particular country situations. There is, however, growing knowledge of the implications and potential of electronics applications and production, and policies and programmes are increasingly being focused on various aspects of such developments.

Role of transnational corporations

44. The role of transnational corporations (TNCs) in transfer of technology to developing countries in the electronics sector has been relatively limited, except for production of consumer electronics through TNC affiliates. In some countries, particularly Brazil and Mexico, TNC subsidiaries have also undertaken manufacture of micro-computers and peripheral equipment, besides telephone and communications equipment. The sales operations of companies such as IBM

have undoubtedly extended the use of computers, both mainframe and desktop, in a number of developing countries, but, apart from offshore production of electronic components, there was relatively little development of production or systems capability till the 1970s, when certain developing countries, such as Brazil and India, embarked on major indigenous development programmes, while several South-East Asian countries developed export capability not only in consumer electronics but for a wide range of peripheral equipment and components. 14/

45. It is important to emphasize the major, even spectacular, developments in production and exports of electronic products from Hong Kong, Singapore, the Republic of Korea and the Taiwan Province, as also the major increase in computer products through nationally-owned companies in Brazil and, to a lesser extent, in Argentina, India and Mexico. These developments were often not primarily based on TNC investments in these fields, though their technological participation was necessary in most cases. In the South-East Asian economies, offshore production of electronics production by TNCs undoubtedly triggered the pace of growth, but export-oriented production of electronics products now largely rests with national companies, including major conglomerates such as Samsung, Hyundai, Daewoo and the Lucky Group in the Republic of Korea. In Brazil and India, increased local production in electronics has taken place primarily through nationally-owned companies. The offshore assembly activities of transnational corporations did lead to significant diffusion of information regarding electronics, including microelectronics, but the initiative for new production activities, based on foreign technology acquired largely through joint ventures or licensing, was primarily that of national firms, supported by integrated effective policies for export development.

46. A great deal of technology licensing and transfer in electronics has undoubtedly taken place among enterprises in industrialized countries, specially between United States and Japanese corporations, particularly in computers, semiconductors and other areas in microelectronics and telecommunications. In the case of developing countries, however, transfer in these fields mainly commenced only in the late 1970s and 1980s. Prior to this, the activities of TNCs other than in consumer electronics was largely confined to sales or leasing of computers and related equipment and offshore manufacture and assembly of electronics products and components in some countries. This was partly because of small markets for such products in most developing countries, but also because production, marketing and usage of microelectronics products was primarily concentrated in highly-industrialized countries.

47. The advantage of cheap labour in South-East Asian countries, however, led to the rapid growth of offshore production and assembly of components through TNC subsidiaries in Hong Kong, Republic of Korea, Singapore, the Taiwan Province, and Malaysia, and other countries to a lesser extent. During the late 1960s and early 1970s, several United States companies, including Fairchild, National Semiconductors, Motorola, Texas Instruments, INTEL, Mostek, RCA and others, as also several Japanese companies, including NEC, Hitachi and Toshiba, and European companies, such as Philips and Siemens set up facilities for electronic component manufacture, including testing facilities in some cases. 15/ The volume of imports of electronic components, including integrated circuits, transistors, thermionic valves and tubes, etc., to OECD countries rose to over $5000 million by 1980. During the 1980s, with greater automation in electronics production operations, however, the trend towards offshore production of components has been significantly reversed. At the same time, several joint ventures and licensing arrangements have been entered into for production of desk-top computers and peripheral equipment in a number of countries, including Brazil, India, the Republic of Korea, Singapore, Hong Kong and Taiwan Province. Development of software has also increased considerably in many of these countries. 16/

48. The banking sector and financial institutions including those involved in financing of R&D, and of exports, in most of these countries, played an important role and were very supportive of local initiatives and entry in electronics production. An effective framework of government policies was also a crucial element in all these countries in establishing a strong infrastructure for the development of microelectronic applications and production. The role of governments, particularly in South-East Asian countries, was also very significant in enhancing local production export capability in the electronics sector and constitute excellent examples for other developing countries to emulate. It would be useful, in this context, to briefly summarize the growth pattern in electronics production in selected developing countries.

G. Experience of Selected Developing Countries

49. The potential for developing endogenous capability in microelectronics and informatics can be better assessed in the light of experience of selected developing countries, which have achieved significant growth in this sector. These include Brazil, India and Mexico from among the larger countries and the Republic of Korea and the Taiwan Province from among the smaller, export-oriented economies of South-East Asia. While policies in these countries differed considerably, the levels of development achieved were, in large measure, due to supportive national policies combined with aggressive industrial initiative on the part of local industrial groups and enterprises.

Brazil

50. The electronics sector in Brazil has grown very rapidly in the past two decades. Apart from substantially increased local production of consumer electronics, there has been major growth in production of automated office equipment and hardware, software and systems for computers and peripherals, besides telecommunications equipment. The critical role of national policies is exemplified in the rapid growth of the locally-owned informatics industry in Brazil during the last decade. A special Secretariat of Information (SSI) was set up in 1979 with policy-making authority in the electronics sector. Funding for local electronics industries was substantially increased by the National Development Bank (BNDE) and a Centre for Informatics Technology was established. A well-defined policy was implemented for encouraging production of informatics products and services by Brazilian firms. In 1984, a law on informatics was promulgated in Brazil, which was primarily designed to promote production capability in computers, telecommunications, software and systems by Brazilian enterprises. The law not only provided a set of positive incentives and facilities, but imposed severe restrictions on imports of electronics products and components including by foreign-controlled companies in Brazil. The latter could primarily concentrate on informatics products and services not undertaken by Brazilian enterprises. As a result of protectionist support and with a growing internal market, Brazilian-owned enterprises were able to expand rapidly and their sales of computers and peripherals alone rose from $190 million in 1979 to over $880 million in 1984, with the percentage of market share vis-à-vis foreign firms increasing from 23% in 1979 to 52% in 1984. 17/ In the telecommunications sector, emphasis was placed on increased local purchase of parts and components and on reducing foreign majority holdings of TNC subsidiaries in this field. Considerable research is also being conducted in the Research and Development Centre of state-owned Telebras, particularly on digitally-stored, program-controlled exchanges, and in other areas of digital exchange, transmission and peripheral technology. 18/ In microelectronics also, national research efforts have been fairly substantial, including by major national producers such as Cobra, whose R&D expenditure rose to $10-15 million in 1982.

51. The expenditure on research in Brazil by local institutions and enterprises, however, has been relatively low, when compared to those of major TNCs in this field and a major problem Brazilian enterprises may face is the higher price of their products and their comparative lack of competitive capability in international markets, besides the difficulties of keeping pace with rapid technological innovations in this field. At the same time, the rapid growth of Brazilian enterprises in the informatics sector and the proportion of market share acquired within less than eight years undoubtedly represents a very significant achievement. With an expanding local market, internal demand may be able to sustain local production and systems capability of nationally-owned enterprises, but these enterprises will gradually need to compete more effectively in international markets.

India

52. The growth of the electronics industry in India has been slower than that of Brazil, but considerable indigenous technological capability has been developed 19/ and the pace of growth has accelerated rapidly during 1985-1987. The policy thrust since 1970, when the state-owned Electronics Commission was set up, was to achieve maximum self-reliance and to utilize indigenously-developed technology as far as possible. An important feature has been that most of the production (70%-75%), particularly of radios, TV sets and components for the consumer electronics industry, was undertaken through small-scale industrial units. Foreign investment was permitted primarily for export-oriented enterprises, including those in the free-trade zone at Santa Cruz (Bombay), which had a slow beginning.

53. In November 1984, a new policy was announced on computers and peripheral equipment, including liberalized licensing and import procedures and providing special facilities and incentives. The earlier policies, which resulted in a growth rate of 18.7% annually during 1971-1983, largely resulted in increased production of consumer electronics, though production was also established of computers and industrial control equipment ($430 million in 1985) and components (over $300 million in 1985). In March 1985, a new package of integrated policy measures on electronics were announced, which were designed to accelerate both the use of electronic equipment in various fields including data processing, control systems and the like, and local production of such equipment. The industrial licensing rules were substantially liberalized for this sector and majority foreign holdings were allowed for electronic components and other high-technology items and up to 40% of equity capital in all fields of electronics. Several facilities and incentives were provided to promote accelerated development of the electronics sector and, since then, the pace of growth of electronics production has been fairly rapid, with production expected to reach $5 billion by 1990, and with exports of around $500 million. Several policy measures and incentives to encourage computer software production and exports were announced in 1986, which have significantly promoted exports of computer software. Such exports are expected to reach $300 million by 1989-90 which will, however, still be less than 1% of estimated intercountry trade in software.

54. Local production in India presently covers desk-top computers and peripheral items and a wide range of electronic components including colour TV tubes, hybrid circuits, connectors, capacitors, floppy disks, ferrites, integrated circuits, printed circuit boards and the like. In telecommunications, a significant development has been the C-DOT indigenous technology for switching systems, besides switching systems for long-distance exchanges and telex exchanges. Most transmission equipment has also been developed through indigenous technology. Telephone instruments, teleprinters, facsimile equipment and most accessories and components are also being produced locally. While the

level of local production falls short of demand for several of these items, local technological development has been fairly significant, particularly in the context of the country's internal requirements.

Mexico

55. There has been considerable growth of consumer electronics production and of usage and local production of computers in Mexico in recent years. Electronics components had been manufactured in the country since the 1960s but it was only during the 1970s that substantial consumer electronics production was undertaken, together with telecommunication equipment. Most of the production was undertaken through affiliates of TNCs from the USA, Japan and Western Europe. The growing demand for computers, which rose to US$ 450 million by 1984, resulted in local production being initiated and several TNC-affiliated joint ventures were licensed to manufacture mini and micro-computers, besides wholly foreign-owned subsidiaries of IBM and Hewlett-Packard. A fairly extensive programme of training of skilled workers in this field has been undertaken through several institutions. A policy framework and guidelines on informatics were implemented in 1983 which, while relying largely on foreign capital and technology for this sector's growth, defined the nature of incentives and restrictions on imports, together with requirements of local integration, technology transfer, local research, and development of export capability. Despite the country's overall economic problems, the electronics industry, including production of computers, peripheral equipment and systems capability has continued to grow fairly rapidly in the last five-year period. 20/

Republic of Korea

56. The most spectacular growth among developing countries, in electronics production, was achieved in the Republic of Korea. Production of electronics products rose from a value of only $107 million in 1970 to over $7.1 billion by 1984 21/ and over $9 billion in 1986. Exports of electronic products increased to over $4.2 billion in 1984, and constituted a rising percentage to total exports. The rate of growth has been 35-40% annually over the last 15 years and continues to grow rapidly. Out of total electronics production in 1984, 34% comprised consumer electronics, 16.9% industrial electronics, while over 49% was of components. While components and consumer electronics still occupy the largest proportion of local electronics production, there is a growing shift towards increased production of computers and peripherals. A large proportion of electronics production is covered by four major Korean-owned conglomerates, with foreign-owned subsidiaries contributing only 15-20% of electronics output in recent years. TNC subsidiaries have, however, been more dominant in semiconductor manufacture, with nine subsidiaries producing 54% of total output.

57. A high degree of priority has been accorded by the Government to the informatics sector and an Electronics Industry Promotion Law and a series of incentives and facilities, including industrial estates, contributed significantly to sectoral development. In the Fifth Plan (1982-87), the electronics industry has been listed as one of the ten major strategic industries. A special development programme has been adopted for the growth of the semiconductor industry, including for development of very large integrated circuits (VLSI). Considerable research support has been provided through the Korean Institute of Science and Technology (KIST) and the Korean Advanced Institute (KAIST), particularly in applied electronics research. Commercialization of local research was undertaken effectively through the Korea Technology Advancement Corporation (K-TAC). Special incentives have also been provided for enterprise-level research. At the same time, considerable imports of electronics technology have been taking place, including through

joint ventures (e.g., Samsung-Hewlett-Packard) and licensing arrangements (for instance, Samsung-ITT and Hyunday-Inmos). During 1980-1984, 27 foreign technology agreements were signed for manufacture of computers and peripherals. All four major Korean conglomerates have set up facilities in the Silicon Valley in California, largely for product design, development and testing, with selected products being mass-produced in Korea. The Republic of Korea has undoubtedly developed a very successful electronics industry, through a highly-effective combination of promotional policies and incentives and dynamic and aggressive industrial groups, now competing effectively in international markets for a wide range of electronics products.

Province of Taiwan

58. While production of electronics components through offshore production units and increasingly of consumer electronics products, had grown considerably in Taiwan during the 1970s, special emphasis was given to the informatics sector since 1980, when informatics and machinery production were defined as the two strategic industrial sectors. Considerable fillip was given with the establishment of the Hsinchu science-based, industry park where, by 1984, 71 plants including those of several major high-technology firms in microelectronics and computers, had been set up. The basic policy has been to adapt and innovate, including with respect to recently-developed technologies, and this has been highly successful in the informatics sector also. The growth rate with respect to informatics has been 278% between 1981 and 1984 and it is expected that domestic production of hardware (computers, peripherals and components) will reach $3.9 billion by 1989, besides $700 million for software. This tremendous rate of growth is taking place largely through local firms, with close linkages with foreign firms, particularly regarding foreign technology and marketing. Considerable financial incentives and support have been provided by the Government, including special, low-interest loans and research funding. 22/

59. The experience of the above countries indicates that national policies inevitably play a critical role in the development of the electronics sector. At the same time, foreign technology inputs are of vital significance, both at the initial stage when foreign technology can be acquired through licensing and at continuing stages when technological innovations and developments have to be incorporated, either through local research, or through external technology inflow. An equally critical element necessary is the presence of dynamic local initiative and entrepreneurial capability, which can combine technology and local factor-situations into effective programmes for production and technological development in this sector.

H. Prospects and Policy Issues in Developing Countries

60. The rapid development of the electronics sector is of vital interest to developing countries as it constitutes a critical phase of industrial and technological development. Such development is essential both from the viewpoint of creating new employment opportunities and of developing competitive skills and capability in a period of rapid technological change. It needs to be emphasized that electronics production often involves less capital investment than many other sectors. While the creation of one job requires a fixed asset investment of up to $30,440 in petrochemicals, $15,000 for ferrous products and $7,494 in textiles, the investment requirements for jobs in electronics is around $3,212, both in semi-assembly operations and in the production of a wide range of products and components. The number of jobs created through an investment of, say, $1 million would be higher in electronics than for most production sectors. The increased use and development of microelectronics and informatics in developing countries is also essential for overall technological development and capability to participate effectively in

international markets. On the one hand, usage of computers and other equipment utilizing microelectronic devices needs to be gradually extended to various industrial and service sectors for greater efficiency, productivity and competitive capability - these fields. While the nature of application and usage may differ, in varying degrees, from that of industrialized countries, microelectronic applications cover a very wide range and have considerable potential for usage in all countries. On the other hand, production capability has also to be developed with respect to both hardware and software. The nature and extent of such developments will inevitably vary in different country situations, but it is essential to develop a concerted strategy for production of software and such elements of hardware as may be feasible from a techno-economic viewpoint. Several developing countries should be able to develop international competitive capability, both with respect to software and for peripheral products and components for exports, apart from meeting internal requirements in different sectors. Capital goods production, which is increasingly being undertaken in many developing countries, should take new technological developments into full account. Production of machine tools and of mechanical, electrical and transport equipment should incorporate electronic components to ensure greater speed and accuracy and to keep pace with global developments in these fields, especially at the lower end of the technological spectrum.

61. With respect to increased usage of computers, modern telecommunications systems and automated equipment, there is also need for evaluation of such usage for office and industrial management, banks, insurance and other services, economic models and macro-planning, census and statistical operations and agricultural and industrial activities. There is also considerable scope for blending microelectronic applications in traditional sectors, particularly in agricultural operations, such as for irrigation control, testing of moisture content. monitoring rainfall and weather conditions, food processing and storage, livestock development, etc., and improving productivity in rural industries. 23/ There is also substantial potential for technology blending in several manufacturing fields and in various services. The use of CAD/CAM needs to be extended to various production sectors, particularly those with export potential. While the use of robotics and of flexible manufacturing systems may be more gradual, numerically-controlled machine tools have increasingly to be utilized, and also produced in developing countries where machine tools are being manufactured. At the same time, because of the continuing and growing pressure for increasing employment opportunities, it would be necessary to determine both the appropriate usage of computers and automated equipment and the extent to which human labour should be replaced in particular sectors and provided with retraining and other facilities, besides alternative sources of employment. The new job opportunities created in the electronics sector would vary considerably. At one end, there would be need for skilled engineers, technicians and programmers, who would require technical degrees and specialized training. At the other end, the requirements would be primarily for semi-skilled personnel, often young women, who require very little training for a variety of jobs in electronics assembly and manufacture. Electronics production can also be undertaken on a relatively small-scale basis, with low investment and little infrastructure, though electric power supply is essential.

62. The determination of appropriate usage of electronic equipment is a key element of technology planning and assessment, which involves analysis of various objectives and priorities, as also choice of the electronics subsectors to be developed, ranging from consumer electronics to production of components and instrumentation and to production of personal computers, peripheral items and telecommunications equipment. The development of software and systems capability is also an important requirement. While

computer usage and microelectronic applications must be increased in several fields and developed for data processing, storage and communications, this must be consistent with broader socio-economic goals. The major constraints in the development of infrastructure for hardware, software and systems capability must also be recognized and provided for. National policies in developing countries should, after taking account of such factors and constraints, determine specific norms and standards regarding computers, microelectronics and telecommunications equipment and components, and should define the desired pattern of growth for production of hardware, software and systems capability. This has to be periodically reviewed because of rapid obsolescence and technological change and the need not only to keep pace with new innovations and developments but to leapfrog such developments through technological adaptation.

63. There is undoubtedly considerable scope and potential for local manufacture of various electronics products and components in a large number of developing countries once the basic infrastructure, particularly human skills, can be developed, and suitable policy measures and incentives are defined. The shift to local production of more sophisticated parts and components may be more gradual in certain countries where the level of technological absorption may initially be low. However, provided the basic infrastructure of electric power and semi-skilled and trained human resources can be made available, the emphasis in most developing countries should be on the development of software capability on the one hand and production and assembly of a wide range of consumer electronics and industrial electronics products on the other.

64. The development of local software constitutes both an essential prerequisite and a major opportunity for several developing countries. With relatively cheap availability of technical personnel in several of these countries, there is considerable potential for development of applications software, both for local needs and for export markets in industrialized countries, where a major shortage of software programmers is expected in the 1990s. Software development may require, apart from basic training in computer programming at local institutions, foreign linkages in the form of joint ventures or subcontracting arrangements with foreign software companies. Several corporations in the United States and Western Europe which are engaged in software development and applications are exploring avenues for subcontracting software applications and development. This has become fairly common in South-East Asia, as also in India and other Asian countries. With the enormous growth of new software applications during the 1990s, 24/ most developing countries should develop a niche for specific fields of software development, with training and incentives oriented towards such development and with linkages and joint ventures with foreign software companies. It may be necessary, in some countries, to provide institutional support and entrust the initial development to parastatal, development-finance organizations or to set up a separate corporation created specifically for this purpose, which can explore the opportunities and negotiate with foreign software companies.

65. The development of electronics hardware, apart from consumer electronics, also presents significant potential for several developing countries. As pointed out in the previous section, it should be possible to undertake local production of a wide range of industrial electronics products in these countries. These could include desk-top computers, disk drives, flexible magnetic disks, component boards, keyboard assembly, display assembly, scanners, printers, plotters and memory storage devices. Besides, a wide range of discrete components can be locally produced, such as diodes, ranging from small, signal diodes to diodes for special applications, transistors, including bipolar power and microwave transistors and thyristors, resistors,

ferrites, condensers, relays, tubes, hybrid circuits, including photo-receiver or transmitter packages, and integrated and printed circuits, ranging from linear, monolithic integrated circuits to interface, and custom-integrated circuits. Audio components would include microphones, loudspeakers and amplifiers. In the communications subsector, local manufacture could be undertaken of telephone hand-sets, two-way communications systems and manual and automatic exchange, in progressive stages. Various instruments can also be locally manufactured, ranging from simple multi-meters to complex control instruments used in industry, power systems and the like.

66. For many of these products, the initial investment is not unduly high in relation to overall investments in the electronics sector. Production processes tend to be similar, so that initial technological absorption could be rapidly extended to technological adaptation, except perhaps at the highest ends of the technology spectrum. The acquisition of foreign technology should not present major problems as there are several alternative foreign sources from which such technologies can be secured, except for advanced technologies and products, whose exports may be restricted. It would, however, be useful to develop a comprehensive information base at national level on alternative sources of electronics technology and on terms and conditions of technology acquisition in the electronics sector. It must also be recognized that initial costs for technology may be fairly high. Developing countries, where significant development of electronics has taken place have paid a considerable price for such technologies, as have Japan and other industrialized countries, and this will continue to be necessary, particularly for new technologies, applications and products. It would also be necessary to group various products and components to ensure techno-economic viability, and initial production stages may be limited to semi-assembly till adequate technological absorption is achieved.

67. Electronics production requires to be closely linked to growth in other sectors. The local machine-tool sector, for example, may need to provide various tools and equipment for the wide range of operations involved in electronics production. The equipment could extend from simple lathes, and drilling and punching machines to complex milling or grinding equipment, or spark erosion machine or fine blanking to form and shape special parts. Facilities for electro-plating, engraving and spray painting are also necessary. If such equipment is not locally manufactured, additional equipment imports would be necessary. Other equipment requirements include those for woodworking, coil-winding, plastic moulding, and for packaging. Most electronics products, particularly consumer electronics, need after-sales service, which is critical for such items as TVs, video recorders (VCRs), etc. For this purpose, service centres would require to be set up, manned by qualified technicians equipped with necessary testing instruments. It may be necessary to train adequate numbers of such technicians and provide them with the necessary tools so as to ensure that locally-manufactured equipment is well maintained.

68. An important aspect is that electronics, being critically technology-dependent, requires continuing contact with innovations and the generation of new electronics technologies. This can pose a problem in most developing countries. One alternative is to maintain continuing links with foreign technology suppliers, if technology is imported as it would be initially in most cases. In such cases also, it is necessary to ensure that the foreign partner or licensor continues to generate and develop new technologies. If not, alternative sources of new technologies will need to be explored. Apart from external technological linkages, it is important to ensure close linkages with local research institutions and centres. This may not normally relate to basic technological advances and breakthroughs, though this may well be

possible in certain developing countries. The linkages would be more related to operational programmes, which would increase productivity or programmes involving blending of technologies in traditional sectors and processes. A close link has to be established and maintained between industry and national R and D efforts in the electronics sector. Electronics enterprises should be encouraged to seek the active assistance of R and D institutions for solution of their problems, including through contract research. It would also be necessary to provide incentives and facilities for enterprise-level research. Since entrepreneurs in this field are often technologists, they should be provided with facilities for doing their own research. This can take the form of tax benefits and other financial incentives, including grants.

69. While significant growth can and should be achieved in electronics and informatics in most developing countries, a comprehensive programme in this sector would require major commitment, initiative and support on the part of national authorities. Apart from development of basic infrastructure, including training programmes, facilities such as industrial estates/parks for electronics production should be considered, preferably in proximity to technical universities and research institutions. Appropriate institutional arrangements should also be made, including a separate para-statal body exclusively for this purpose in countries where local entrepreneurship may be lacking. The parameters of production activities will need to be defined and negotiations undertaken with TNCs and foreign producers of hardware and software for setting up or participating in local production facilities. A local market should be created, uniting the efforts and requirements of defence, telecommunications, information sciences and the industrial sector as a whole. At the same time, a niche should be gradually developed at the international level for exports, including through foreign networks of TNCs participating in local projects and production activities.

70. The above approach is not easy to implement and requires considerable drive and initiative both on the part of policy-makers and local entrepreneurs. At the same time, it is a vital and essential programme, if developing countries are to participate and compete in the coming decades when microelectronics, informatics and telematics will develop towards new levels of advancement and sophistication. Once the initial base for local production and technological development in this field is created, it would be possible to gradually restructure systems of education in developing countries so as to enable knowledge and skill development in microelectronics and informatics from the earliest stages of technical education. It is necessary in the present situation, however, to provide potential entrepreneurs in developing countries with certain basic information and data on electronic products and projects having significant potential in a large number of developing countries. For this purpose, a series of project profiles have been prepared and incorporated in Part IV of this study. These profiles provide the basic investment costs and manufacturing processes involved in the production of selected electronics products. These will, however, need to be reviewed and modified in the context of the market and other factor-endowments and situations prevailing in particular countries.

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GLOSSARY OF TERMS

1.	Electronics	Is defined as science and technology for control of movement of free electrons in order to receive, process or transmit information or to use such movement as energy.
2.	Electronics equipment	This is the arrangement of a number of electronics circuits to perform a particular task. Equivalent or similar terms are apparatus, appliance, device, instrument, items or products. Input and/or output of electronic equipment could be a non-electrical signal.
3.	Element	This is the smallest unit into which a circuit or network can be subdivided.
4.	Electronics circuit	This is the arrangement of at least two elements to perform any function as defined in electronics.
5.	Consumer electronics	This refers to electronic products which are consumed by the general public.
6.	Electronic component	This is the smallest discrete item to perform any particular function in electronic circuits. It may be of any complexity in a single case (e.g., integration of several elements) but does not allow any further division without impairing its basic function. In the literature, the term "electronic part" is often used instead of "electronic component".
7.	Active component	This is an element which converts the energy of one frequency to another.
8.	Passive component	This is an element which absorbs or stores energy.
9.	Chip	A generic name popularly used for integrated circuits, it refers to a single package holding a large number of electronic components. The term is derived from chips of silicon, the material commonly employed. Where the number of components is very large and the chip is small, it is called 'micro-chip'.
10.	CAD/CAM	Computer-aided design/computer-aided manufacturing or management. These are major areas for industrial application of computers.

11. Computer network — Two or more computers that are inter-connected in a manner so as to exchange information.

12. CPU — Central processing unit, which is the heart of a computer and controls all operations of the computer and does the actual calculations.

13. Display — A method of representing information in a visible form. The most common displays used are printed paper, cathode ray tube and light emitting diodes or crystals.

14. Ferrites — Powdered and compressed ferric oxide mixed with other materials and then sintered to possess special magnetic properties, classified as 'soft' and 'hard' depending on the magnetic characteristics.

15. Fibre optics — A recently developed technique of transmitting information through thin tubes of silica laced with germanium oxide; such fibres absorb and disperse light so little that as many as 20,000 telephone, several video circuits can be operated on them.

16. Floppy disk — A storage device made from a thin circular piece of magnetic material (usually in sizes 5 1/4" or 8").

17. Hardware/software — The physical part of electronics equipment is referred to as 'hardware' as against 'software', which refers to programme material or data to be processed.

18. Integrated circuits (IC) — Is the technique of packaging a number of components and circuits on a single base. The expression 'large scale integration' (LSI) is used when their number is in hundreds, while 'very large scale integration' (VLSI) refers to numbers of the order of 10^5.

19. Laser — These are light beams that are 'coherent', that is, its waves have identical shapes and frequencies. Lasers can pack high energy because of this property and have found wide application in metallurgy, industry, medicine, micro-electronics and defence.

20. Micro-electronics — May be defined as the technology to pack components in increasingly smaller packages resulting in greater storage of information and speed of operation. Micro-electronics has progressed with astonishing rapidity to integrate as many as a million components on a tiny wafer, with speeds up to hundreds of millions per second at a fraction of the original cost.

21. Micro-computer	This is the central processing unit of a computer that holds all the elements required, usually on a single IC.
22. Printed circuit board (PCB)	This consists of a copper clad laminate or glass epoxy board used to mount electronic components and to etch electronic circuits. These are now almost exclusively used in equipment design and can be single-sided, double-sided or plated through.
23. Peripherals	Equipment external to the computer, these commonly used include disc drives, printed keyboards, and cassette tape recorders.
24. PC	Stands for personal computer which is built around a micro-processor. The PC has brought the computer into the home to perform a variety of functions.
25. RAM	Stands for Random Access Memory which is the type commonly used in a small computer, the time taken to find the information is essentially the same irrespective of where it is stored.
26. Robots	Machines that are designed to perform repetitive manual tasks as a human would (or even better), thus replacing operators on the assembly line and on repetitive operations.
27. Satellite	Metallic spheres and objects placed in geo-synchronous orbit to relay and generate information, they are used in long distance communication, for telephone and TV links and for weather forecasts, etc.
28. Semiconductors	Materials which possess special conducting properties that are used in electronics to measure and control parameters. Silicon, arsenic, gallium, etc., are some of the materials that exhibit such properties.

II. NATIONAL POLICY STATEMENT ON ELECTRONICS (NPSE)

71. The major impact of technolgical developments in electronics, particularly the pervasive effects of microelectronics and informatics in a number of production and service sectors, necessitates that each country should review its national situation with respect to electronics development and formulate specific policies and programmes to meet national objectives and priorities in this vital sector. National experience in a large number of developing countries already reflects rapid increase in demand not only in consumer electronics but for various levels of office automation, for increased computerization in service sectors, such as banking, airlines and tourism, and use of digital systems and computer applications in various fields of production. In the telecommunications sector, use of satellite communications and digital transmission systems has extended to a large number of developing countries. These trends are likely to increase further during the next decade and, as highlighted in Chapter I, it is essential for each country to determine its growth pattern and implement a comprehensive development programme for the electronics sector. The nature and coverage of such a programme would obviously differ from country to country. In some developing countries, the rapid progress already achieved in microelectronics and informatics will enable them to keep pace with continuing technological developments taking place in industrialized countries. In other countries, the levels of development may differ, but certain aspects of electronics developments can and must receive special emphasis, both in terms of increased use and applications and growth of endogenous production and technological skills and capability.

72. National Policy Statement: The need for a National Policy Statement on Electronics (NPSE) stems primarily from the fact that specific policies, measures and programmes are necessary for the development of microelectronics and informatics at the national level. Such policies and measures are also necessary to indicate the priority accorded to the growth of this sector in particular countries. A policy statement on this sector would also be instrumental in attracting critical new investments in this field, within the framework of defined national policies. The development of new skills, through specialized technical education and training, would also require to be integrated within an integrated policy framework.

73. National policies on electronics have been adopted in several countries. In some countries, specific legislation has been promulgated for this purpose, as in the case of Brazil, where a Law on Informatics was passed, which placed electronics policy under a Council attached to the President and which prescribed several specific policies and instruments for their implementation. In other countries, specific policy announcements have been made for this sector, as in India's statement on "Integrated Policy Measures on Electronics" in March 1985. In South-East Asian countries, a series of specific policies were introduced to enable the rapid growth of consumer and industrial electronics. Such policy announcements are generally promotional in nature and are designed to attract major new investments in this field. Such policies have also, with the exception of Brazil, been designed to attract new foreign direct investments in electronics manufacture, though major emphasis in most of the policy statements has been on growth of local production and technological capability.

74. Annotated Outline of NPSE: It is against the above background that an annotated outline has been prepared, which describes the elements to be covered in a national policy statement. The contents of the policy statement

will naturally vary considerably, depending on the level of industrial and technological growth, the state of development of the electronics sector, the potential and desired pattern of future development, the role envisaged for foreign direct investments, the incentives, concessions and facilities which would be provided to new investment projects in this field, problem areas and possible solutions, and various other aspects, where perspectives, strategies and policies may be different in specific country situations. Nevertheless, these and other key aspects of promotion and development of the electronics sector need to be covered in the NPSE.

75. Basically, the NPSE should highlight the conditions favourable for investments in the electronics sector and the specific fields in which such investments would be particularly welcome. It should also indicate the potential that exists in the country for the growth of the electronics industry, including software, and the likely demand and potential in the next few years. Any problems likely to be encountered should also be identified, together with remedial suggestions. The NPSE, besides being an objective assessment of the socio-economic climate for investments in electronics, should also provide an opportunity for planners and policy-makers to assess and review their policies and programmes in this key sector of growth.

76. Basic statistics: It is necessary for the NPSE to provide some basic information regarding national economic features and trends which would be relevant for investment decision-making. The size of the country, its total population and the distribution between urban and rural population, together with demographic trends, should be indicated. It would also be necessary to provide basic economic indices such as the Gross Domestic Product (GDP), the Gross National Product (GNP), per capita income, rate of industrial growth, the balance of payments and debt situation, etc. Trends in these figures should be provided and estimates made of growth rates of the economy at constant prices. The consumption and savings pattern should be stated, as this would indicate the purchasing power and consumption habits, which would be an important parameter when assessing likely local demand for consumer electronic products.

77. Development Plans and Policies: The basic features of national development plans, insofar as they relate to developments in electronics, should be highlighted. These would cover human resource development, as envisaged in programmes for higher technical education and specialized training, infrastructure development, particularly electricity generation and distribution and internal transportation, together with the growth pattern envisaged in various production and service sectors, which would constitute major users of electronics products and systems. These would, in particular, relate to sectors such as engineering-goods production, including capital goods, automobiles and other durable consumption products and other production sectors utilizing sophisticated instrumentation and control systems, besides service sectors such as telecommunications, banking, insurance, tourism, etc., which extensively utilize electronics systems. Apart from the large and medium-scale industrial sectors, most developing countries also have small-scale sectors which are widely dispersed. Small-scale industries may contribute a significant proportion of total industrial output and can also serve as supplier of parts and components to the large-scale sector. It would be useful for the NPSE to also indicate the pattern of growth for the small-scale sector.

78. The administrative framework and procedures to promote, monitor and regulate the growth of the electronics sector in the country should be described. Normally, the Ministry of Industry deals with the entire sector. Sometimes a separate agency under the Ministry is designated to deal exclusively with electronics. In some countries, however, electronics is treated on a

priority basis with a separate Ministry, to emphasize its role in modernization and raising productivity in the economy. The priority accorded by national authorities to the electronics sector can often be assessed from the administrative arrangements made to encourage national development in this field. It would be important to emphasize the specific administrative procedures for dealing with projects and investment proposals in the electronics sector. This is particularly important in this field, since production and other facilities have to be speedily established to capitalize on new markets for rapidly changing electronics products and systems. The procedures defined should cover both the approval of new investments, and regulatory arrangements, if any, relating to supply of equipment and for technology, knowhow and technical services.

79. The role ascribed to foreign direct investments needs to be specifically discussed in the NPSE. If any specific liberalisation or relaxation is provided on the extent of foreign ownership and holdings in the electronics sector, this should be highlighted. The desired pattern of foreign investment and technological participation should be emphasized.

80. It is also important to define the role of the private sector in the development of electronics production. In some developing countries, state-owned enterprises have been set up in this field. It is important to clearly define the areas which are open to private investors, including foreign investors.

81. Most countries provide a package of incentives for new ventures, some or all of which are available to investors from abroad. These include: industrial estates and availability of built-up work sheds for hire at subsidised rents, grants or interest-free loan, if sited at preferred locations, hire purchase facilities for machinery or supply on a leasing basis, water and power at concessional rates, tax holiday for the first few years of operation, accelerated depreciation allowance, supply of scarce raw materials, loans at preferred rates of interest, waiver of import duties on capital equipment and raw materials, and waiver of sales tax or conversion of tax into interest-free loans. The NPSE should indicate which of the above incentives, or any others, are offered to investors, both local and foreign.

82. The NPSE should also define the import/export policy, particularly relating to the electronics sector. This should relate both to finished products and to supply of raw materials, components and subassemblies.

83. An important aspect of particular importance to foreign investors relates to freedom for repatriation of profits and fees. This also applies to salaries of expatriate personnel. The existence of any agreement for avoidance of double taxation on such earnings may also be indicated.

84. Local facilities for banking, insurance and other financial services should also be provided in the NPSE. This is particularly necessary in countries where government tends to regulate banking practices. Investors would also be interested in information, apart from interest rates and margins, on the more intangible degree of support the banking sector extends specifically towards the electronics industry.

85. The NPSE should obviously provide basic information on the status of the existing electronics industry in the country. The extent of local production, the fields of production, and the number of enterprises should be indicated.

86. It would be useful to refer, in the NPSE, to any special problems which electronics units in the country may be faced with. Some countries have

guidelines on the ethnic composition of labour to be employed. Again, female labour, which often forms a sizeable percentage of the labour force in the electronics sector, may require special treatment and facilities.

87. A point of interest could be the degree of sub-contracting which electronics manufacturers could resort to. This would depend on the availability of ancillary facilities for sheet metal working, wood working, electroplating or such jobs as coil winding, spray painting, engraving, etc.

88. Import and export statistics on electronic products would undoubtedly be essential for potential investors and can generally be provided, since most countries maintain such information. The problem, however, is that data on imports of electronics equipment and components does not usually indicate what these components are -- whether resistors, capacitors, or integrated circuits and the like. Where the statistics are not complete or entirely reliable, rough estimates may need to be given, indicating their degree of uncertainty.

89. Electric power is an essential requirement for the electronics industry, though the sector is not particularly power-intensive. In fact, the power requirements for electronics production can be so small that solar panels and wind-activated devices may be adequate in some cases. What is, however, critical is the stability of operating voltages and frequency as well as an uninterrupted supply of electricity. For many electronics plants, it may be necessary to set up special devices which ensure that voltage fluctuations do not vary beyond certain limits and emergency generators can be switched on automatically whenever there is a failure of power supply.

90. Ancillary facilities are important for development of a significant electronics industry, particularly well-equipped workshops which can undertake various precision jobs. Apart from simple bending and shearing presses, there is need for facilities for milling, grinding and other more complex operations. For some parts, a jig borer, or equipment for spark erosion or fine blanking may be necessary. Again, wood working, electro-plating, engraving and painting facilities are required for most electronic projects. The availability of such facilities should be indicated in the NPSE.

91. Testing facilities are essential in the electronics industry because of the need to maintain high precision of parts and quality of the final product. However, test equipment is costly and it may be difficult, for local enterprises, to provide investments for this purpose. It may, therefore, be necessary to operate common test centres either through a governmental or para-statal agency or by the industry on a co-operative basis. It would be useful to deal with this aspect in the NPSE.

92. The availability of skilled and semi-skilled personnel is of course an important criterion and the NPSE should indicate such availability or measures that may be necessary in this regard. Skilled personnel will be required for production operations from several disciplines -- fitters, lathe operators, foundry men, carpenters, coil workers, and others trained in vocational schools. For the computer subsector, personnel requirements will include programmers and operators. Another key group are the technicians who would be responsible for after-sales service of electronics equipment, particularly in consumer electronics where such facilities are a critical factor in product marketing. For the higher technical posts, engineering graduates would be required. The availability of graduates in electronics and engineering should be indicated in the NPSE.

93. An important requirement for local electronics production is the scope for interaction with research and development institutions, particularly

applied research institutions, which can assist in technological adaptations. R and D institutions can also serve as a training base for personnel for servicing or for design engineers and can also act as a source of technology or assist in the acquisition of technology, particularly for small and medium-size enterprises which require assistance in this regard. The relative merits of competing foreign technologies may have to be assessed in the context of the country's needs and the ability to adapt to the local environment. R and D institutions can also advise industry on the purchase of suitable capital equipment and machinery and can serve as consultants to initiate production. The research institution or laboratory may also function as a testing laboratory for certifying whether the product conforms to standard specifications laid down by national or international standards bodies. The existence of a research institution or laboratory devoted exclusively to electronics constitutes an important asset for the development of the electronics industry and it would be useful to indicate in the NPSE whether such a facility exists or is likely to be set up in the near future. It should also be indicated whether the institution has been accorded any special role for testing and standardization.

94. A necessary corollary to institutional R and D facilities is the availability of a well-organized technology information system, which could provide assistance by supplying references on any specific topic. The availability of such information services and facilities which are linked to international data bases should be indicated in the NPSE.

95. It is necessary for the NPSE to provide broad forecasts of demand for major electronic products and items over the next few years so that the market potential can be judged. Such forecasts should take account of developments in technology, public demand for new types of products, impact of life styles in advanced countries and availability of local products at reasonable cost. The growth of consumer electronics demand is dependent to some extent on the expansion of broadcast/transmissions, both audio and video. Since these are often undertaken by government agencies, it is possible to assess the proposed coverage through these services and relate these to the likely consequent demand for products such as TVs and videos. Broad demand projections can also be made with respect to automated office equipment and computer-aided designs and production facilities in various industrial sectors. It is also necessary to provide broad demand projections for the principal peripheral equipment, as also for major components. The latter can be derived from the demand projections for consumer electronics and for computerized office and industrial equipment. In general, the consumer electronics subsector generates most of the demand for components that can be locally manufactured in most developing countries. For communications equipment, demand is based on the expansion of telecommunications networks and the increased capacity the country proposes to acquire. In other fields, such as defence, space and aviation, government programmes in these fields largely determine the demand for electronic equipment and components. Industrial electronic systems, equipment and software depend on the growth of the industrial sector as a whole and the need for computerized control and monitoring such operations. For medical electronics, the expansion of medical services by government agencies as well as greater public awareness would determine the growth in demand.

96. The NPSE should indicate whether offshore assembly or manufacture of electronic components has been undertaken in the country and if so, the experience of such production and the further possibilities in this regard, together with government policies, facilities and incentives for such production.

97. The NPSE should also indicate whether any free-trade or export zones exist in the country and if not, whether government has any plans for setting up such a zone or zones either exclusively for electronics or where it would be an important sector of production. The special facilities proposed to be provided in such zones, as also any restrictions imposed, should be defined. The median wage levels in the zone or proposed zone should be indicated, since these still constitute the basic attraction for offshore investment and production.

98. The NPSE should define the special facilities, incentives and concessions provided for growth of the electronics sector. Such assistance usually takes the form of fiscal incentives and concessions, including grants for setting up training facilities or to participate in advanced courses abroad, or facilities for import of equipment and maintenance inputs.

99. The extent to which multilateral assistance, if any, is being provided by United Nations bodies and other international organizations for the development of the electronics industry should also be indicated.

100. The NPSE is intended to provide an overall perspective of economic and technological development of the country, particularly with respect to development of the electronics industry, including hardware, software and systems. It should indicate the likely growth potential of the sector and the special incentives offered to local electronics enterprises and should provide the potential investor with adequate justification for investment and/or technological participation.

III. ELECTRONICS INDUSTRIAL INVESTMENT PROJECT QUESTIONNAIRE (EIIPQ)

101. An important aspect of investment promotion and securing participation from enterprises having the necessary knowhow and expertise in the field is to provide essential information regarding the proposed project to various potential sources of investment and technology. Most developing-country enterprises in the electronics sector will, for the present, require external investment or technological participation in one form or another. These can extend from joint ventures involving foreign majority or minority holdings to non-affiliate technology licensing agreements and contractual arrangements of various types, including turnkey contracts and buyback agreements for components, subassemblies and the like. For the type and range of electronics products which are of interest to most developing countries, comprising consumer electronics, automated office equipment, personal computers and peripherals, and certain categories of industrial electronics, including instrumentation and control systems, several sources of technology in different countries can be identified for each product and the acquisition of technology and knowhow is not an unduly difficult process. At the same time, knowledge of such alternative sources and with regard to the intricacies of investment and technology agreements in the electronics sector is of course of critical importance. Expert assistance in this regard may need to be obtained, particularly through an international agency such as UNIDO.

102. The first stage in the investment promotion process is the identification of the basic information requirements regarding the project to be promoted. For this purpose, an Electronics Industrial Investment Project Questionnaire (EIIPC) has been designed to provide necessary information on a specific industrial project for which technical assistance or financial investment, or both, are sought.

103. The questionnaire is patterned on the general questionnaire formulated by the UNIDO Investment Co-operative Program for various industrial projects, with some modifications relating to the electronics industry. There may be further variations between different electronics sub-sectors such as consumer electronics, components, etc. However, since such variations would be comparatively limited, a common format has been prepared for all electronic subsectors. It is recognized that data on some aspects included in the questionnaire may not be readily available. In this event, such information should be furnished as is practicable.

ELECTRONICS INDUSTRIAL INVESTMENT PROJECT QUESTIONNAIRE (EIIPQ)

(FOR SECURING FOREIGN PARTICIPATION)

1. <u>Basic Project Information</u>

1.1 What are the products proposed to be manufactured and proposed level of production.

1.2 Has a market survey and feasibility study been done for the project? If not, the basis for project formulation should be indicated.

1.3 If a market demand survey has been conducted, what is the current and projected internal demand for the product/products proposed to be manufactured and what is the normal retail price (band of prices) at which it is sold?

1.4 Is the product(s) already being manufactured/assembled within the country and by how many enterprises? What is the total production capacity of existing local enterprises?

1.5 Are any exports planned, including to neighbouring countries, through the project? Is the product(s) being exported from the country by existing local enterprises? What are the facilities and incentives for such exports?

1.6 What is the estimated capital cost of the project as on (date) . Have arrangements been made negotiated for loan capital, including working capital? Is there any requirement for foreign investment or loan to cover external costs of the project?

1.7 Nature of foreign participation. Whether joint venture, or non-affiliate technology license, or other contractual arrangement? If joint venture, indicate proportion of foreign equity considered desirable?

2. Project Details

2.1 Phasing of production: Indicate the phased programme of manufacture of the product/products, as also the local content to be achieved at the end of the first year, third year and fifth year of commencement of production.

2.2 Is the proposed level of production based on projections of internal market demand or any other factors?

2.3 What specific steps have already been taken for project implementation?

Has government approval (if required) been secured?

Has the plant site been selected?

Has the land required for the project been purchased?

Has construction of buildings for the plant been completed or undertaken?

Has machinery and equipment for the plant been ordered or selected?

2.4 When is the project scheduled to commence production?

2.5 Are any specific arrangements for by-product disposal necessary to conform to the country's environmental laws?

3. Location of Plant

3.1 Where is the proposed plant located and what are the principal reasons for the choice?

3.2 Is the site located convenient for transportation of labour, raw materials and finished products?

3.3 Are adequate housing and other facilities such as bank, post office, telephone, school, recreation, etc., available close by?

3.4 Are there any technical and R&D institutions nearby to which the plant may have access?

3.5 Are any special facilities required to be provided at project cost?

4. Building and Utilities

4.1 What are the building requirements for the project (square meters)?

4.2 Are special precautions necessary to ensure freedom from dust?

4.3 Is adequate electric power available at the site and are voltage and frequency fluctuations within tolerance limits?

5. Machinery and Equipment

5.1 What is the total cost of the plant machinery and equipment, including equipment for testing and ancillary services?

5.2 What is the value of machinery and equipment required for the project that requires to be imported?

5.3 Are special facilities (such as leasing, etc.) available in the country for import of machinery and equipment?

6. Raw Material, Parts and Components

6.1 For assembly operations: What are the parts and components required for project assembly which will require to be imported during the first year, third year and fifth year of production, and their total value?

6.2 For production of parts and components: Are any special materials required for production which will need to be imported? If so, indicate the appropriate annual value of such imports. What is the tariff on raw or processed material that requires to be imported?

7. Technology and Knowhow

7.1 Is it intended that production technology and knowhow for the project will be acquired from foreign sources? Are there any restrictions on such imports and will the agreement for supply of technology and knowhow be subject to review by a government agency? Are there specific, prescribed guidelines in this regard? If so, these should be enclosed.

7.2 Is there any national R&D institution that functions exclusively with respect to the electronics sector? If so, is it intended that such an institution will be utilized for future technical assistance for the project?

7.3 Are the following technical-support services available within reasonable distance from the project site?

General engineering workshop, foundry, electroplating, jig boring, spark erosion, moulds and dies, wood-working, spray painting?

8. Foreign Personnel Requirements

Indicate the requirements, if any, of foreign personnel for the project, including for in-plant training, and the period for which they would be required.

9. Information on Sponsor(s)

9.1 Name of company, address, telephone, telex, telefax.

9.2 Background of business and industrial experience of sponsor(s).

IV. PROJECT PROFILES FOR SELECTED ELECTRONICS PRODUCTS

Introduction

104. The following descriptions of products have been prepared to assist potential manufacturers and assemblers to gain better understanding of the products and the processes, machinery, equipment and materials necessary to start production. Special emphasis has also been given to the personnel and quality control aspects.

Intellectual property rights

105. It is important to note that many of the products described may be subject to stringent intellectual property rights regarding the use of materials and processes which are covered by patents or copyrights. It is important for intending entrepreneurs to determine which, if any, of the processes or materials to be used are covered by intellectual property rights and to obtain licenses from the holders of the rights before production is started. In most instances, the suppliers of parts, components, and supplies can furnish the information to whether the supplied item is covered and, if so, whom to contact to obtain the necessary permission or licence. While such permission may be freely given in certain cases, more often an arrangement to pay a royalty or licensing fee is required. Such costs must be factored into the economic and financial plans of the proposed production operation.

Cost of Technology

106. The estimates provided in the project profiles do not include the cost of technology acquisition, including royalty or licence fee or other payment for using patented technology, or copyrights, as in software, or unpatented but proprietary knowhow in the electronics sector. This is because such payments can differ considerably and are dependent on several factors, including size of the market to be covered, the likely growth potential, various factor conditions impinging on electronics production, and the bargaining capacity of the prospective licensee enterprise. These factors vary considerably from country to country, resulting in significant variations in technology costs for enterprises in different countries. For purposes of initial costing, a royalty of 5% of net sales may be assumed. The actual payment for foreign technology may, however, prove to be substantially higher, or may even be lower, depending on the stage of development of the technology and several other determinant factors. In this regard, it needs to be emphasized that national guidelines in certain countries which prescribe ceilings on royalty payment may need to be reviewed insofar as the electronics sector is concerned, particularly if substantial inflow of foreign technology is sought.

Estimates of equipment costs

107. The estimates of costs of machinery and equipment which have been included in the various project profiles are based primarily on current U.S. costs of equipment. These would be fairly competitive in relation to costs of machinery from other industrialized, developed countries. Certain specific items of equipment may be able to be obtained at lower cost, including in certain developing countries such as Brazil, India and the Republic of Korea, but these would not have major impact on the overall costs of machinery and equipment required for particular projects. Machinery costs could also be

spread over a wider range of products and it may, therefore, be necessary to group various electronics products and components which could be manufactured in the same project. The information and estimates included in the project profiles should be reviewed in the context of particular country situations and will need to be developed into detailed techno-economic feasibility studies before specific projects can be considered for implementation.

Project profiles

A. DICTATION MACHINE

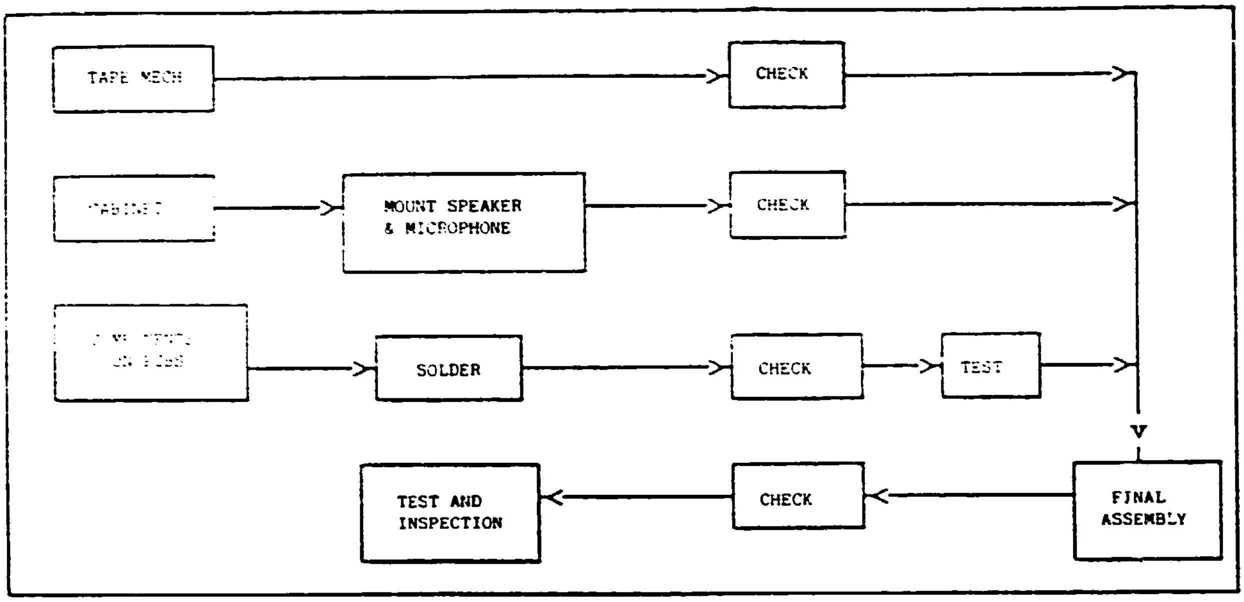
Introduction: This is a simple device for recording and reproducing sound through electro-magnetic means. A built-in microphone picks up the sound, converts it into an electrical signal which is received by a magnetic head. The signal is recorded on a moving magnetically coated tape which, when played past a second magnetic head, reproduces the original sound made audible through a loudspeaker. The tape is generally contained in a cassette, which may be of two internationally standardised sizes. Dictation machines are used in business, commerce and government to record ideas, letters, etc., for later review and transcription. Different from entertainment tape recorders, the dictation machine is monaural and must be of rugged construction.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

The dictation machine is a combination of the mechanical assembly involved in the tape mechanism and the electronic circuitry for the recording, amplification and reproduction of sound. The tape mechanism basically consists of a recording head, a reproducing head, a micro-motor and a drive mechanism for the tape cassette. It may be imported since the audio quality of the device depends on the precision alignment of the heads and the constant speed of the motor under varying degrees of tension of the tape. At a later stage, the tape mechanism may be fabricated locally, although the heads and the motor may still have to be imported.

The electronic circuitry is simple and the electronic components, e.g., transistors, resistors, diodes and transformers, are mounted on the Printed Circuit Board (PCB) and soldered. The subassembly is tested for amplification and frequency response characteristics. The subassemblies are then assembled into the main housing which is a plastic cabinet in which are fixed the built-in microphone and the loudspeaker or output to earphones. The final assembly is tested for electrical characteristics; frequency response, distortion, noise level. It is also tested for mechanical features such as flutter and wow. Standard specifications, either national or the IEC are used for these tests.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	10,000 Units	
Turn Over	$250,000	
Space Required	350 square meters	
	Work area	250 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:
- Drilling Machine
- Shearing Machine
- Tools, Dies and Fixtures
- Stroboscope
- Insulation Tester
- Hand tools, soldering irons

Equipment:
- Audio Oscillator
- Transistor tester
- Oscilloscope
- Output meter
- Distortion factor meter
- Stabilised power supply
- Wow and Flutter meter
- Test Tapes

Materials:
- Tape Mechanism
- Microphone
- Plastic cabinet
- Loudspeaker
- Printed Circuit Boards
- Transistors
- Earphone jacks
- Capacitors
- Volume Control
- Resistors
- Switches
- Diodes
- Connectors and cables

Cost: Machinery cost will be around $8,000; equipment cost will be $18,000, of which the most important items are Wow and Flutter Meter, Oscilloscope and Transistor Tester. These may be imported from USA or UK. Tape mechanism may be obtained from Singapore, Hong Kong or Taiwan at the rate of $10/20 per piece.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist	
	Shop Foreman	
	Assembly Operators	(9)
	Line Inspectors	(2)
	Sales/service technicians	(4)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Line Inspector to Shop Foreman or Testing Specialist
Sales/service Technicians to Testing Specialist
Line Inspectors to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

B. COMPONENT BOARD FABRICATION

Introduction: The Printed Circuit Board (PCB) has become the standard base for the wiring of all electronic circuits utilized in Electronic Devices, Recorders, Radio, TV, and especially Microcomputers, and hence is an essential accessory for development of the electronics industry. Many of the enhancements to the basic microcomputer are achieved through the use of PCBs which provide new functionalities to the computer, such as colour output, expanded memory, graphics capability, etc. These are achieved through the assembly of specialized chips (EPROMs, RAMs, etc.) on a PCB which can then be inserted into vacant slots on the "mother" or host PCB of the computer. Indeed, the production of mother boards for use in supplying manufacturers of microcomputers is a profitable business. In all of these applications it is necessary to obtain, through license, the design and specifications for the board, contract for the components, assemble and test the board and then market the product.

Manufacturing Process: A Component Board is a PCB consisting of an insulated material such as Fibre mat or Fibre-glass impregnated with a thermo-resin binder such as Paper or Glass epoxy. Electronic circuits are designed into the board to connect specialised integrated circuits (chips) to accomplish a particular function.

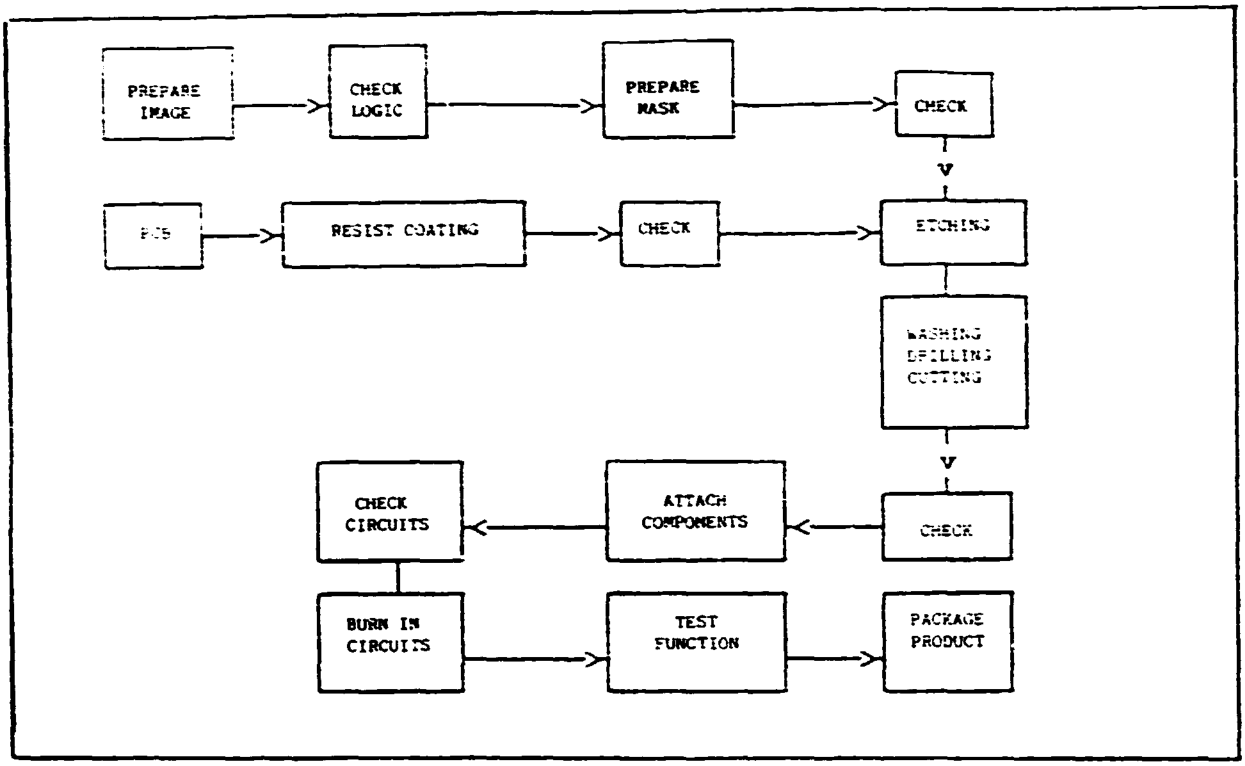
The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

Art work is prepared first, depicting the pathways and connections for the circuitry on the board, according to customer requirements. This is then processed, either through Computer Aided Design or Photography to prepare a photomask. The image is then transferred to a copper clad laminate which has been cleaned well and coated with a photo-sensitive resist using one of the three methods -- Screen Printing, Wet Process or Dry Film System. Screen Printing is the cheapest method but does not ensure sharpness of lines and the quality depends on the skill of the individual printer. Semi-automatic or Automatic Screen Printing machines are also available depending on the volume of production and the density of the packing of components on the board.

After printing, the board is plated in a tin bath or tin/lead bath. After the plating process, the extra copper in the PCB which is not plated is etched. Before etching, it is necessary to remove the ink,which is done by a suitable solvent depending on the ink used. The etching is done with various solutions such as Ferric Chloride - chromic-ammonia, etc.

After the board has been etched and dried, holes are drilled for the insertion of components. Drilling machines used vary from single-spindle, low-speed to high speed and very high speed (45,000 rpm) and NC controlled multi-spindle machines. The boards are finally cut to size,for which various methods such as slitting saws, shears and, now, lasers are employed. Connecting fingers are plated with nickel or nickel and gold. For cutting contours Routing Machines are available. The PCBs are then ready for packing and shipping.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	5000 sq. meters (Product Mix depends on actual orders)
Turn Over	$800,000
Area required	500 square meters

Machinery:

Screen Printing Machine
Precision Camera or CAD Imager
Plating Bath
Etching Machine
Shearing Machine
Drilling Machine (Precision)
Circular Saw for PCB Cutting

Equipment:

High Voltage Tester
Continuity Tester
Insulation Resistance Tester
Microscope for checking patterns
Circuit testing Equipment
Micro computer

Materials:

Copper clad phenolic or Glass-Epoxy sheets
Chemicals for plating
Photo film
Chips as required for specific orders

Costs: Copper clad laminates will need to be imported as also the chemicals for plating and etching; these will cost about $18 per square meter for a single-sided PCB. Cost of machinery will be $40,000. Equipment cost will be around $50,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist/Programmer	(4)
	Skilled Workers	(6)
	Assembly Operators	(6)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Skilled Worker to Testing Specialist
Sales/service Technicians to Testing Specialist

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing specialist/programmer and skilled workers, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company.

The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

C. MAGNETIC TAPE CARTRIDGES/CASSETTES

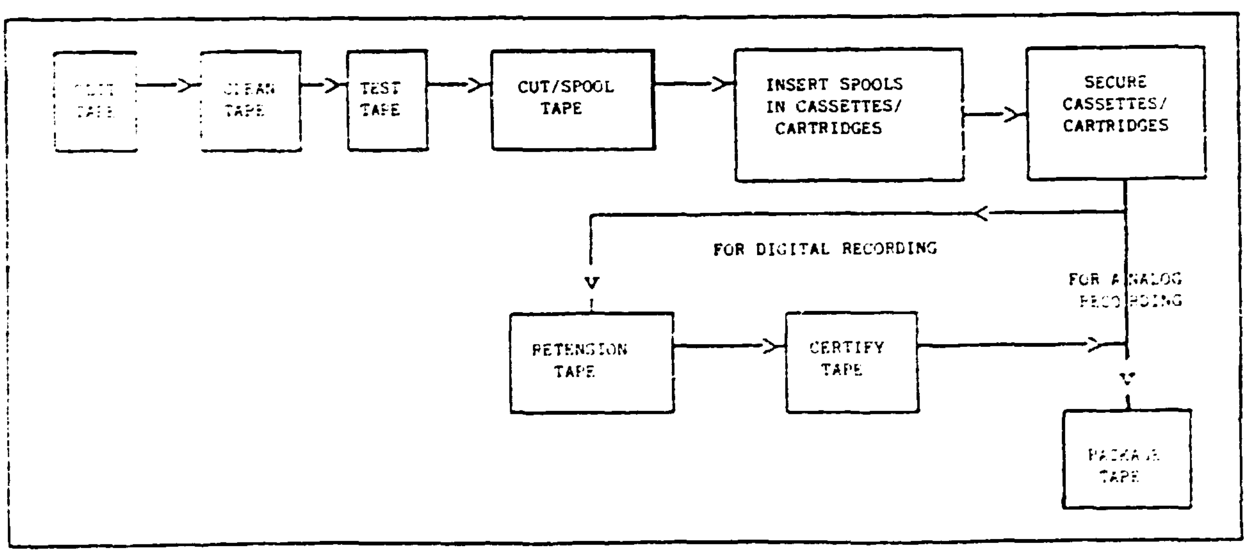
Introduction: Magnetic tape cartridges and cassettes are metal or plastic enclosures housing two reels and a length of magnetic tape. They are used in a variety of applications, including dictation machines, stereo entertainment systems and computers. The quality of the tape and the precision of the housing are governed by the application of the product, with more precision required for stereo and computer use than with dictation.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

Bulk magnetic tape is acquired through outside purchase. This tape will have the characteristics required for the intended application, e.g., Chromium oxide for high-quality stereo reproduction or coated ferrous oxide for computer applications. Bulk tape can be purchased from manufacturers in the US, UK, Germany or Japan. The bulk tape is slit to the appropriate width for the particular application, cleaned (utilizing solvents and ultrasonic cavitation machines) and rewound onto feed spools. The Cassette or Cartridge housing is then prepared for inserting the reels. The tape is wound from the feed spools onto the take-up reel, which is then placed in the housing. The tape is led through the feed path and attached to the housing's feed spool. (In some applications special leaders are used to attach the tape to the spools. These leaders provide extra strength, and in some cases, clean the magnetic heads in the tape units.)

The housing is then closed and secured and the tape is wound and rewound to balance the tension. In critical applications, the tape is certified for its surface and magnetic characteristics. Special equipment is used for this operation. In the case of audio tapes this step may not be necessary. Finally, the housing is placed in a protective cover, usually a plastic enclosure, and shrink-wrap sealed to protect the product from humidity and dirt.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity		
Turn Over		
Space Required	350 square meters	
	Work area	250 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:	Shearing Machine Drilling Machine Hot Stamping Machine Tapping Machine Power Press Grinding Machine Tools, Jigs, Dies and Fixtures Hand tools, soldering irons Tape Slitter Tape Cleaner Tape Winding/Stuffing Machine Housing Sealing Machine Packaging Machine
Equipment:	Tape Certifier
Materials:	Bulk Tape Housings for Cassettes/Cartridges Spools, Rollers, Pads, etc. Packing Material

Cost: Machinery/Equipment ocst will be around $30,000-50,000 depending on production volume. Cost for Materials will change with production volume, quality of tape and housings used. Prices vary widely and are subject to change depending on demand, petroleum supplies and coating availability.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialist	
	Shop Foreman	
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(4)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastropic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

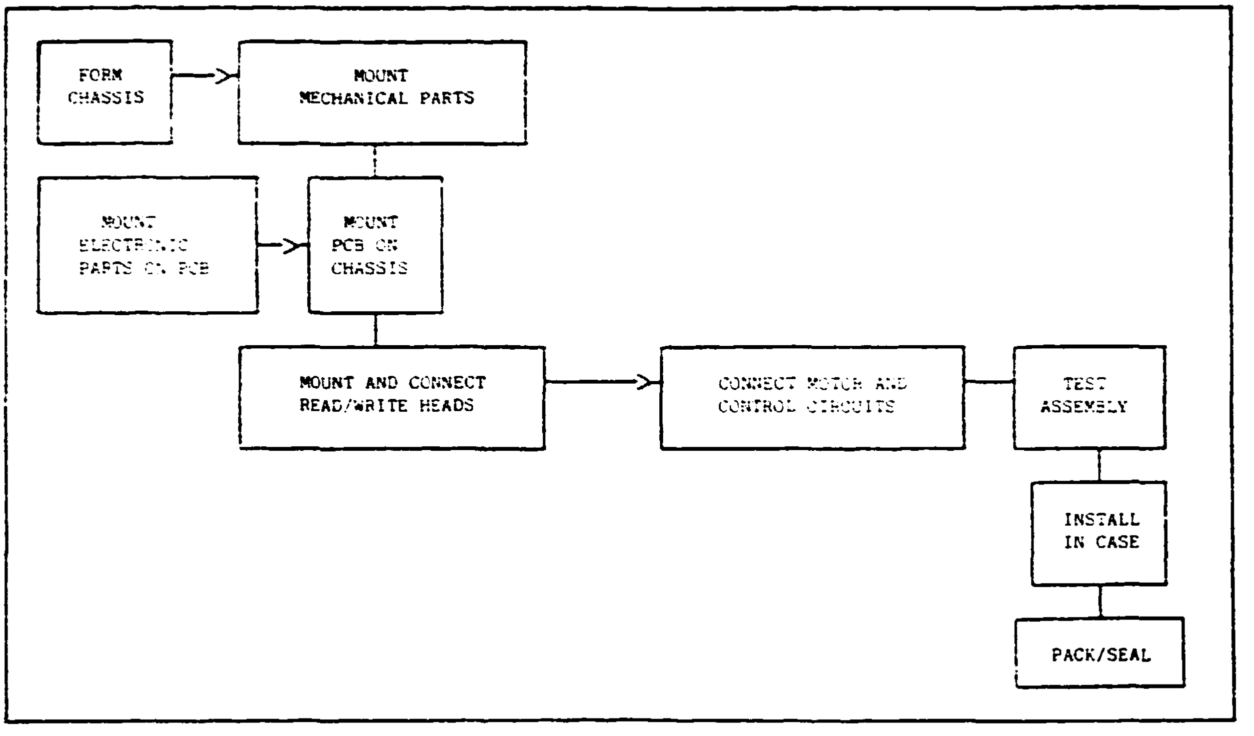
D. MAGNETIC TAPE CARTRIDGES/CASSETTES UNITS

Introduction: Magnetic tape cartridges/cassettes units are assemblies comprised of an electric motor, drive mechanisms for two reels and the read/record tape transport, magnetic read/record heads, electronic circuitry to amplify the magnetic signals and to control the motion of the tape, connectors to attach the assembly to the using unit and a suitable cabinet to house the assembly (internal to a computer or external for interconnection).

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

In the initial assembly a chassis is prepared to accept the mechanical parts of the tape drive mechanism, the motor, gears, belts, capstans, rollers, and posts, which are mounted and tested for mechanical operation. The electronic components are mounted on a PCB, which is then installed in the chassis. The read/record heads are mounted on the chassis and connected to the electronic circuitry. The motor is connected to the control circuits and the assembly is then tested for speed, tracking, signal generation, amplitude tolerance, etc. The chassis is then mounted in an appropriate cabinet, packed, sealed, and labelled for shipment.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	12,000 Units	
Turn Over	$600,000	
Space Required	400 square meters	
	Work area	350 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:	Shearing Machine
	Drilling Machine
	Soldering Stations
	Hot Stamping Machine
	Painting Equipment
	Tapping Machine
	Power Press
	Grinding Machine
	Tools, Jigs, Dies and Fixtures
	Insulation Tester
	Hand tools, soldering irons
Equipment:	Wide band oscilloscope (350 MHz)
	Power Supplies (2)
	AC Milli-voltmeter
	Function Generator
	IC Tester
	Continuity Tester
	Circuit testing Equipment
	Oscilloscope
	Output meter
	Stabilised power supply
	Test Tapes

Materials:

Chips as required for specific orders
Cabinet
Transistors and Diodes
Capacitors
  Plastic Film, Electrolytic, Ceramic
Resistors
  Carbon Film, Wire Wound
Potentiometers
Printed Circuit Boards
Hardware Items
Tape Mechanism
Switches
Connectors and cables

Cost: Machinery/Equipment cost will be around $30,000-50,000 depending on production volume. Cost for Materials will be around $30,000-50,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialists	(4)
	Shop Foreman	(2)
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibil[illegible] a manufacturer hinges on adequate quality control. This control must [illegible]intained throughout the manufacturing or assembly process. Tests must [illegible] on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

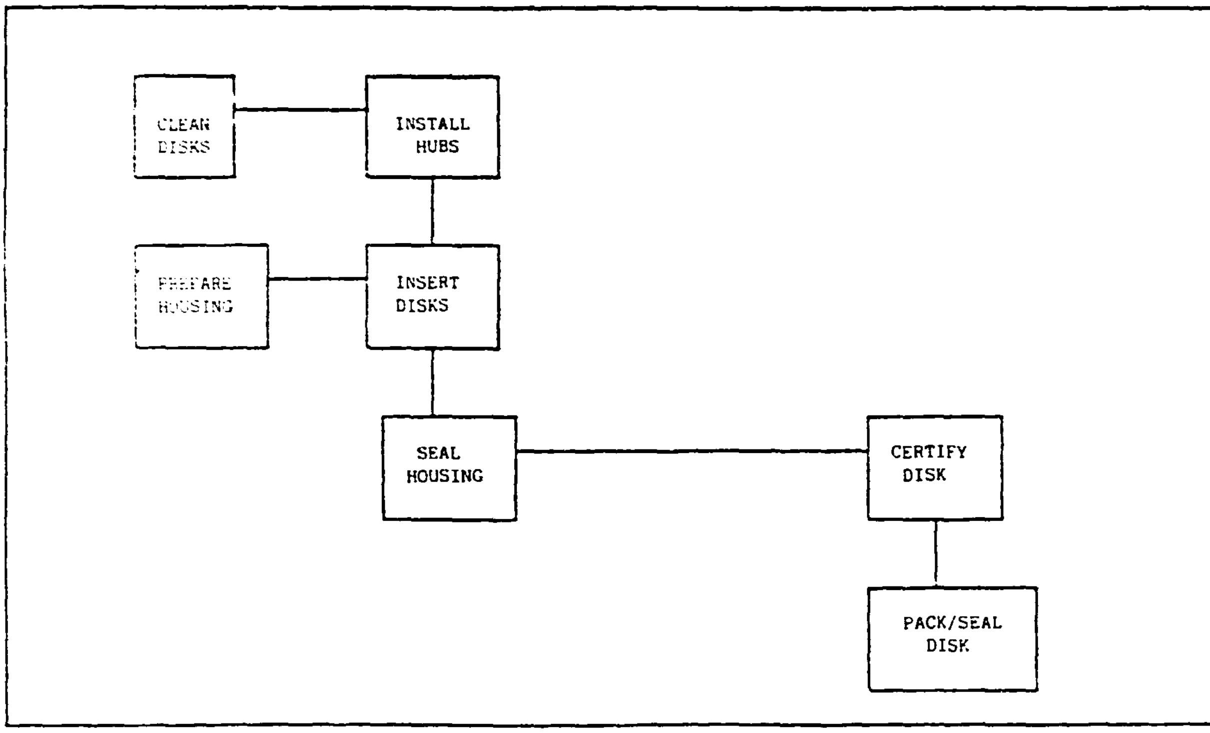
E. FLEXIBLE MAGNETIC DISKS

Introduction: The flexible magnetic disk is a plastic disk on which a coating of magnetic material is placed and on which digital signals are recorded for use in computing and data processing applications. Primary uses are with microcomputers. There are two principal types of flexible disks which are defined by ISO standards for both unrecorded media and the recording and certification of such media. The manufacture of the plastic film and the coating of the surface are extremely complex processes and highly capital intensive. It is better to purchase the bulk stock than to attempt domestic manufacture.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

Bulk magnetic stock (disks) is acquired through outside purchase. This stock will have the characteristics required for the intended application, e.g., High or Low density recording, Teflon-coated for dirt resistance, etc. Bulk stock can be purchased from manufacturers in the US, UK, Germany or Japan. The bulk stock is cleaned (utilizing solvents and ultrasonic cavitation machines) and inserted into the housing. In some applications a special hub must be attached to the disk prior to insertion into the housing. The housing may be lined with special material that lifts dust and dirt from the disk surface. The housing is then closed and sealed, ultrasonically or mechanically. The disk is certified for its surface and magnetic characteristics. Special equipment is used for this operation. Finally, the housing is placed in a protective cover, usually a Tyvek envelope, and shrink-wrap sealed in shipping containers to protect the product from humidity and dirt.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	100,000-500,000 Units	
Turn Over	$500,000-5,000,000	
Space Required	500 square meters	
	Work area	400 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:

Shearing Machine
Drilling Machine
Hot Stamping Machine
Tapping Machine
Power Press
Grinding Machine
Tools, Jigs, Dies and Fixtures
Hand tools, soldering irons
Disk Inserter
Housing Sealer
Packaging Machine

Equipment:

Disk Certifier

Materials:

Bulk Magnetic Disks
Housing Assemblies
Packing Material

Cost: Machinery/Equipment cost will be around $50,000-70,000 depending on production volume. Cost for Materials will change with production volume, quality of tape and housings used. Prices vary widely and are subject to change depending on demand, petroleum supplies and coating availability.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialist	
	Shop Foreman	
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(4)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

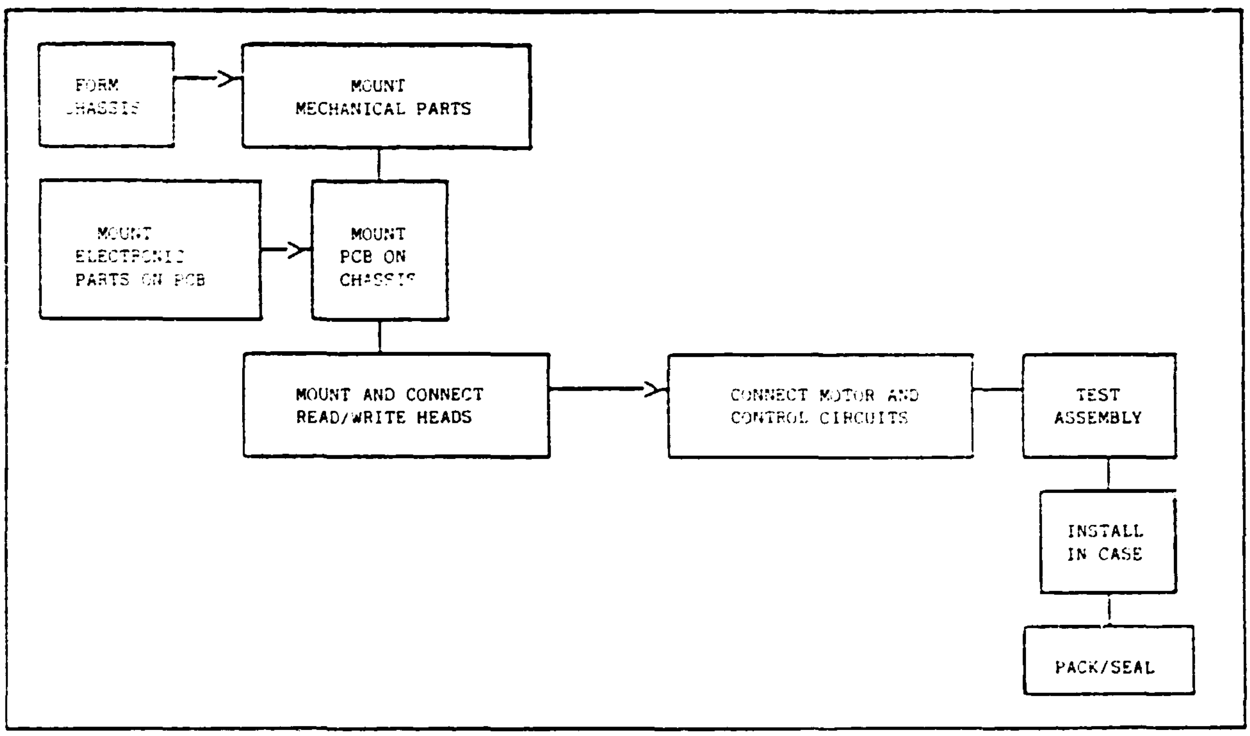
F. FLEXIBLE MAGNETIC DISK DRIVES

Introduction: Flexible magnetic disk drives are assemblies comprised of an electric motor, drive mechanisms for the disks and the read/record mechanism, magnetic read/record heads, electronic circuitry to amplify the magnetic signals and to control the motion of the disk, connectors to attach the assembly to the using unit and a suitable cabinet to house the assembly (internal to a computer or external for interconnection).

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

In the initial assembly a chassis is prepared to accept the mechanical parts of the disk drive mechanism, the motor, gears, belts and capstans, which are mounted and tested for mechanical operation. The electronic components are mounted on a PCB, which is then installed in the chassis. The read/record heads are mounted on the chassis and connected to the electronic circuitry. The motor is connected to the control circuits and the assembly is then tested for speed, tracking, signal generation, amplitude tolerance, etc. The chassis is then mounted in an appropriate cabinet, packed, sealed and labelled for shipment.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	12,000 Units	
Turn Over	$1,500,000	
Space Required	400 square meters	
	Work area	350 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:	Shearing Machine Drilling Machine Soldering Stations Hot Stamping Machine Painting Equipment Tapping Machine Power Press Grinding Machine Tools, Jigs, Dies and Fixtures Insulation Tester Hand tools, soldering irons
Equipment:	Wide band oscilloscope (350 MHz) Power Supplies (2) AC Milli-voltmeter Function Generator IC Tester Continuity Tester Circuit testing Equipment Oscilloscope Output meter Stabilised power supply Test Disks

Materials:	Chips as required for specific orders
	Cabinet
	Transistors and Diodes
	Capacitors
	  Plastic Film, Electrolytic, Ceramic
	Resistors
	  Carbon Film, Wire Wound
	Potentiometers
	Printed Circuit Boards
	Hardware Items
	Disk Mechanism
	Switches
	Connectors and cables

Cost: Machinery/Equipment cost will be around $40,000-60,000 depending on production volume. Cost for Materials will be around $45,000-90,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialists	(4)
	Shop Foreman	(2)
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastropic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

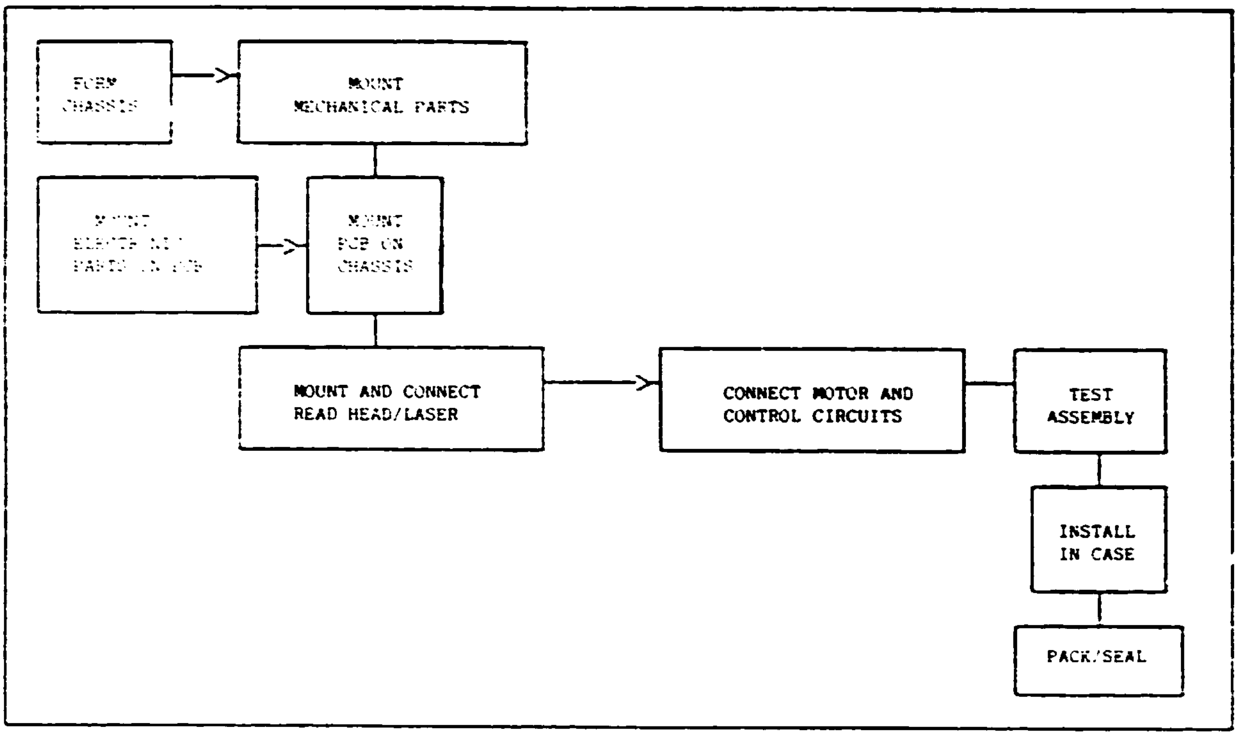
G. OPTICAL DISK SCANNER UNIT

Introduction: Optical disk scanner units (drives) are assemblies comprised of an electric motor, drive mechanisms for the disks and the read mechanism, laser unit, electronic circuitry to amplify the laser signals and to control the motion of the disk, connectors to attach the assembly to the using unit and a suitable cabinet to house the assembly (internal to a computer or external for interconnection).

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic and optical tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

In the initial assembly a chassis is prepared to accept the mechanical parts of the disk drive mechanism, the motor, gears, belts and capstans, which are mounted and tested for mechanical operation. The electronic components are mounted on a PCB, which is then installed in the chassis. The read head and laser are mounted on the chassis and connected to the electronic circuitry. The motor is connected to the control circuits and the assembly is then tested for speed, tracking, signal generation, amplitude tolerance, etc. The chassis is then mounted in an appropriate cabinet, packed, sealed and labelled for shipment.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	12,000 Units	
Turn Over	$1,500,000	
Space Required	400 square meters	
	Work area	300 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:

- Shearing Machine
- Drilling Machine
- Soldering Stations
- Hot Stamping Machine
- Painting Equipment
- Tapping Machine
- Power Press
- Grinding Machine
- Tools, Jigs, Dies and Fixtures
- Insulation Tester
- Hand tools, soldering irons

Equipment:

- Wide band oscilloscope (350 MHz)
- Power Supplies (2)
- AC Milli-voltmeter
- Function Generator
- IC Tester
- Continuity Tester
- Circuit testing Equipment
- Oscilloscope
- Output meter
- Stabilised power supply
- Test Disks

Materials:	Chips as required for specific orders
	Cabinet
	Transistors and Diodes
	Capacitors
	Plastic Film, Electrolytic, Ceramic
	Resistors
	Carbon Film, Wire Wound
	Potentiometers
	Printed Circuit Boards
	Hardware Items
	Disk Mechanism
	Switches
	Connectors and cables

Cost: Machinery/Equipment cost will be around $40,000-60,000 depending on production volume. Cost for Materials will be around $45,000-90,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialists	(4)
	Shop Foreman	(2)
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastropic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its sub-assemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

H. KEYBOARD ASSEMBLY

Introduction: The digital keyboard is the primary input unit for microcomputers. It consists of a set of keys representing the alphabet, numerals, punctuation marks and special functions which the microcomputer can perform. Each of the keys, when depressed, produces electronic signals representing codes for the operation of the microculture or data to be processed by the microcomputer. Keyboards are usually produced separately from the computer and in many cases are interchangeable among computers of different manufacture, as long as the operating systems of the computers are the same. This means that there is a separate market for keyboards, independent of specific microcomputers.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

The manufacture of the keyboard begins with the purchase of the major components. They are the keys, the PCB, the chassis and the housing. As production grows, it will be possible to fabricate the chassis and housing in-plant, but it is easier to continue to purchase the PCB stock and the keys from outside sources. The key is an assembly consisting of an electronic chip, embedded in a plastic enclosure to protect it from dirt and moisture, which produces a unique code when power is passed through the chip. The key assembly also has a key-top with the symbol of the character or function the key encodes, and a spring mechanism to return the key-top to the disconnect position.

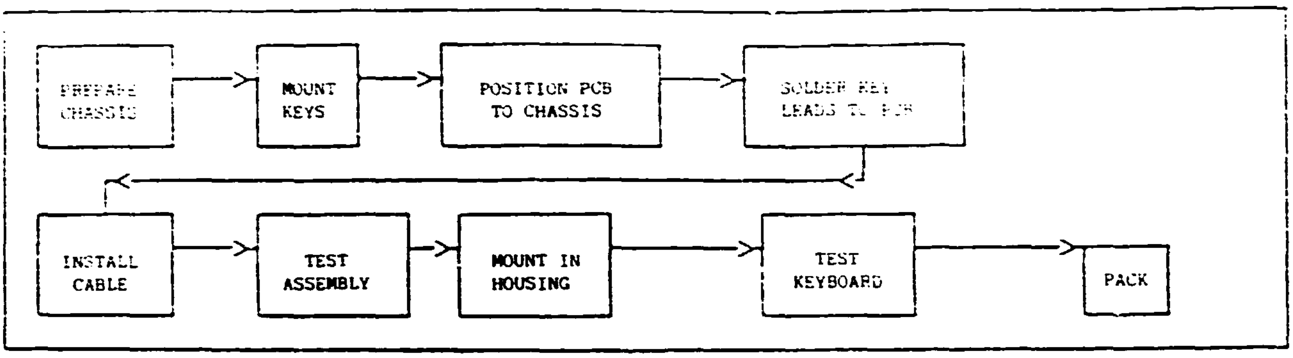
The PCB is generally a through-hole type with holes for both the leads from the key assemblies and the anchor lug of the key assembly which holds the assembly in place.

The chassis is a formed metal plate with holes for the key assemblies. These holes are used to mount the plastic enclosure of the key assembly. When the assemblies are in place, the plastic enclosures and the chassis form a dirt resistant barrier for the PCB which is mounted directly below the chassis.

The manufacture or assembly process begins by mounting the appropriate key assemblies in the proper location on the chassis. The electronic leads of the assemblies are then positioned through the PCB, which is then attached to the chassis and the leads are soldered to the PCB. The connector cable is then attached to the chassis and the keyboard is tested by connecting it to a test device and each key is tested to determine if the proper code is transmitted.

After testing the subassembly of the chassis with keys and PCB, it is mounted in the housing. The housing can be a moulded plastic enclosure or a plastic top with a metal base plate. When fully assembled, the keyboard is again tested to check all possible codes and combinations. The keyboard is then packed in an impact resistant container and sealed, with instructions for installation and use.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	12,000 Units	
Turn Over	$600,000	
Space Required	400 square meters	
	Work area	300 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:
- Shearing Machine
- Drilling Machine
- Soldering Stations
- Hot Stamping Machine
- Painting Equipment
- Tapping Machine
- Power Press
- Grinding Machine
- Tools, Jigs, Dies and Fixtures
- Insulation Tester
- Hand tools, soldering irons

Equipment:
- Power Supplies (2)
- AC Milli-voltmeter
- Insulation Tester
- IC Tester
- Continuity Tester
- Circuit testing Equipment
- Micro computer
- Oscilloscope
- Output meter
- Keyboard Test Machine

Materials:
- Keys as required for specific orders
- Transistors and Diodes
- Capacitors
  - Plastic Film, Electrolytic, Ceramic

Resistors
  Carbon Film, Wire Wound
Printed Circuit Boards
Hardware Items
Switches
Connectors and cables

Cost: Machinery/Equipment cost will be around $40,000-60,000 depending on production volume. Cost for Materials will be around $45,000-90,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialists	(4)
	Shop Foreman	(2)
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

I. DISPLAY (CRT) ASSEMBLY

Introduction: The Cathode Ray Tube display is the primary output device for operator use on microcomputers. A Monochrome display is similar to a B/W TV, while a Colour display resembles a colour TV. Assembly of these devices is a relatively simple procedure. Manufacture of the cathode ray tubes is complex and needs greater technological skill; their production becomes viable only in large volumes. CRT displays meant for the domestic market will have to conform to national radio frequency interference standards, but those meant for export markets may need to meet different standards, such as FCC, PAL, SECAM, NTSC and CCIR.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

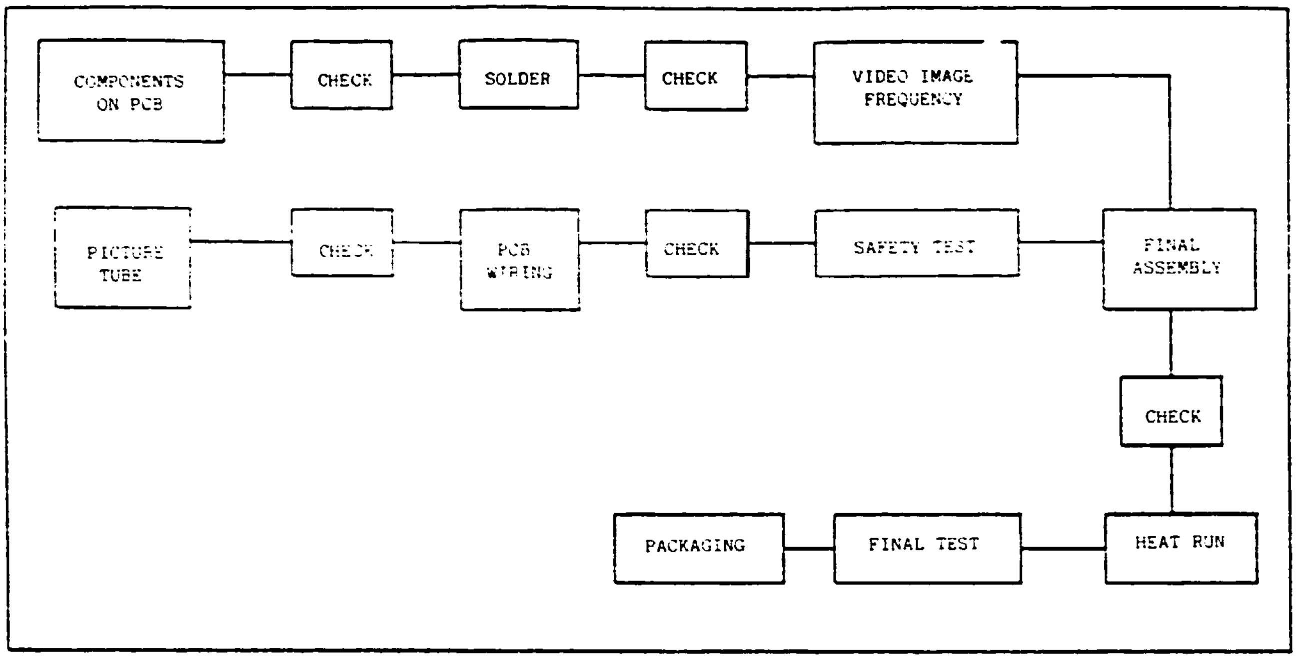
Both Monochrome and Colour Displays use a sequential assembly system. Initially with low volumes of production, this can be done manually; later a conveyor belt may be used. In the preliminary process, components are tested, formed, bundled and insulating tubes are inserted. (These steps are labour intensive and require patience.) Various resistors, condensers, coils and transformers are mounted on the PCB, followed by inspection.

ICs and transistors are then fixed on the back of the PCB and soldering is done by an auto-soldering machine. The assembled PCB is tested for functional response to microcomputer output, including colour board for colour displays.

The wiring is then completed to the PCB assembly. It is then moved to the finishing section for the final assembly inside the cabinet in which the Cathode Ray Tube is already fixed. The assembly then undergoes an adjustment of the deflection yoke and a final inspection of its frequency and insulation with its backplate fixed, where the computer connections are made and adjusted. Hazards due to high tension on the controls (due to faulty insulation in the fly-back HT transformer) or due to picture implosion are tested according to the IEC standards.

Final packaging is important due to the fragile nature of the product, particularly to avoid damage to the surface of the cathode ray tube; operating instruction and guarantee card are inserted before the set is finally sealed, with appropriate markings for delivery to the dealer or for export abroad.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	10,000 Monochrome Displays	
	4,000 Colour Displays	
Turn Over	$1.8 million	
Space Required	1500 square meters	
	Work area	800 square meters
	Store	500 square meters
	Office	200 square meters

Machinery:

- Soldering Stations
- Hot Stamping Machine
- Temperature controlled oven
- Painting Equipment
- Spot Welder
- Tapping Machine
- Power Press
- Grinding Machine
- Drilling Machine
- Shearing Machine
- Tools, Jigs and Fixtures

Equipment:

- VHF Sweep Generator
- Alignment Scope
- Colour TV Pattern Generator
- Colour Analyser
- VTVM (with HT probe)
- Audio Power Output Meter
- LCR Bridge/Q-Meter
- Wide band oscilloscope (350 MHz)
- Power Supplies (2)
- AC Milli-voltmeter
- Function Generator

Wave Form Monitor (625 lines)
Insulation Tester
IC Tester
Variacs

Materials:

Cathode Ray Tube
Cabinet
Deflection Components
Transistors and Diodes
Capacitors
  Plastic Film, Electrolytic, Ceramic
Resistors
  Carbon Film, Wire Wound
Potentiometers
Printed Circuit Boards
Hardware Items

Cost: To start with, components may be imported in CKD form which consist of all the components including picture tube; they are available for $25 per kit for a Monochrome display (12"-14") and $75 for a colour display (20") from Korea or Taiwan. While production of Colour displays may need to continue on this basis due to low demand, many components for a Monochrome display such as the deflection components, PCB, plastic and metal parts can be produced in-house or sub-contracted locally when production of such items is established in the country.

Cost of machinery required for production will be around $50,000 depending on the extent of 'in-house' production planned. Cost of test equipment will be around $50,000, of which the more important are:

VHF Sweep Generator
Colour TV Pattern Generator
Colour Analyser
Oscilloscope
Wave Form Monitor (625 lines)
Q Meter

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:

Production Manager	
Testing Specialist	(8)
Shop Foreman	(2)
Assembly Operators	(20)
Sales/service technicians	(6)
Administration	(6)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Testing Specialist
Skilled Worker to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

J. PC/MICROCOMPUTER ASSEMBLY

Introduction: The Personal Computer or Microcomputer is a free-standing computer for individual or shared use, usually based on a 16 or 32 bit architecture. The PC generally is configured to have internal (chip) random access memory (RAM), one or more flexible disk drives and a variety of optional connected peripheral equipment, e.g., hard disk drives, tape cassette or cartridge units, printers, communications interfaces (modems), etc. It is the fastest growing device in the business marketplace and because of its utility, versatility and ease of use it promises to continue strongly into the future.

Manufacturing Process: The manufacturing process starts with the purchase of parts from a variety of vendors. When the parts arrive, samples are sent for quality assurance testing. Mechanical tests are made to check tolerances and wear or survivability. Electronic tests are made for function, current and safety. Once a shipment is approved, the parts are stored on shelving for easy identification and access. The parts are unpacked before bringing them to the assembly line, placed in rubber bins or baskets for distribution and placed at the appropriate workstations.

Printed Circuit Boards (PCBs) are the first components to be assembled. There are usually from 4 to 6 PCBs in a PC. Board assembly is complex and needs a separate production line.

Preprinted boards with electronic circuits, but no components are bought from an outside supplier. Production workers bend small electronic wire leads at specific angles or sleeve the leads with insulation. Other parts are sorted by machine in specific order and attached to reels of special adhesive tape. The reels are then fed into another machine that rapidly picks off the parts, in order, and places them on the boards.

Some parts may be acquired on reels of sprocketed plastic film already positioned for automatic placement on the PCBs.

The PCBs contain hundreds of components. About 85 percent of the parts can be placed automatically by machine. For example, one machine can install integrated circuits (ICs) at the rate of 4,000 chips per hour. A second machine can insert resistors, fuses and diodes at the rate of 26,000 per hour. A third machine places capacitors, transistors and other components at similar high speeds. An automatic conveyor shuttles the boards between machines.

The remaining 15 percent of the parts, including large capacitors and integrated circuits, are installed by hand. A "buddy system" is used for this work. The system is one in which workers inspect the previous person's work before performing their own assembly tasks. This system catches most assembly errors and helps promote a high-quality attitude.

After all the parts are placed on the PCBs, the boards pass down a conveyor to a soldering machine. This machine bonds the electrical leads of all components to each board's preprinted circuitry.

As the production facility progresses, surface-mount technology (SMT) can be employed. With SMT most components are attached directly to the surface of the board, instead of having their leads inserted through pre-drilled holes and then soldered. SMT components are much smaller than the through-hole counterparts. SMT components can also be mounted on both sides of the board, which is not possible with through-hole boards. SMT requires an "intelligent" machine to place hundreds of SMT parts on the board accurately to within 5 ten-thousandths of an inch. Such machines are very expensive and available from only a few sources.

Both SMT and through-hole boards are subjected to electronic testing before being released to the computer assembly line. Each board is placed in a custom built machine, which gives the board complex electronic commands to perform to test the functional capability of the board. Failed boards are shunted to a rework area for diagnosis and rework.

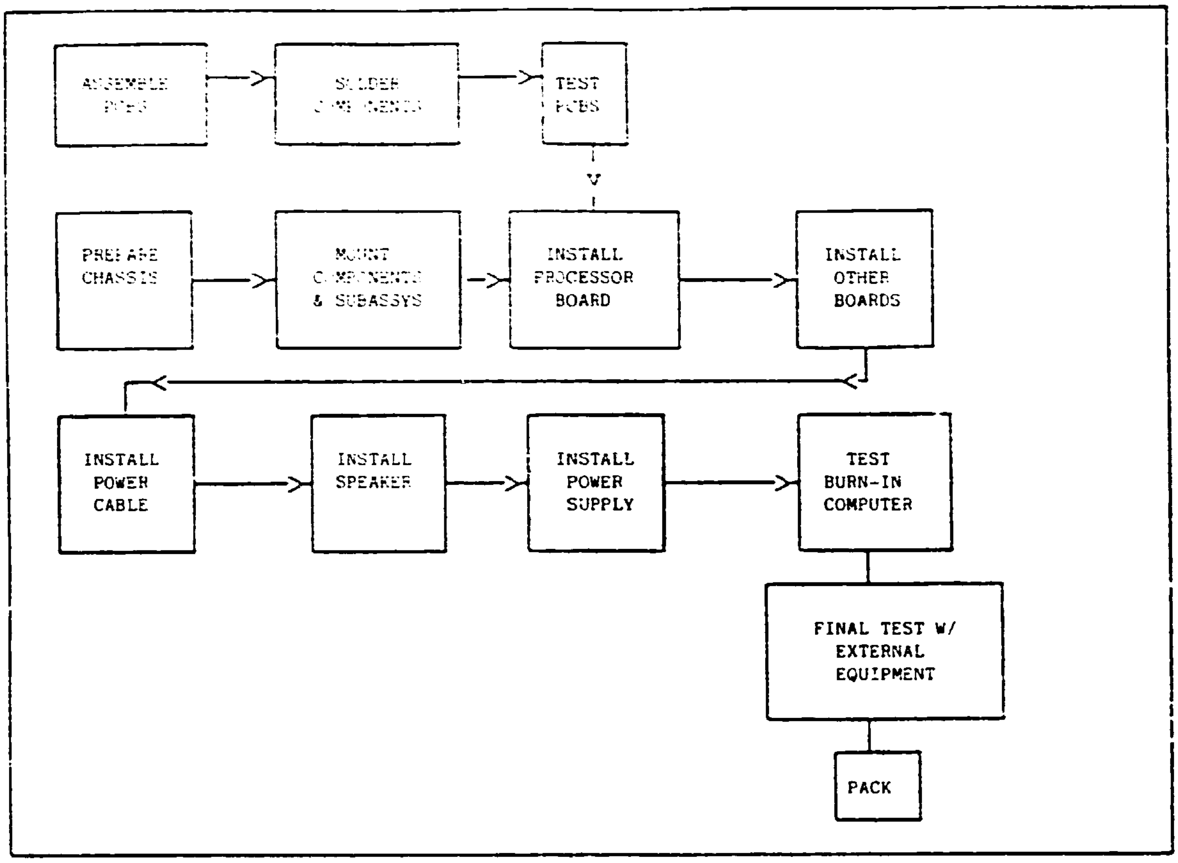
The passed boards are sent to the main assembly line. At the head of the line is the chassis fabricating machine. It is programmed to crimp, bend and rivet pieces of sheet metal in the PC chassis. The chassis is then sent to the first of a series of workstations. At each workstation an assembly team worker adds components to the chassis. At successive stations other workers pull parts from the rubber bins to install them on the chassis. As the chassis moves down the line it is equipped with shock mounts and disk drives. The main processor board is installed, as are the boards for disk and power supply controllers, random access memory and a multifunction board, as well as a power cable, speaker, and the final component, the power supply.

Upon leaving the final assembly station the completed computer is shuttled to a series of test stations. The unit is plugged in and powered up. A Flexible disk containing diagnostic software is inserted and the unit is thoroughly tested for all designed functions. After successfully completing the first test, the unit moves to the "burn-in" test. At this site the diagnostic software causes the computer to run continuously through all its key functions for 24 to 96 hours.

After testing and burn-in the computer is taken to the final electronic test station. The computer, still without its external housing, is connected to a variety of monitors, printers and keyboards and again put through exhaustive tests.

Finally, the unit receives the external housing and is packed for shipment in a shockproof carton along with its keyboard and power cord.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	25,000 Units	
Turn Over	$1,800,000	
Space Required	1,000 square meters	
	Work area	750 square meters
	Store	150 square meters
	Office	100 square meters

Machinery:

- Plating Bath
- Shearing Machine
- Drilling Machine
- Circular Saw for PCB Cutting
- Soldering Stations
- Hot Stamping Machine
- Temperature controlled oven
- Painting Equipment
- Spot Welder
- Tapping Machine
- Power Press
- Grinding Machine
- Tools, Jigs, Dies and Fixtures
- Insulation Tester
- Hand tools, soldering irons

PCB Test Machines
Component Placing Machines
Chassis Fabrication Machine

Equipment:

Wide band oscilloscope (350 MHz)
Power Supplies (2)
AC Milli-voltmeter
Function Generator
Wave Form Monitor (625 lines)
IC Tester
High Voltage Tester
Continuity Tester
Microscope for checking patterns
Circuit testing Equipment
Oscilloscope
Output meter
Stabilised power supply
Test Disks

Materials:

Chips (ICs) as required for specific orders
Cabinet
Transistors and Diodes
Capacitors
  Plastic Film, Electrolytic, Ceramic
Resistors
  Carbon Film, Wire Wound
Potentiometers
Printed Circuit Boards
Hardware Items
Disk Mechanism
Loudspeaker
Switches
Connectors and cables

Cost: To start with, most components will be imported. Some components such as the PCBs, plastic and metal parts can be produced in-house or sub-contracted locally when production of such items is established in the country.

Cost of machinery required for production will be around $250,000 depending on the extent of 'in-house' production planned. Cost of test equipment will be around $150,000. Materials cost will be around $300-$500 per unit, depending on the complexity of the unit.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:

Production Manager	
Purchasing Specialists	(4)
Testing Specialist	(8)
Shop Foreman	(2)
Skilled Workers	(10)
Assembly Operators	(20)
Sales/service technicians	(6)
Administration	(6)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Testing Specialist
Skilled Worker to Testing or Purchasing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure, rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its sub-assemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

K. DOMESTIC AND CAR RADIOS

Introduction: Transistor Radios (including Car Radios) are a central element of Consumer Electronics and represent a starting point for the growth of the Electronics Industry in any country. There is a good domestic market in most countries with increased coverage of radio broadcasts; there is also an export market potential.

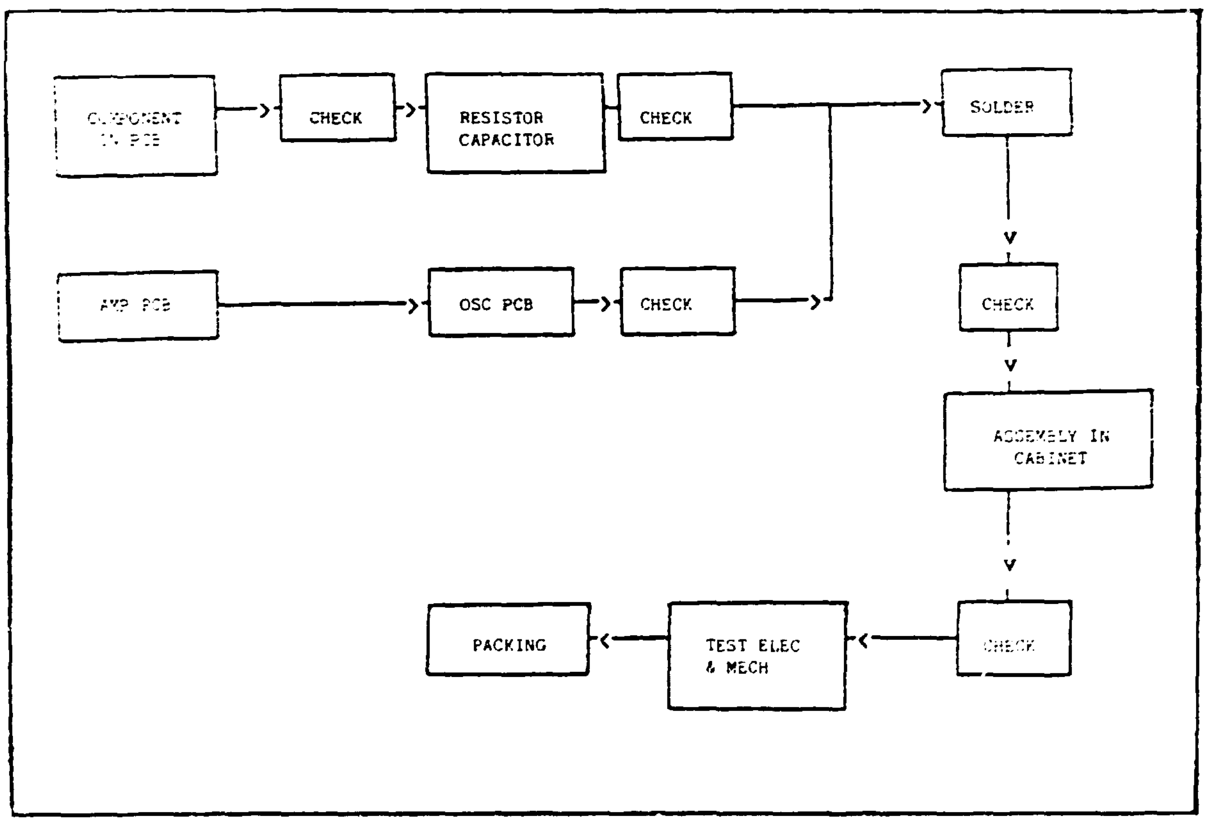
Manufacturing Process: The manufacturing process is comparatively simple, consisting of assembly of components, acquired through purchase, and testing the final product; later, it will be possible to make, in-house, some of the parts such as resistors and IF (Intermediate Frequency) transformers.

Components such as transformers and coils are first mounted on the Printed Circuit Board (PCB). Later, transistors, resistors and capacitors are fixed on the PCB and then soldered. Separate PCB cards are used for the oscillator and amplifier sections to avoid feed-back. The assembly is then tested for sensitivity, selectivity, frequency response, output gain, etc. The subassemblies are then connected together and mounted in a cabinet, usually plastic, fitted with volume control, band-change switch (in case of multi-band radio) tuning control, loudspeaker and aerial assembly. Wooden cabinets may be used where quality wood is easily available. The final assembly is then tested for the electrical characteristics in an interference-free chamber. The set is subjected to a life test, as well as mechanical tests (drop test, climatic and humidity test, etc.) as prescribed in the national specifications or as specified by the IEC.

Domestic Radios are usually single band (medium wave 525-1600 KHz) or three band (one medium wave and two short waves 2-6 MHz and 6-18 MHz). In some countries where FM broadcasts are operated, an FM band (88-108 MHz) is also provided, but the circuitry becomes more complex because of both amplitude and frequency discrimination.

Car radios have basically the same design as the domestic radios, but they have to withstand greater vibration and also be compact enough to fit into the car dashboard panel. There is also need for a special filter arrangement to suppress the interference due to the car's electrical system; for this purpose, inductive tuning is generally employed.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	10,000 Domestic Radios	
	2,000 Car Radios	
Turn Over	$400,000	
Space Required	400 square meters	
	Work area	300 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:

- Coil Winding Machine
- Soldering Irons
- Grinder
- Drilling Machine
- Transformer Winding Machine
- Stoke Press
- Air Compressor (with Spray Gun)

Some of the machinery will be available locally; other may need to be imported, as well as most of the test equipment.

Equipment:

- Double beam Oscilloscope (0-10 MHz)
- RF Signal Generator/Oscillator
- Audio Oscillator
- Power Supplies (4)
- General Purpose Oscilloscope
- Distortion Meter
- Vacuum tube Voltmeter
- Multi-meter
- Interference-free Test Chamber

Materials:

- Permeability Tuner
- Transistors/ICs
- PCB
- Condensers
- Resistors
- Inductance coils
- Band change switches
- Volume Control
- Tuning Control
- Loudspeaker
- Ferrite Rods
- IF Transformer
- Dial
- Cabinet (plastic or wooden)
- Battery holder

With respect to raw materials, initially much of it will be bought locally or imported, but later, some of the items such as PCBs, Resistors, IF transformers, etc., can be made within the plant. In the case of car radios, an attractive finish is important from the point of sales appeal. The front plate should be chromium plated or finished in matte black; if facilities are not available locally, the grille and accessories may also need to be imported.

Cost: Total cost of machinery will be around $10,000; cost of Test equipment will be $20,000, of which the important items are Double beam Oscilloscope; RF Signal Generator. These may be imported from USA, UK, West Germany or Japan.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:

- Production Manager
- Purchase Specialist
- Testing Specialist
- Shop Foreman

Assembly Operators	(10)
Line Inspectors	(4)
Sales/service technicians	(4)
Typist	

The lines of professional development are:

Assembly Operator to Line Inspector to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Line Inspectors to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components, and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

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L. TAPE RECORDERS - AUDIO, CAR CASSETTE, AND 'TWO-IN-ONE'

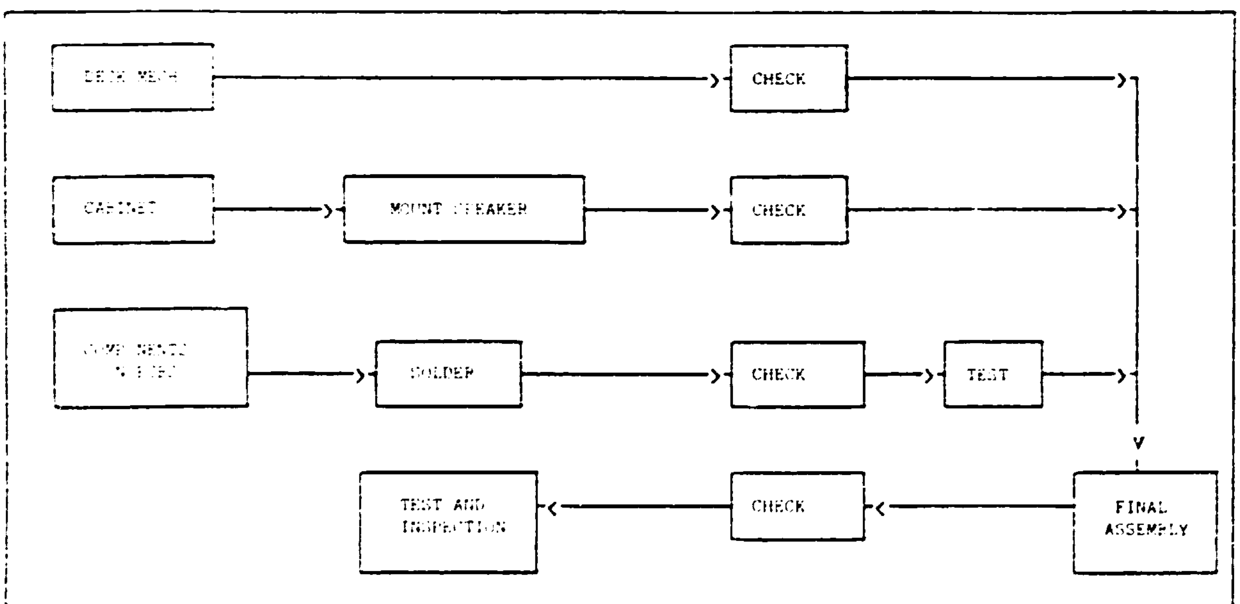
Introduction: This is a simple device for recording and reproducing sound through electro-magnetic means. A built-in microphone picks up the sound, converts it into an electrical signal, which is received by a magnetic head. The signal is recorded on a moving magnetically coated tape which when played past a second magnetic head reproduces the original sound made audible through a loudspeaker. Tape recorders come in different kinds: mono or stereo; car cassettes for use in the automobile; dictaphones primarily for speech. A popular version is to use it along with a radio ('two-in-one'), which besides the radio, also provides the facility to record internally from radio broadcasts.

Manufacturing Process: The tape recorder is a combination of mechanical assembly involved in the tape deck mechanism and the electronic circuitry for amplification and reproduction of sound. The tape transport mechanism which, basically, consists of a recording head, reproducing head and a micro-motor, may be imported since the audio quality of the device depends on the precision alignment of the heads and the constant speed of the motor under varying degrees of tension of the tape. At a later stage, the tape deck may be fabricated locally, although the heads and the motor may still have to be imported.

The electronic circuit is simple and the electronic components, which are transistors, resistors, diodes and transformer, are mounted on the Printed Circuit Board (PCB) and soldered. This is tested for amplification and frequency response characteristic. These are then assembled into the main housing, which is a plastic cabinet on which are fixed the built-in microphone and the loudspeaker or output to earphones. The final assembly is tested for both electrical characteristics -- frequency response, distortion, noise level -- as well as mechanical features such as flutter and wow. These are laid down in standard specifications, either national or the IEC.

In the case of the car cassette player, the speakers are separated from the main assembly to be fitted at the back of the car; further, the mounting needs to be vibration proof. For the two-in-one radios, a radio (usually one band or three band) is housed in the same cabinet along with an aerial attachment.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	6,000 Units	(Product mix will depend on the market)
Turn Over	$600,000	
Space Required	450 square meters	
	Work area	350 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:	Drilling Machine Shearing Machine Tools, Dies and Fixtures Stroboscope Insulation Tester Hand tools, soldering irons
Equipment:	Audio Oscillator Transistor tester Oscilloscope Output meter Distortion factor meter Stabilised power supply Wow and Flutter meter Test Tapes
Materials:	Tape Deck Mechanism Built-in microphone Plastic cabinet Loudspeaker Printed Circuit Boards Transistors Earphone jacks Capacitors Volume Control Resistors Ornamental front panel Diodes Connectors and cables

Cost: Machinery cost will be around $10,000; equipment cost will be $20,000, of which the most important items are Wow and Flutter Meter, Oscilloscope and Transistor Tester. These may be imported from USA or UK. Tape Deck mechanism may be obtained from Singapore, Hong Kong or Taiwan at the rate of $10 per piece for the simple mono-cassette recorder; for the more complex car cassette (with auto reverse feature) or for the 'two-in-one' recorder, the price of the Deck mechanism will be around $20 per piece.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Purchase Specialist	
	Testing Specialist	
	Shop Foreman	
	Assembly Operators	(10)
	Line Inspectors	(4)
	Sales/service technicians	(4)
	Typist	

The lines of professional development are:

Assembly Operator to Line Inspector to Shop Foreman or Testing Specialist
Sales/service Technicians to Purchasing or Testing Specialist
Line Inspectors to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components, and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months and upon introduction of any new products.

M. TV RECEIVERS - BLACK/WHITE AND COLOUR

Introduction: The assembly of TV receivers is complex, but has become now well standardised. Its investment is comparatively low and it is pollution-free. A B/W TV receiver will need as many as 400 components, while a Colour receiver may need about 800 of them. There is thus a 'spread' effect in the demand for components once the TV receiver manufacture gathers momentum. Manufacture of picture tubes and display devices is more complex and needs greater technological skill; their production becomes viable only in large volumes. TV receivers meant for the domestic market will have to conform to national transmission standards, but those meant for export markets may need to meet four different standards: PAL, SECAM, NTSC and CCIR.

Specifications:

A B/W TV Receiver has the following characteristics:

- A fully solid state design using integrated circuits (ICs), transistors, which makes for reliability, stability and durability;
- Low power consumption;
- Picture tube that uses no power when the set is off;
- Automatic gain control (AGC) to keep out RF interference from automobiles and low flying aircraft producing 'snow' and flutter;
- VHF and UHF tuners that 'lock' onto the specified frequencies;
- Regulated power supply which gives good picture with fluctuating AC voltages;
- CATV/MATV for Cable TV or Master Antenna hook-up

A Colour TV Receiver has the following characteristics in addition:

- In-line gun, slotted mask and black matrix for better contrast and brighter colour;
- Auto Colour/AFT (Automatic Fine Tuning) adjusts automatically the picture for colour and tint;
- Automatic de-gaussing to prevent magnetically caused colour distortion

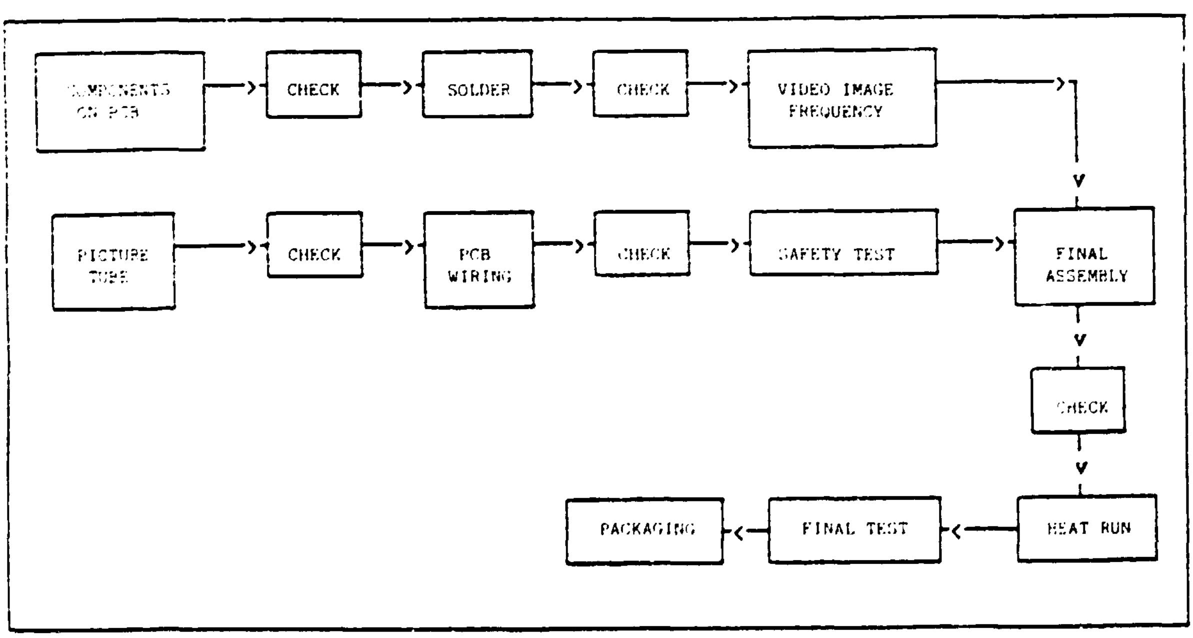
Manufacturing Process: Both B/W and Colour TV receivers use a sequential assembly system. Initially, with low volumes of production, this can be done manually; later, a conveyor belt may be used. In the preliminary process, components are tested, formed, handled and insulating tubes are inserted. (These steps are labour intensive and require patience.) Various resistors, condensers, coils and transformers are mounted on the PCB, followed by inspection.

ICs and transistors are then fixed on the back of the PCB and soldering is done by an auto-soldering machine. The assembled PCB is adjusted for VIF (Video Intermediate Frequency) and AIF (Audio Intermediate Frequency) to make the picture and sound adjustments.

The wiring is then taken up; a tuner and VR are connected to the PCB assembly and after inspection, is followed by a second VIF adjustment. It is then moved to the finishing section for the final assembly inside the cabinet in which are already fixed a Speaker, Picture Tube and mask element. The assembly then undergoes an adjustment of the deflection yoke and a final inspection of its frequency and insulation with its backplate fixed, where the aerial connections are made and adjusted. Hazards due to high tension on the controls (due to faulty insulation in the fly-back HT transformer) or due to picture implosion are tested according to the IEC standards.

Final packaging is important due to the fragile nature of the product, particularly to avoid damage to the surface of the picture tube; operating instruction and guarantee card are inserted before the set is finally sealed with appropriate markings for delivery to the dealer or for export abroad.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (annual)	10,000 B/W TV Receivers	
	4,000 Colour TV Receivers	
Turn Over	$1.8 million	
Space Required	1,500 square meters	
	Work area	800 square meters
	Store	500 square meters
	Office	200 square meters

Machinery:

Soldering Stations
Hot Stamping Machine
Temperature controlled oven
Painting Equipment
Spot Welder
Tapping Machine
Power Press
Grinding Machine
Drilling Machine
Shearing Machine
Tools, Jigs and Fixtures

Equipment:

VHF Sweep Generator
Alignment Scope
Colour TV Pattern Generator
Colour Analyser
VTVM (with HT probe)
Audio Power Output Meter
LCR Bridge/Q-Meter
Wide band oscilloscope (350 MHz)
Power Supplies (2)
Audio Distortion meter
AC Milli-voltmeter
AM/FM Signal Generator
Function Generator
Wave Form Monitor (625 lines)
Insulation Tester
IC Tester
Variacs
Centralised Signal System (if production is above 100,000 sets annually)

Materials and Sub-assemblies:

TV Picture Tube
Cabinet
Tuner
Deflection Components
Transistors and Diodes
Capacitors
  Plastic Film, Electrolytic, Ceramic
Resistors
  Carbon Film, Wire Wound
Potentiometers
Loudspeakers
Printed Circuit Boards
Hardware Items

Cost: To start with, components may be imported in CKD form which consist of all the components, including picture tube; they are available for $35 per kit for a B/W Receiver (12"-14") and $100 for a colour receiver (20") from

Korea or Taiwan. While production of Colour receivers may need to continue on this basis due to low demand, many components for a B/W receiver, such as the deflection components, PCB, speaker, plastic and metal parts, can be produced in-house or sub-contracted locally when production of such items is established in the country.

Cost of machinery required for production will be around $50,000, depending on the extent of 'in-house' production planned. Cost of test equipment will be around $50,000, of which the more important are:

VHF Sweep Generator
Colour TV Pattern Generator
Colour Analyser
AM/FM Signal Generator
Oscilloscope
Wave Form Monitor (625 lines)
Q-Meter

With larger volumes of production, a Centralised Signal System may become necessary.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist	(8)
	Shop Foreman	(2)
	Assembly Operators	(20)
	Sales/service technicians	(6)
	Administration	(6)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Testing Specialist
Skilled Worker to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

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N. HEARING AIDS/AUDIOMETER

Introduction: A Hearing Aid is a device to compensate for auditory deficiency in a person who is hard of hearing; it is now recognized that the number of such persons is much larger than was thought at one time. To detect such deficiencies, the Audiometer is used to plot the hearing effectiveness of the person over the speech frequency. Thus these two devices will find wide application in hospitals and clinics and by those whose hearing is impaired.

Product Description: A hearing aid is basically an amplifier of sound and consists of an earphone, microphone and an amplifier. The microphone converts the sound signals to electric impulses which are amplified and fed to the ear plug which reconverts them to sound waves to stimulate the auditory nerves of the ear. The amplifier is housed in a compact box which is carried in the pocket; with recent trends in miniaturisation, it is now common to house the amplifier on the spectacles, and worn behind the ear. To avoid positive feedback which can cause distracting noise, the ear plug must be firmly inserted in the ear mould. Hearing aids are also fitted to telephone receivers to enable deaf people to converse easily on the telephone. They may also be mounted on the table for use in discussions.

The Audiometer is an instrument which feeds signals at various frequencies into the ear and measures the response of the ear to them. This provides a clear indication of the defect, if any, in the auditory system. The instrument is thus an oscillator/output device and the response is measured by varying the level to determine the threshold of audibility.

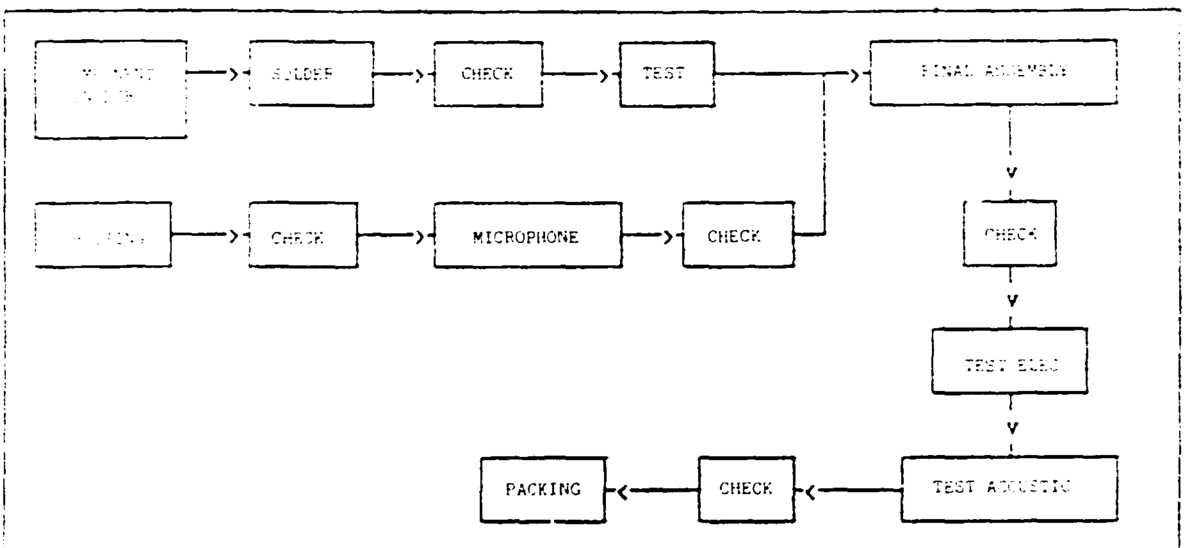
Typical Specifications of a Hearing Aid are as follows:

Minimum Output	50 db
Maximum Output	122 db
Power consumption	5 mW
Approx. dimension	6 x 4 x 1.6 cm
Approx. weight	50 gms.

Manufacturing Process: Various components such as capacitors, transistors and resistors are mounted on the printed circuit board (PCB). They are then soldered and checked. Volume control and earphone sockets are mounted on the PCB. The microphone is mounted inside the case on foam rubber to avoid hissing and crackling noise due to vibration. These are then placed in a plastic or metallic housing. The front grille is perforated to enable sound waves to reach the microphone. A battery container is also mounted on the box. To begin with, the microphone and earphone can be bought locally or imported. After the final assembly, the finished product is tested to see that the electrical and acoustical characteristics conform to the standard specifications.

With the help of Audio Signal Generator, Oscilloscope and Output Meter the frequency response, fidelity, distortion and phase shift are tested. The acoustical tests are carried out in a 'dead' room which is suitably treated with acoustical materials to prevent any reverberation of sound. For this purpose, an artificial head and a sound level meter are required. The assembly of the Audiometer is simple: various components are mounted and soldered on the PCB. The assembly is then tested for several characteristics such as stability, noise, input and output impedances, frequency response, gain and distortion.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	5,000 Hearing Aids	
	200 Audiometers	
Turn Over	$350,000	
Space Required	300 square meters	
	Work area	250 square meters
	Office/Store	50 square meters
Machinery:	Bending Machine	
	Hand Press	
	Drilling Machine	
	Injection moulding machine (if production of housing is planned)	
Equipment:	Audio Signal Generator	
	Output meter	
	Distortion Factor meter	
	Oscilloscope	
	Acoustic Chamber	
	VTVM	
	Multi-meter	
	Sound Level Meter (Precision)	
	Artificial Head	

Materials:	Foam Rubber/plastic Transistors, Resistors, Capacitors Input/output transformers Potentiometer Sliding Switch 1.5 V batteries PCB Plastic or metal housing Ear phone Connecting cord

Cost: Cost of machinery is likely to be around $5,000, while equipment costs will be about $10,000. Most of the components may be imported in a kit form consisting of the PCB, ear plug, microphone, volume control and housing cabinet. These cost $20 per kit and are available from Korea and Taiwan. At a later stage, some of the components such as the PCB, housing and plug may be made in-house or sub-contracted locally.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist	(2)
	Shop Foreman	
	Assembly Operators	(4)
	Skilled Workers	(2)
	Sales/service technicians	
	Administration	(4)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
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Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

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O. DIGITAL METERS

Introduction: Digital Panel Meters and Multimeters are widely used in almost all electronic circuits for measuring voltages, current and resistance. Modern industry needs a large number of such instruments for control and monitoring purposes. Hence, there is likely to be a sizeable demand within the country for such items; there may also be a good export potential for them.

Product Description:

A Digital Panel Meter is basically a voltage measuring device. It consists of analog switches, integrator, comparator and control circuits with display unit. These find wide application in industrial plants such as refineries and fertiliser units.

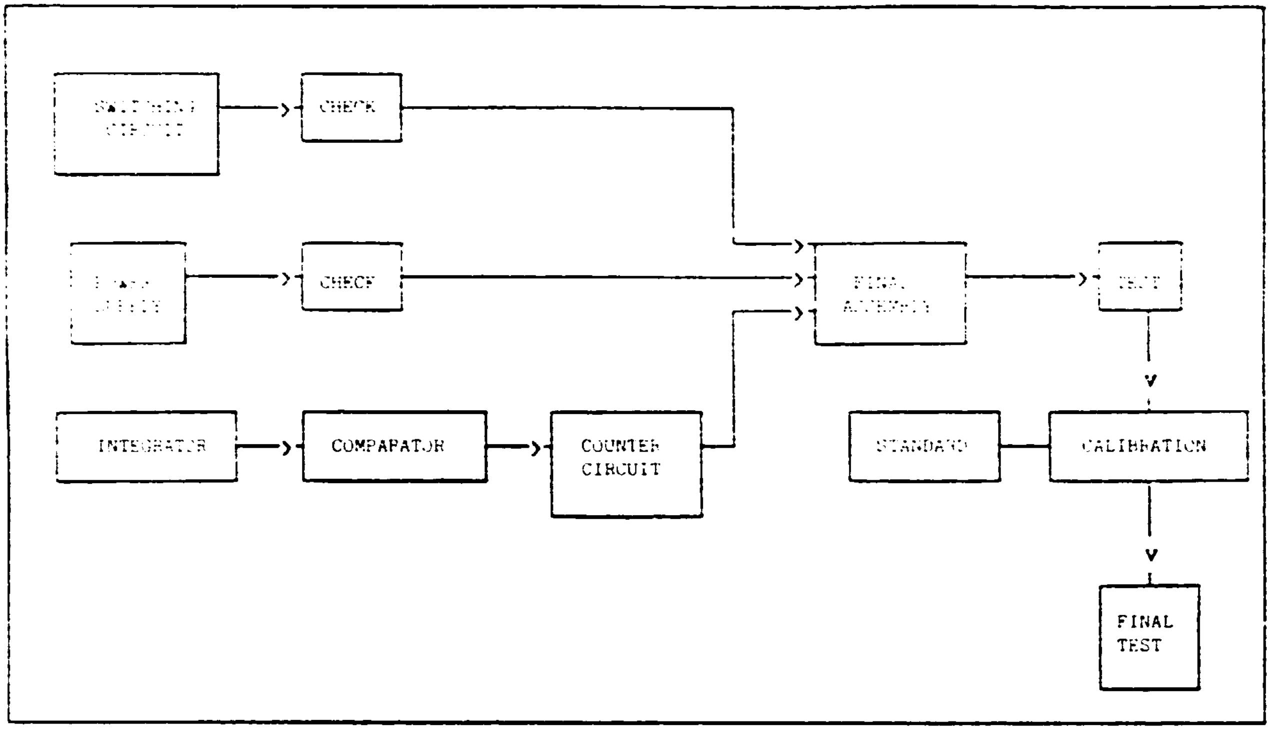
A Digital Multimeter is a device to measure voltage, current and resistance of any circuit. The basic principle is to convert analog signals to equivalent digital pulses. First, the signal passes through a converter which generates corresponding DC voltages. These are then passed on to two different types of circuits -- one responding to the rms values, and the other to averages. Logic and display circuits are then employed to give the reading. This equipment finds wide use in industrial automation, defence and precision electronic measurements.

Manufacturing Process:

Digital Panel Meters: Various electronic components such as resistors, capacitors and transistors are soldered on the printed circuit board (PCB). Sub-assemblies of power supply, switching circuit, integrator, comparator and counter circuit are assembled and tested for accuracy, resolution drift, operational amplifier characteristics, input impedance, etc. The output is checked on a jig fitted with nixie tubes. Standard voltages are fed to the input circuit and is again calibrated and tested.

Digital Multimeter: Electronic components such as resistors, capacitors and special purpose transistors are soldered on double-sided printed circuit board. The sub-assemblies are tested for voltage range, input range, accuracy, input impedance, display rate, output, frequency range, etc. It is connected to nixie tubes, LEDs or other electronic displays which are fixed on a cabinet. This is again tested by feeding standard voltages. It is tested to obtain accuracy of ± 0.1%.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	500 Digital Panel Meters	
	500 Digital Multimeters	
Turn Over	$300,000	
Space Required	400 square meters	
	Work area	300 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:

- Drilling Machine
- Shearing Machine
- Bending Machine
- Instrument Lathe
- Dies, Jigs and Fixtures, etc.

Equipment:

- Oscilloscope
- Signal Generator
- Multimeter
- LCR Bridge
- Standard Voltage for calibration
- Time mark generator

Materials:

- PCB
- COS/MOS switches
- Seven segment nixie tubes
- Electrolytic capacitors
- Ceramic capacitors
- Low leakage transistors
- Zener diodes
- Switching transistors
- Wires and other hardware

Cost: It is possible to import kits containing the housing, display device, PCB and ICs and do the assembly within the country. The kits are available for $40-100 per piece from Korea and Taiwan. Subsequently, items such as the PCB assembly can be done in-house. Display devices and ICs will have to be imported, while cabinets may be sub-contracted locally.

Cost of machinery will be around $20,000, and equipment costs will also be around $20,000, of which the Standard Voltage required for Calibration, the Oscilloscope, the Signal Generator and the LCR Bridge are the most important.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialists	(4)
	Shop Foreman	
	Assembly Operators	(10)
	Skilled Workers	(4)
	Sales/service technicians	(2)
	Administration	(4)

The lines of professional development are:

Assembly Operator to Skilled Worker to Shop Foreman or Testing Specialist
Sales/service Technicians to Testing Specialist
Skilled Worker to Testing Specialist or Shop Foreman
Shop Foreman to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components, and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

Attention to quality control is critical when selecting supervisors, inspectors and technical employees. The design of adequate programs may require the use of outside consultants for original testing schemes. Review of the processes must occur periodically for static products (every 3-6 months) and upon introduction of any new products.

P. TELEPHONE INSTRUMENT

<u>Introduction</u>: The telephone has become one of the versatile tools of modern life for communication in business and social activities. Basically, a telephone instrument consists of a transmitter and receiver which is able to reproduce human voice. For intelligibility, it is adequate if the frequency limit for reproduction is up to 3 KHz. The assembly of the instrument is labour-intensive.

<u>Product Description</u>: In many countries, the telephone network is operated by a government agency which prescribes the specifications for the telephone instrument. Typical specifications of such an instrument are as follows:

- Transmitter sensitivity must be 52 $\pm$ 6 db at 1 KHz.
- Dynamic impedance of the transmitter is 20-60 ohms at 1 KHz.
- Continuous noise in the transmitter must be less than -90 db.
- Receiver sensitivity is 71 $\pm$ 6 db at 1 KHz.
- Impedance of the receiver is 160 $\pm$ 50 ohms.
- Impedance resistance of the receiver between coil terminal and protective panel must be more than 50 meg-ohms.
- Average impulse speed is 10 $\pm$ 0.8 pulses per second.
- Call initiated either through dialing or push-button.
- Other specifications relate to weight, resistance to shock, resistance to wear, etc.

<u>Manufacturing Process</u>: Manufacture of the telephone instrument can be merely an assembly-oriented operation with purchase of metallic and plastic parts and electronic components. Investment will be in land and buildings, as well as test equipment. Initially, all of the parts may be imported in kit form, but at a subsequent phase, some of the plastic and metal parts may be made in-house or sub-contracted locally.

Assembly is carried out through three lines. The first assembles and tests the induction coils and springs. The second assembles the housing, handle and rubber or plastic items. The third assembles other items such as levers, base plate and terminals, as well as the final assembly.

The manufacturing process for some of the parts is given below:

<u>Housing</u>: Thermo-plastic resin is formed into the required shape through an injection moulding machine. Adjustment of operating parameters such as time, temperature and pressure is vital for the process. The working conditions prescribe a cooling time of 50-80 seconds, temperature of 180-190 C at the middle of the screw, and pressure of 70-80 kg/sq.cm. Colour is determined separately.

<u>Hook Switch</u>: This is also made through injection moulding, operating conditions being 20-30 seconds, temperature of 190-220 C, and primary injection pressure of 90-100 kgs/sq.cm.

<u>Levers</u>: These are made through a plunger type die casting machine using a four cavity die casting mould from aluminum melted in a furnace at 650 C. Cooling time is 40-50 seconds and casting pressure is 650-770 kgs/sq.cm.

Base Plate: Mild steel is used as raw material and pressed in a shearing machine and 50 ton eccentric press, performing cutting, shearing, boring, drawing and embossing.

Terminal and Pin Parts: Material used is copper plate or copper alloy and the equipment is a high speed press simultaneously performing shearing, cutting and boring. The precision mould is used to punch 1 to 3 pieces at one time depending on the form of the components.

Iron Core: This is made from an iron bar with a circular sawing machine and an automatic bench lathe.

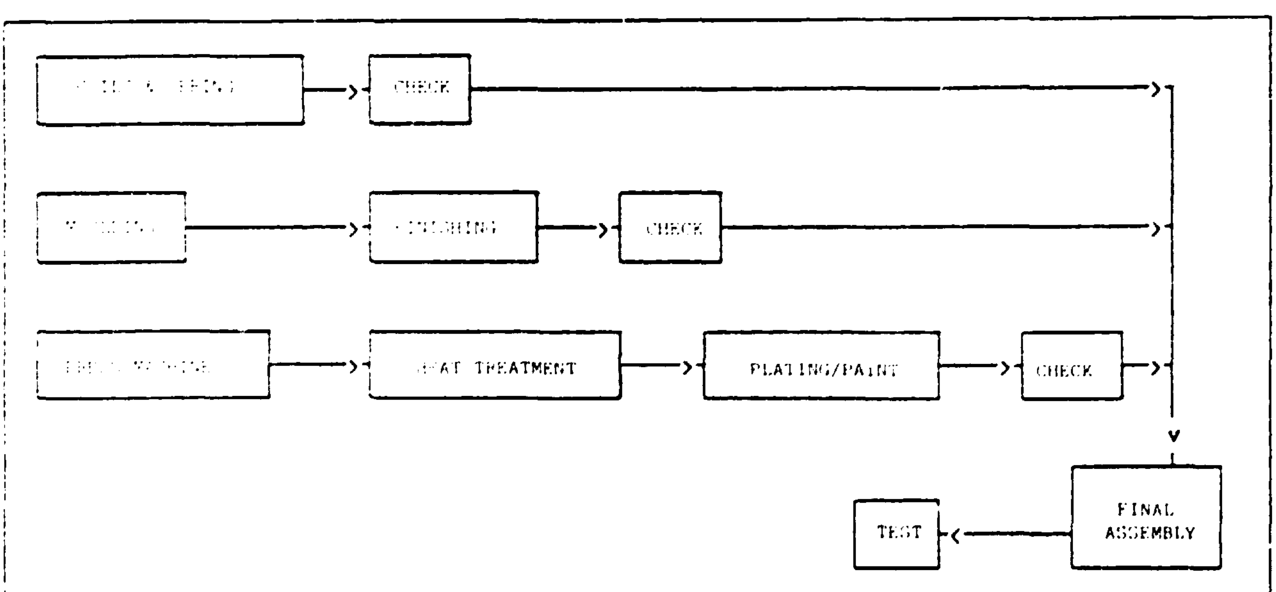
Heat Treatment: This is done in a chamber furnace (21 KVA) with temperature at 850 C for [illegible] hours. It is then cooled to 350 C in the furnace and the products are then taken out for cooling to room temperature. Care must be taken not to let oxidation occur on the surface of the product while working.

Surface Treatment: A PVC lined tank is used and the plating liquid is made by blending NHSO4NiCl2 and H3BO3. Working conditions such as reaction temperature, pH and electric currents at the cathode and anode are important. Process includes degreasing, hydro-chloric acid treatment, copper plating and semi-dull nickel plating completed with hot water drying.

Spot Welding: An automatic spot welding machine is used. The material used is 1.6 mm diam. alloy wire for cutting, spot-welding and forming into an appropriate spot size.

Winding: Product is fixed in a winding jig holder and the required number are wound as registered on the counter. The resistance meter is set at 1000-1500 ohms. After winding, coil resistance is measured on a Wheatstone Bridge and changes in resistance are measured through temperature difference.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	100,000 sets per year
Turn Over	$2.5 million per year
Space Required	500 square meters if only assembly is undertaken, otherwise, a much larger area - 3,000 square meters - will be required.

Machinery:

Injection moulding machine
Crusher
Shearing Machine
Eccentric Press
Drilling Machine
Tapping Machine
Bench Lathe
Engine Lathe
Furnace Chamber
Sawing Machine
Rectifier
Air Press
Die Casting Machine
Transformer
Tools, Jigs and Fixtures

Equipment:

Automatic telephone Test Set
Side tone attenuator Tester
Tension Gauge
Sensitivity Tester
Maxwell Meter
Breakdown Voltage Tester

Materials:

Dials/Push Button Assemblies
Receiver and Transmitter Capsules
Ferrite Magnets
PCB
Enamelled Copper Wire
Resistors and Capacitors
Hardware - Levers, Pins
Housing

Cost: If kits are used to start production, they may be imported for about $12 per piece from Korea or Taiwan. Cost of machinery if production of metal and plastic parts is taken up is likely to be around $800,000; depending on the actual products made, equipment costs will be about $100,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:

Production Manager	
Testing Specialist	(8)
Shop Foreman	(2)
Quality Control Manager	
Machine Operators	(12)
Assembly Operators	(50)
Skilled Workers	(10)
Sales/service technicians	(4)
Administration	(6)

The lines of professional development are:

Assembly Operator to Skilled Worker or Machine Operator
Sales/service Technicians to Testing Specialist
Skilled Workers to Testing Specialist or Shop Foreman
Shop Foreman or Quality Control Manager to Production Manager

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and shop foreman, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

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Q. LOUDSPEAKER ASSEMBLY

Introduction: The loudspeaker is an important component used to convert electrical power into acoustic energy. It is used in many consumer electronic products, such as Radios, TV sets, Tape recorders, Record Players, etc.

Product Description: Loudspeakers range widely in quality and specifications. In High Fidelity Systems, the speakers are required to reproduce a wide frequency range up to 20 KHz, while in low-cost applications the frequency limit is up to 6-8 KHz, and in the horn systems used for public meetings and sports functions up to only 3 KHz. In this description, two types of speakers are described:

- High Fidelity Loudspeakers of round and oval shapes and sizes 30 cm x 6 cm with response up to 18,000 KHz and flux densities of the order of 10,000 Gauss;

- General purpose speakers of round and oval shapes with frequency response from 3,500 c/s to 10,000 c/s and powers up to 10 watts.

In both cases, the speaker consists of a paper cone which is activated by a voice coil into which are fed the electrical signals that are required to be reproduced. A magnet (usually ferrite) is used to set up the magnetic field on which are superimposed the electrical signals. The paper cone, held by a metallic frame (usually known as the 'basket') moves in response to the variations of the magnetic field and produces sound waves audible to the human ear. The quality of the speaker is dependent on the quality of the paper cone, the voice coil and the strength of the magnetic field.

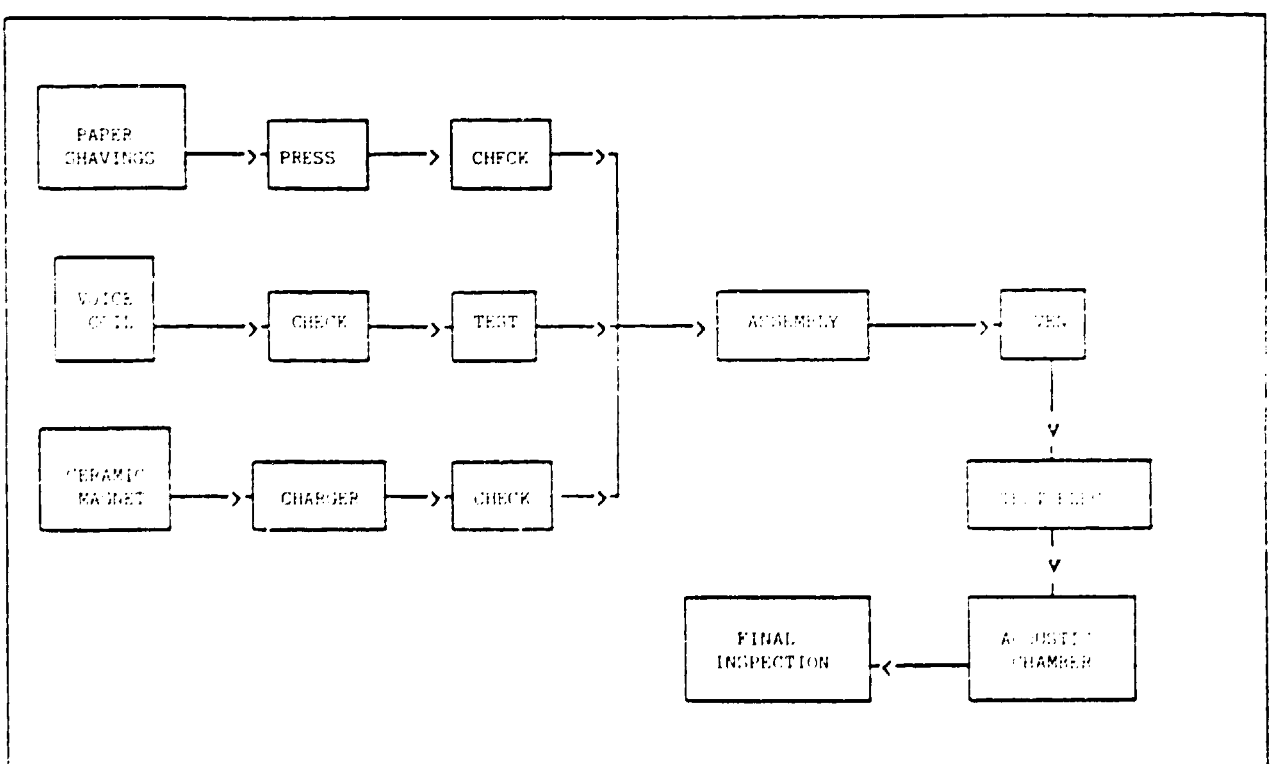
Manufacturing Process: It is possible to buy most of the components initially, but it is possible to make them in-house at a later stage. The paper cone is made from special paper shavings which are mixed together and moulded into a paper cone of the required shape and size in a 10 ton press. However, it is preferable to buy locally or import them. The Voice coil is made separately by fixing the core on a winding machine and winding enamelled copper wire of the required gauge on it. The permanent magnet is bought, but can be made in-house by magnetising the soft iron core on magnetising equipment. The voice coil, basket, and the paper cone are fixed on the yoke and spider assembly with special adhesives. The rubber lining is placed along with the edge of the basket. Leads are taken out to each terminal eyelets.

The final assembly is tested for:

- Impedance, Frequency Response, Non-linear distortion, Output, insulation.

For the acoustic tests, a specially treated 'anechoic' (reverberation-free) chamber is required.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	200,000	
Turn Over	$300,000 (depending on product mix)	
Space Required	400 square meters	
	Work area	300 square meters
	Store	50 square meters
	Office	50 square meters

Machinery:

Coil Winding Machines (2)
Welding Machine
Riveting Machine
Magnetiser
Temperature controlled Oven
Drilling Machine
Buffing/Grinding Machine
Tools, Jigs and Fixtures

Equipment:

Audio Oscillator (BFO)
Amplifier with Stereo Player
Audio output Meter
Sound Level Recorder
Resonant Frequency tester
Wow and Flutter Meter
LCR Bridge
Multi-meter
Acoustic Analyser
Anechoic Chamber
Noise Generator

Materials:

Enamelled Self-bonding copper wire
Paper Cone
Ceramic/Permanent Magnet
Metal Yoke
Braided wire, special rivets
Adhesives

Cost: Cost of machinery will be about $20,000, and that of Test equipment around $30,000, of which the Acoustic Analyser (with monitor), Sound Level Recorder, Resonant Frequency Tester, Wow and Flutter Meter, Audio Oscillator and Noise Generator are the more important pieces. Most of the equipment may be imported from USA, UK, Japan, West Germany, Sweden or Denmark.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Machine Operators	(2)
	Testing Specialists	(4)
	Assembly Operators	(4)
	Administration	(3)

The lines of professional development are:

Assembly Operator to Machine Operator or Testing Specialist
Machine Operator to Testing Specialist

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and skilled workers, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of a manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components, and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

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R. REGULATED POWER SUPPLIES

Introduction: Regulated power supplies are essential equipment in various organisations such as production units, R&D establishments and educational institutions. They can be Automatic Voltage Stabilisers which supply a constant AC output with fluctuating inputs, or DC Regulated Power Supply which provide fixed or variable DC voltages as required for the electronic circuit.

Product Description:

An Automatic Voltage Stabiliser adjusts excessive fluctuations in line voltage (common in many developing countries) to tolerable limits. In a typical case, input voltages may vary between 160-260 V, while the output is between 220-240 V. The constant output voltage is independent of the load without introducing harmonic distortion. Stabilisers were formerly controlled by servo-motors, but it is now common to employ electronic switching circuits for greater reliability and speed of operation.

A DC Regulated Power Supply provides constant voltages to other equipment such as amplifiers, electro-medical equipment and for various test purposes. This can be $\pm$ 5 V required for testing ICs or other voltages required for the particular circuit. It mainly consists of a line transformer which steps down the line voltage (220 V or 110 V) to the required value, rectifies it and then regulates it with respect to line or load variations. This equipment is essential in a wide variety of applications.

Manufacturing Process:

Automatic Voltage Stabiliser: The assembly operation can be divided into three sub-assemblies:

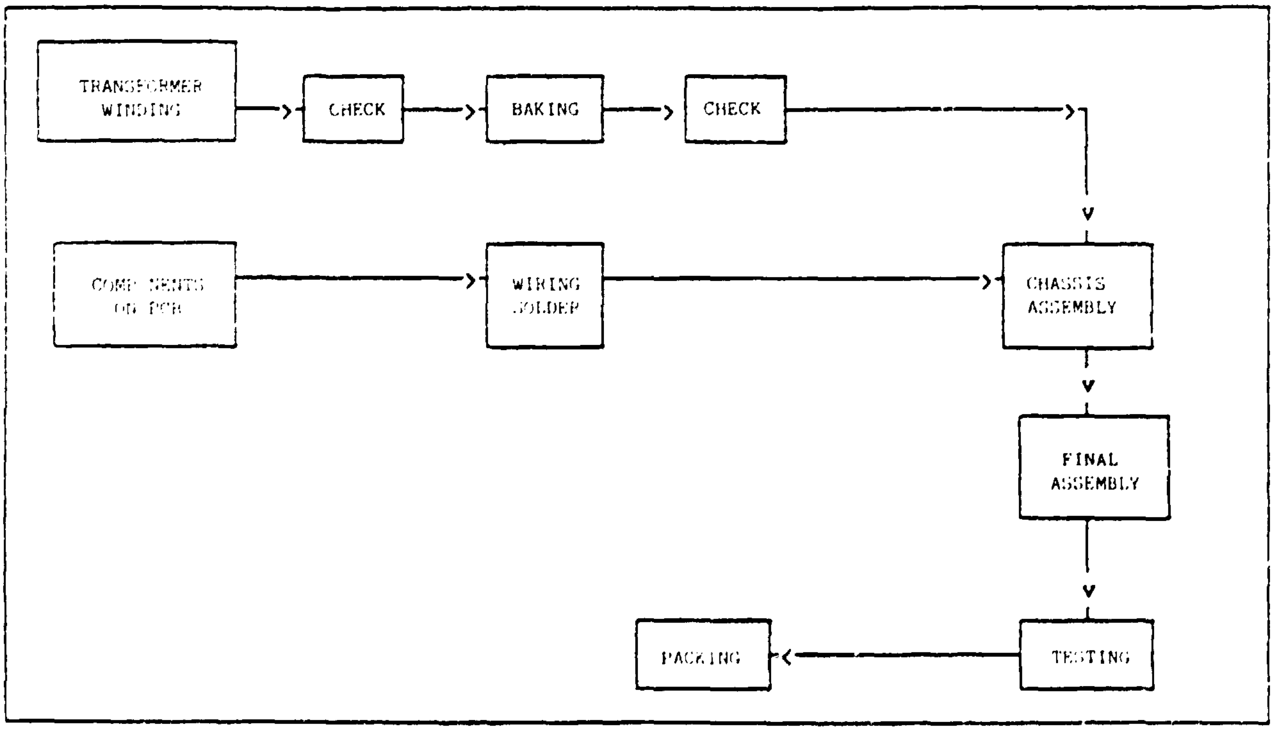
The first part consists of assembling various electrical and electronic components and electro-magnetic relays to form a circuit which operates the relays to choose the appropriate tappings of the transformer to supply the desired output voltage, when the input voltage varies within certain limits. The setting of the relays is done at different voltages to get the desired operation. Electronic circuit is based on the switching principle of transistors.

The second operation is the assembly of the transformer, which essentially consists of winding and core. The required number of primary and secondary turns are wound on the bobbin. Tappings are taken out from the secondary winding at the proper number of turns. The coil is then heated and impregnated with varnish at a suitable temperature. The core is then fitted into the coil and clamps are fixed on the core.

The third operation is the final assembly of the transformer and the electronic circuit on the chassis. The assembly is then checked for its performance according to the standard specifications.

DC Regulated Power Supply: The fabrication is similar to the Automatic Voltage Stabiliser, except for an additional stage of rectification to convert it from AC to DC voltages. The electronic components such as resistors, electrolytic capacitors and transistors are mounted on a PCB which is wired and soldered. The transformer is then mounted, and the total assembly is fixed on a chassis and housed in a metal cabinet. The final assembly is then tested for ripple, stability, temperature coefficient, etc., according to the standard specifications or customer requirements.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	Automatic Voltage Stabiliser - 9,000 DC Regulated Power Supply - 1,000
Turn Over	$250,000
Space Required	400 square meters
Machinery:	Transformer Winding Machine (Semi-automatic) Impregnating Tank Baking Oven Drilling Machine Bending Machine Instrument-maker lathe
Equipment:	Cathode Ray Oscilloscope Multi Meter (Digital) Audio Generator LCR Bridge Test Bridge HT Test equipment Megger Variacs
Materials:	Chassis Dial Plate Relays Volt meter Transformer Stampings Indicator Lamp Bridge Rectifier Transistors Resistors Electrolytic Capacitors PCB Enamelled copper wire Knobs, plugs, socket, PVC sleeves Joggle switches and other hardware

Cost: Manufacture can be started with voltage Stabilisers imported in a CKD form. This consists of an auto-transformer, relays, voltmeter, transistor, diodes, resistors, capacitors, PCB, cabinet and other accessories. The cost of the kit will be about $12 and may be imported from Hong Kong, Korea or Taiwan. Later, the transformer, cabinet, PCB, metal parts, can be made in-house or sub-contracted. The cost of machinery is about $10,000, and that of the Test equipment around $20,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:		
	Production Manager	
	Testing Specialists	(4)
	Assembly Operators	(6)
	Machine Operators	(6)
	Sales/service technicians	(2)
	Administration	(4)

The lines of professional development are:

Assembly Operator to Machine Operator or Testing Specialist
Sales/service Technicians to Testing Specialist
Machine Operator to Testing Specialist

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

Skills required for assembly are simple and require a week's training on the job; for testing or inspection specialists and machine operator, a vocational school background is necessary, while the Production Manager should preferably have a diploma in Electronics. Sales/service technicians can receive job specific training on the job, but should have a background in one or the other subject from prior experience.

Quality Control: In the field of electronics, quality control is particularly important. The reason for this is that deviation from quality standards more often than not leads to catastrophic failure rather than reduced performance. The acceptance of a product, and indeed, the credibility of : manufacturer, hinges on adequate quality control. This control must be maintained throughout the manufacturing or assembly process. Tests must be made on all components which are sourced from outside the company. The final product is no better than the worst of its components, and continuous testing is necessary to assure that the supplier has not slipped in his quality control processes. All products must have a formal process which tests the product and its subassemblies at logical points during manufacture so that corrections can be made, or the manufacture aborted.

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S. WIRE-WOUND RESISTORS

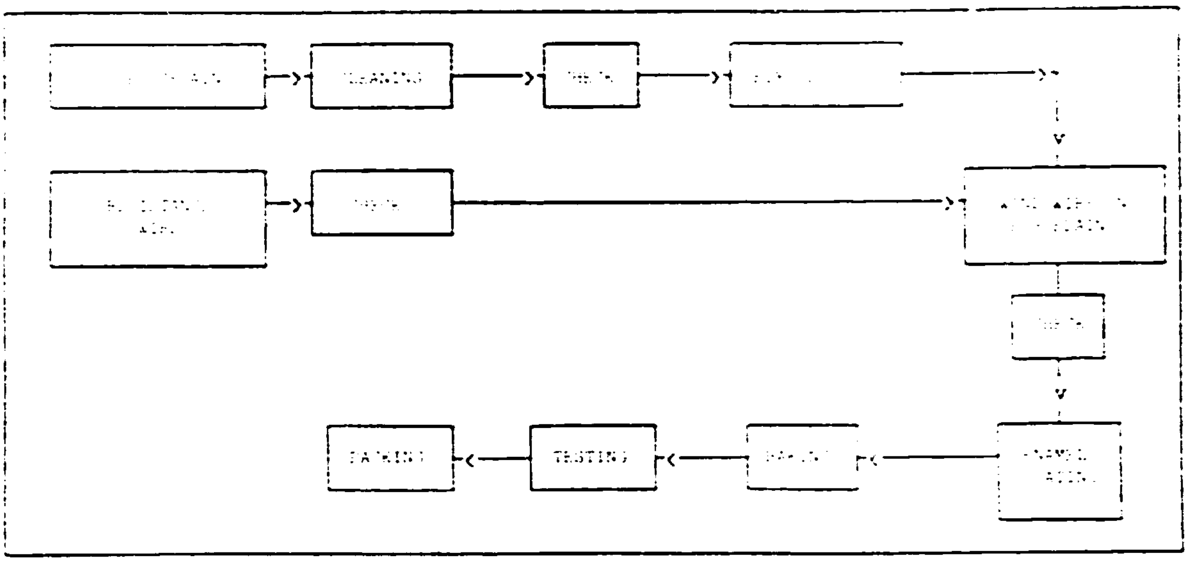
Introduction: Wire-wound resistors find extensive application in radios and also as meter shunts, ratio-arm resistor in Wheatstone Bridge, and various other electronic equipment where stability of the calibration is essential. They are also employed in circuits where high power dissipations are involved.

Product Specifications: Typical specifications of Wire-wound resistors are as follows:

Range	10 ohm to 47 K ohms (3 Watts to 10 Watts)
Tolerance	+ 5%
Temperature Range	55° C to 200° C
Temperature Coefficient	0.2 per 0° C (max.)
Insulation Resistance	Minimum 500 Meg Ohms at 500 V DC -- can withstand 1,500 V DC or AC peak.
Load Stability	Does not change more than 5% after 1,000 hours of intermittent full rated load at 70° C.

Manufacturing Process: Porcelain pipes are cut to the required size and cleaned. The brass nickel, silver clamps are fixed on the ends. Nichrome or other resistance wire of required gauge is then tested to the specification. The ends of the resistance wire are soldered with the clamps on both the ends of the porcelain pipes. The resistors are then given a coat of vitreous enamel and baked in a furnace. The process is repeated two or three times for perfect insulation. They are finally tested on a random sampling basis against the standard specification.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity (Annual)	3 million Wire-Wound Resistors
Turn Over	$300,000
Space Required	500 square meters
Machinery:	Coil Winding Machine High speed cutting machine for cutting porcelain tubes Spot welding transformer [illegible] Muffle Furnace Hand shear Double end bench grinder Baking oven Power Press Power operated stirrer for enamel preparation Drilling Machine Shearing Machine
Equipment:	Wheatstone Bridge Multi-meter Load tester consisting of various rheostats Ammeter Voltmeter Q-meter

Materials:	Nichrome Wire Porcelain/ceramic tubes Vitreous enamel powder

Cost: Cost of machinery will be about $20,000. Test equipment will be about $15,000.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist	(4)
	Skilled Workers	(10)
	Sales/service technicians	(4)
	Administration	(4)

The lines of professional development are:

Skilled Worker to Testing Specialist
Sales/service Technicians to Testing Specialist

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

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T. PRINTED CIRCUIT BOARD

Introduction: In recent years, the Printed Circuit Board (PCB) has become the standard base for the wiring of all electronic circuits and hence is an essential accessory for any electronic industry. The simplest type is the Single Sided Board, followed by Double Sided with Plated through Holes (PTH) and Multi-layer Boards, in order of complexity.

Product Description: A Printed Circuit Board consists of an insulated material such as Fibre mat or Fibre-glass impregnated with a thermo-resin binder such as Paper or Glass epoxy. PCBs can also be classified as rigid or flexible. The rigid types can be single, double or multi layered; the flexible types consist of a number of conductors between two or more layers. Initially, single and double layer types can be taken up for production.

Manufacturing Process: Single Sided Boards are simplest to manufacture. Art work is prepared first according to customer requirements; usually it is 4 to 30 times larger than the final size. This is then photographed using special graphic line film to give a sharp focus. The image is then transferred to a copper clad laminate which has been cleaned well and coated with a photo-sensitive resist using one of the three methods: Screen Printing, Wet Process or Dry Film System. Screen Printing is the cheapest method, but does not ensure sharpness of lines, and the quality depends on the skill of the individual printer. Semi-automatic or Automatic Screen Printing machines are also available, depending on the volume of production.

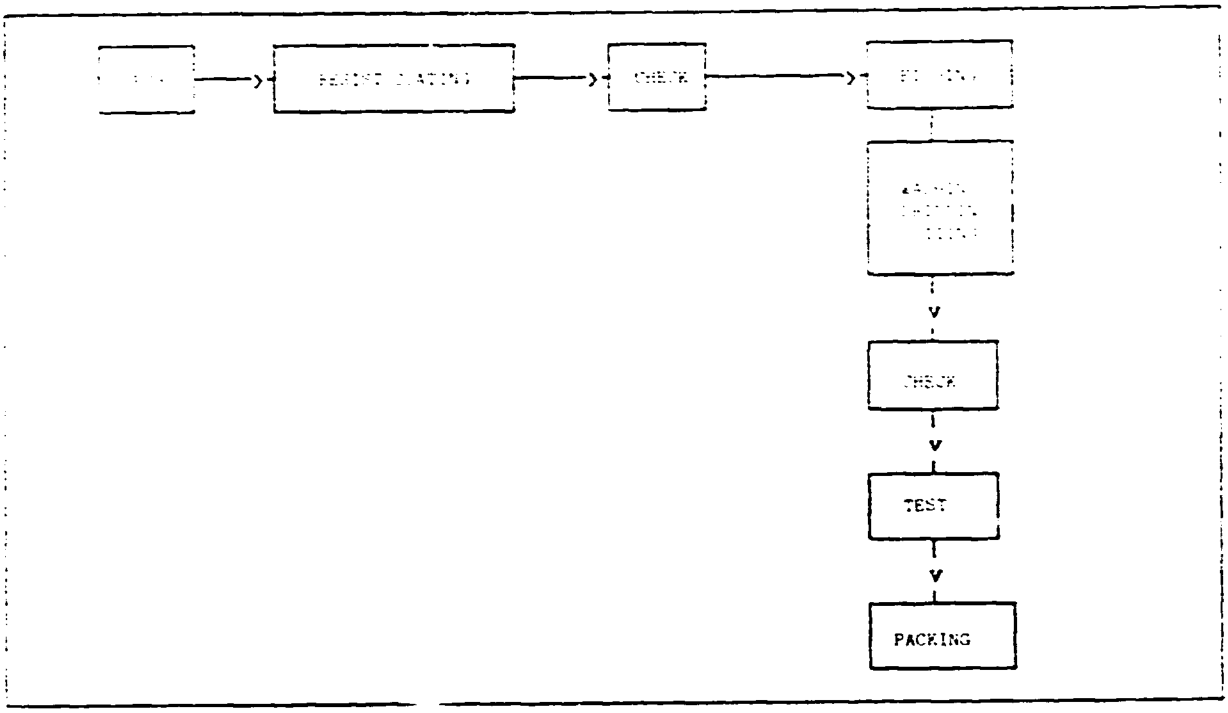
After printing, the board is plated in a tin bath or tin/lead bath; alternatively, it can be passed through a roller-tinner in which the tracks are coated with tin/lead. The quality of the roller tinned boards is not high, but it is cheaper and faster, and quality is generally acceptable for the entertainment electronics field. After the plating process, the extra copper in the PCB which is not plated is etched. Before etching, it is necessary to remove the ink, which is done by a suitable solvent depending on the ink used. The etching is done with various solutions such as Ferric Chloride, chromic-ammonia, etc.

After the board has been etched and dried, holes are drilled for the insertion of components. Drilling machines used vary from single-spindle, low-speed to high speed and very high speed (45,000 rpm) and NC controlled multi-spindle machines. For single type boards, punches using presses and tools can also be used.

The boards are finally cut to size, for which various methods such as slitting saws, shears and, now, lasers are employed. Connecting fingers are plated with nickel or nickel and gold. For cutting contours, Routing Machines are available.

Double Sided Plated through Hole Boards begin as glass epoxy sheets with copper cladding on both sides. The process starts with drilling the holes to be plated through; the diameter selected for the drill is slightly larger than the size of the final holes required. After the holes have been drilled, deburred and polished, if necessary, using Silicon Carbide, the boards are sent to the plating solution for electrolytic plating. This is a carefully controlled process where Nickel/Platinum is deposited in the holes; thereafter, the thickness of the copper inside the holes is increased by electrolytic copper plating. After the PTH process, the boards are imaged on both sides. The simplest method is to coat the board with a dry film (photopolymer resist film) using a laminator. After the film is developed, the process of plating, etching and finishing is carried out.

Schematic Process Flow Diagram:



Characteristics of a Typical Production Unit:

Capacity	5,000 square meters (Product Mix depends on actual orders)
Turn over	$800,000
Space Required	500 square meters
Machinery:	Screen Printing Machine Precision Camera Plating Bath Etching Machine Shearing Machine (foot operated) Drilling Machine (Precision) Circular Saw for PCB Cutting
Equipment:	High Voltage tester Continuity tester Insulation resistance tester Microscope for checking patterns
Materials:	Copper clad phenolic or Glass-epoxy sheets Chemicals for plating Photo film

Cost: Copper clad laminates will need to be imported, as also the chemicals for plating and etching; these will cost about $18 per square meter for a single-sided PCB. Cost of machinery will be $20,000. Equipment cost will be around $15,000. It may be preferable to begin with the simpler single-sided PCB and go to the more complex double-sided and plated through boards at a later stage.

Personnel: The following personnel will be needed to staff the enterprise. Persons should be recruited who have the ability and background for the particular job specification and who have the ability to grow or develop into the logical successor positions.

Personnel required:	Production Manager	
	Testing Specialist	(4)
	Skilled Workers	(6)
	Sales/service technicians	(2)
	Administration	(2)

The lines of professional development are:

Skilled Worker to Testing Specialist
Sales/service Technicians to Testing Specialist

Training: Some specialized training will be necessary for personnel to become fully qualified to perform the tasks necessary for the specific job classification. Some of this training can be obtained from suppliers of particular equipment, some can be obtained from local educational institutions, and some can only be obtained through special training provided by the employer.

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Profiles on selected electronic components

An electronic component is the small discrete item which performs certain control functions in electronics.

Project profiles are included for certain commonly-used components, particularly resistors and diodes, which can be locally manufactured in a large number of developing countries.

1. RESISTORS

1.1 CARBON COMPOSITION RESISTORS

Carbon composition resistors use a composition of conductive carbon and non-conductive resins.

1. APPLICATION AND MARKET

Carbon composition resistors are relatively uncomplicated fixed elements which are used in electronic equipment for general-purpose application, especially consumer electronic items.

The production of carbon composition resistors is shown in the table below (in millions of dollars):

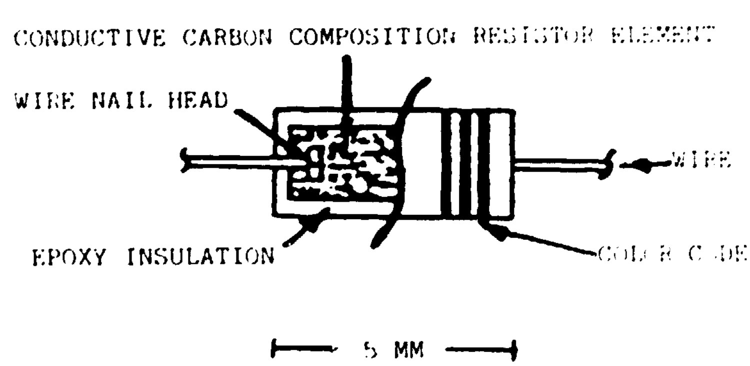
	1982	1983	1984	1987 (Estimates)
Europe (West)	126.0	131.7	[illegible]	137.1
Japan	320.2	354.2	[illegible]	530.8
United States	56.1	58.7	[illegible]	82.0

2. DESCRIPTION

A carbon composition resistor consists mainly of conductive carbon powder (soot), graphite and non-conductive epoxy resins. The proportion of the conductive parts versus the non-conductive materials defines the conductivity of the compound. This material is pressed between two connection wires and is coated with an insulating surface.

A typical size for carbon composition resistors is shown below in Figure 1.

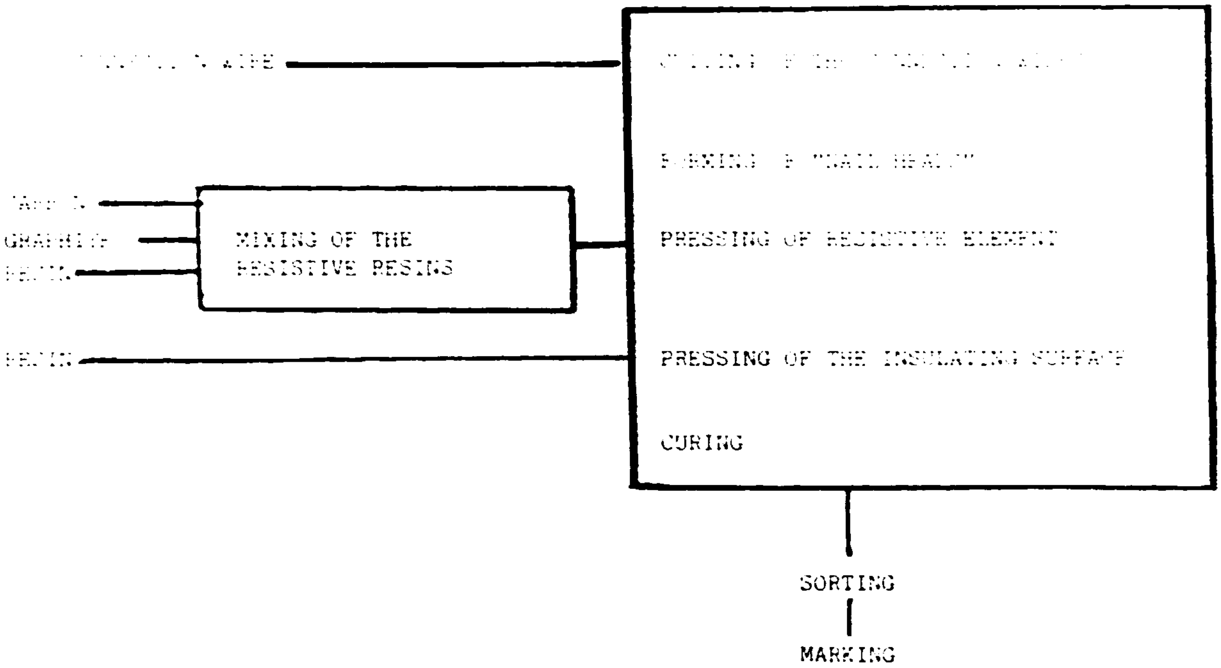
Figure 1. Construction of a carbon composition resistor



3. PRODUCTION PROCESS TECHNOLOGY

A typical process flow chart for carbon composition resistor production is given in Figure 2.

Figure 2. Process flow chart



The production process of carbon composition resistors starts with the preparation and mixing of the compound.

The kind of raw materials, their treatment and their composition is very critical for the quality of the later product.

The main step of the production is the resistor pressing process. A single machine cuts two pieces of wire coming from a bobbin, forms two "nail heads" at one end of the wires and presses the resistance compound around the nail head tops. (See Figure 1.) By this process, the properties of the resistors are fixed. The following step, done by the same or a different machine, is the molding of an insulating layer of epoxy resin around the resistors and the curing of the whole element. The curing process depends very much on the materials used and the quality of the final product.

4. LOCATION CONDITION

The total area requirement is about 700 m². The resin preparation area should be temperature controlled.

5. The minimum economic production for the popular small size of 2 x 5 mm resistors is around 1 million resistors per week, or 4 million resistors per month, based on a production of two 8-hour shifts.

Cost of production, machines and equipment (F.B.)

Air filtering and conditioning equipment	$ 10,000
Milling and mixing equipment	$ 10,000
Trial press	$ 40,000
3 molding machines	$ 450,000
Curing stove	$ 30,000
Sorting machine	$ 20,000
Marking machine	$ 10,000
Other required equipment (e.g., for production control and final inspection)	$ 30,000
Subtotal equipment	$ 600,000
Subtotal building	$ 100,000
Manufacturing plant	$ 700,000

Raw materials and other production materials required	Quantity per 1,000 resistors	Price per 1,000 resistors
Resins	1 kg	$ 2
Carbon, graphite, additives	100 g	$ 0.5
Copper wire, tinned	80 m	$ 1
Paints for marking	10 g	-

Manpower requirements

Engineers	1
Skilled technicians for maintenance of equipment and machinery	1
Skilled workers to be trained on the job	3
Unskilled workers	3
Complete manufacturing plant	8

Utility requirements	Quantity per 1,000 resistors	Price per 1,000 resistors
Electrical power	3 kW	$ 0.3

1.2 WIRE-WOUND POWER RESISTORS

Wire-wound power resistors use a wire made of temperature-resistant metal alloy with low temperature coefficient as the material producing the resistance.

1. APPLICATION AND MARKET

Wire-wound resistors are relatively simple fixed elements which are used in all electronic equipment for professional and general-purpose application where higher power dissipation is required.

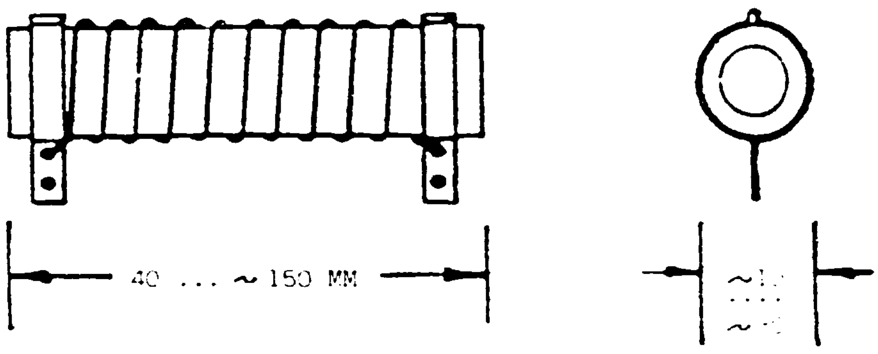
The production of fixed wire-wound resistors in the United States rose to over $100 million in 1986-1987.

2. DESCRIPTION

A wire-wound power resistor consists mainly of a ceramic rod of porcelain, steatite or aluminia on which usually one layer of metal wire is wound. The metal alloy, of which the wire is made, defines the properties of the component and has, therefore, to be selected with care.

A typical size for wire-wound power resistors is shown in Figure 1.

Figure 1. Construction example of wire-wound power resistor

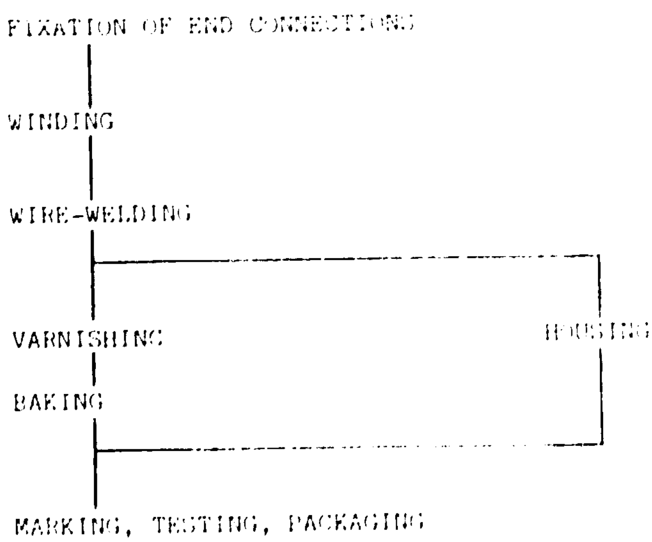


3. PRODUCTION PROCESS TECHNOLOGY

A typical process flow chart for wire-wound power resistor production is given in Figure 2. The production process starts with the fixation of the end connection to the ceramic rod. Depending on the size, quantity and design of the component, this is done by hand-operated fixtures or by automatic machines.

The main step is the following winding of the bobbin. Normally, one layer of the wire is put on the carrier substrate. If the wire is insulated, they might touch each other. If non-insulated wire is used, a certain distance of at least one wire diameter has to be left between the wires. The number of turns has to be calculated in advance, but can be controlled by the winding machine.

Figure 2. Process flow chart



The next step is the welding of the wire to the end connections. This process allows an adjustment of the resistance to the required value.

Consequently, the bobbin is varnished with a temperature-resistant and insulating paint, or covered with a ceramic coat, or housed within the ceramic tube. A subsequent baking process burns the insulating material and fixes and anneals the wire.

4. LOCATION CONDITION

The total area required is about 100 m^2.

5. The minimum economic production can vary between 1 to 10 thousand resistors per week based on two 8-hour shift production.

Cost of production, machines and equipment (FOB)

Air filtering and conditioning equipment	$ 10,000
Fixation of end connections	10,000
Wire winding machines	100,000
Wire welding machines	10,000
Varnishing or housing and packing	50,000
Other required equipment (e.g., for production control and final inspection)	20,000
Subtotal equipment	$ 200,000
Subtotal building	50,000
Manufacturing plant	$ 250,000

Raw materials and other production materials required	Quantity per 1,000 resistors	Price per 1,000 resistors
Ceramic rods	1,100 pieces	$ 2 ... 20
End connections	2,100 pieces	$ 1 ... 10
Metal alloy wire	10 g ... 20 kg	$ 10 ... 100
Varnish, ceramic coating or housing tubes	1 ... 10 kg 2,100 pieces	$ 2 ... 20
Paints for marking	10 g	

Manpower requirements

Engineers	1
Skilled technicians for maintenance of equipment and machinery	2
Skilled workers to be trained on the job	6
Unskilled workers	3
Complete manufacturing plant	12

Utility requirements	Quantity per 1,000 resistors	Price per 1,000 resistors
Electrical power	2 - 20 kWh	$ 2

Normal electrical power supply with 110/220/380 V is required.

1.3 CARBON FILM RESISTORS

Carbon film resistors use a thin film of crystalline carbon as the material producing the resistance.

1. APPLICATION AND MARKET

Carbon film resistors are fairly simple fixed elements which are used in all electronic equipment for general-purpose application under average quality requirements. They are used, therefore, mainly for consumer electronics.

2. DESCRIPTION

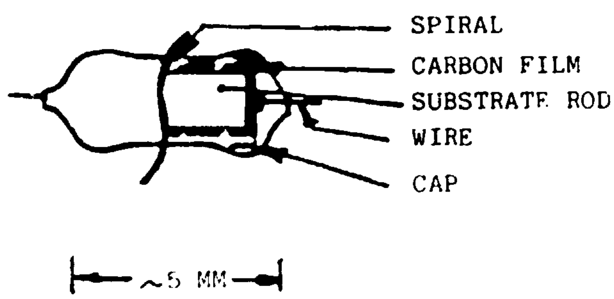
A carbon film resistor consists mainly of a ceramic rod of porcelain, steatite or aluminia on which a thin layer ($\sim$0.1 - 1 µm) of crystalline carbon is deposited. This carbon film defines the properties of the component and has, therefore, to be produced under strictly controlled conditions.

The following technical data are achieved with the present technology:

resistance value	1 Ohm ... 100 M Ohms
dissipation power	30 mW ... 3 W
stability (e.g., change of resistance value after 1,000h at full load and rated temperature)	$<$ 3% per 1,000h
temperature coefficient	0.3 ... 1.4×10^{-3}/K

A typical size for carbon film resistors is shown below in Figure 1:

Figure 1. Construction of carbon film resistors

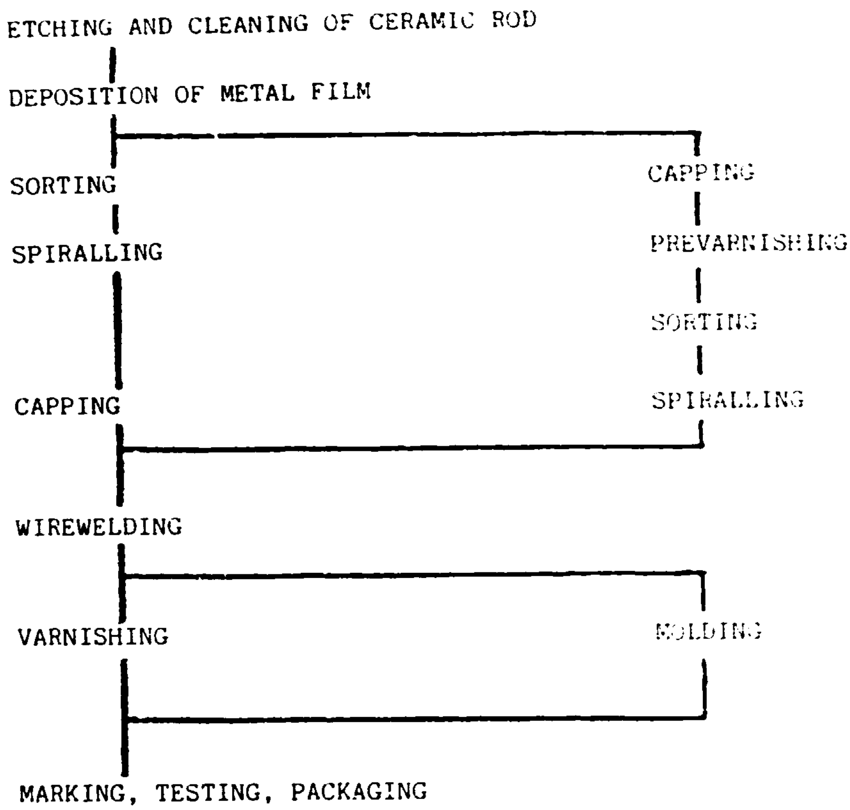


3. PRODUCTION PROCESS TECHNOLOGY

A typical process flow chart for carbon film resistor production is given in Figure 2. The production process of carbon film resistors starts with the tumbling, etching and cleaning of the carrier substrate. This is required to obtain a proper shape for later capping and a suitable surface for carbon deposition.

The main step is the following deposition of the carbon film. It is generated by cracking of hydrocarbons at a temperature of around 1,320 K. The reaction time varies around one hour, depending on the aimed resistance value. For the reaction, two production furnace alternatives are in use. The tube furnace is better suited for larger sizes, higher values and low quantities, whereas the batch furnace is used for smaller sizes, low values and high quantities.

Figure 2. Process flow chart



The next step is the sorting of the semi-finished product into classes of various film resistivities. Should it be significant to determine values properly, then the substrates are generally capped and prevarnished before setting.

The order of production flow may also be altered depending on the technology applied.

The final resistance value is determined by the spiralling, where the carbon film is cut helicoidally to form a spiral around the carrier rod. The required machines use either a sharp high speed grinding wheel or a laser beam for very fine helix cuts.

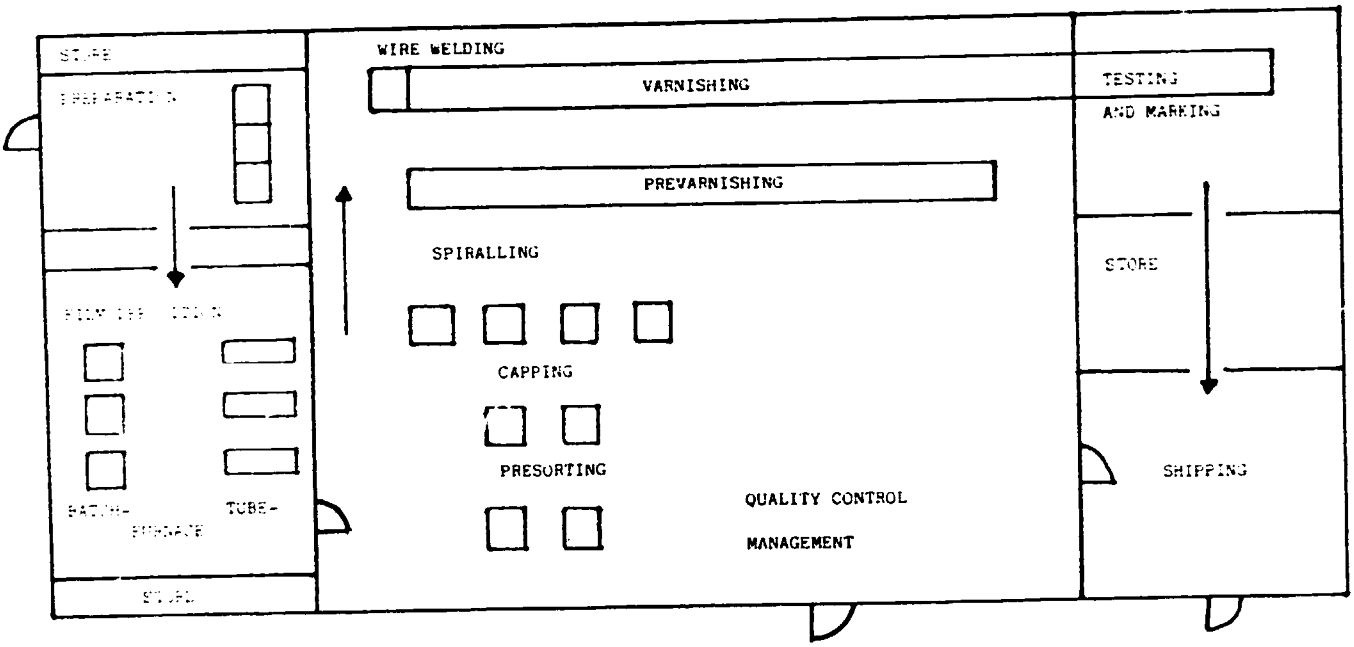
In the last production phase, the connecting wires are welded to the caps. The product is then varnished or molded with epoxy resin in order to isolate and protect it properly. It is then tested, marked, and packaged. In this stage the resistor is ready for shipment.

4. LOCATION CONDITION

The production plant has to be divided into the following four areas (see Figure 3):

1. Ceramic rod preparation
2. Carbon film deposition in tube or batch furnaces
3. Capping, spiralling, varnishing or molding
4. Testing, marking, packaging, storing and shipping

Figure 3. Layout of the manufacturing plant



5. The minimum economic production for small 2 x 5 mm resistors is around 1 million resistors per week or 4 million resistors per month based on a two 8 hour shift production.

<u>Cost of production, machines and equipment (FOB)</u>

Air filtering and conditioning equipment	$ 10,000
Carbon deposition furnaces	60,000
Presorting, capping and spiralling machines	80,000
Prevarnishing line	20,000
Production line with welding, varnishing and testing units	200,000
Other required equipment (e.g., for production control and final inspection)	30,000
Subtotal equipment	$ 400,000
Subtotal building	100,000
Manufacturing plant	$ 500,000

Raw materials and other production materials required	Quantity per 1,000 resistors	Price per 1,000 resistors
Ceramic rods	1,200 pieces	$ 1 ... 2
Fluoric acid		
Hydrocarbons (Methane, Benezene)	1 ... - 10 g	
Pure Nitrogen gas	100 g	
Varnish or epoxy resin for protecting coating	100 - 1,000 g	$ 1 ... 2
Caps	2,200 pieces	$ 1
Copper wire, tinned	30 m	$ 1
Paints for marking	10 g	
Paper tape for production and shipment	100 m	

Manpower requirements

Engineers	1
Skilled technicians for maintenance of equipment and machinery	2
Skilled workers to be trained on the job	6
Unskilled workers	3
Complete manufacturing plant	12

1.4 METAL FILM RESISTORS

Metal film resistors use a thin film of a metal alloy as the resisting determining material.

1. APPLICATION AND MARKET

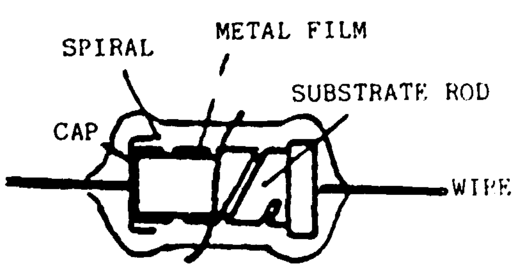
Metal film resistors are relatively uncomplicated fixed elements which are used in all electronic equipment where the requirements for quality are above average. They are used, therefore, especially for professional electronic items.

2. DESCRIPTION

A metal film resistor consists mainly of a ceramic rod of high percentage aluminia (85 to 96% Al_2O_3) or glass on which a thin layer ($\sim$ 10 ... 100 mm) of metal alloy is deposited. This metal film defines the properties of the component and has, therefore, to be produced under strictly controlled conditions.

A typical size for metal film resistors is shown in Figure 1.

Figure 1. Construction of metal film resistors



The following technical data are achieved with the present technology:

resistance value	1 Ohm ... 10 M Ohms
dissipation power	10 mW ... 2 W
stability (e.g., change of resistance value after 1,000h at full load and rated temperature)	> 0.5% per 1,000h
temperature coefficient	10 ... 100 x 10^{-6} K

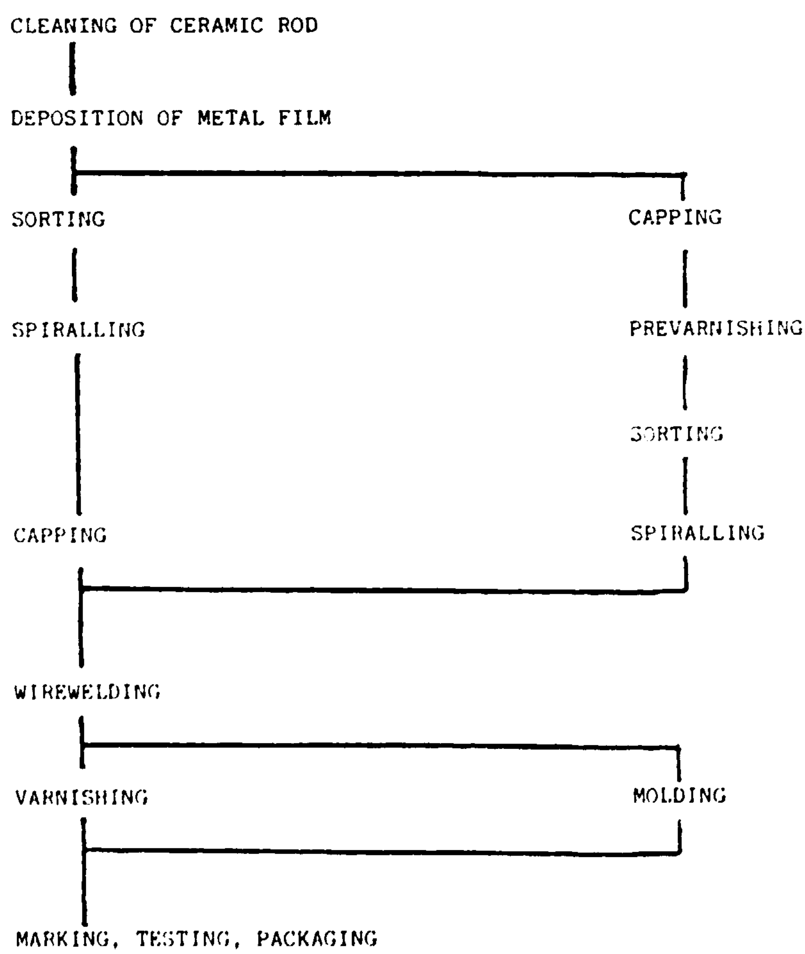
3. PRODUCTION PROCESS TECHNOLOGY

A typical process flow chart for metal film resistor production is given in Figure 2. The production process of metal film resistors starts with cleaning of the carrier substrate.

The main step is the following deposition of the metal film. Depending on the technical parameters to be achieved, high vacuum evaporation of metal-alloys (e.g., Nickel-Chromium) or chemical deposition (e.g., Phosphor-Nickel) are applied.

The next step is the sorting of the semi-finished product into classes of various film resistivities and temperature coefficients. To determine values properly, the substrates are capped and prevarnished before.

Figure 2. Process flow chart



The order of production flow may also be altered depending on the technology applied.

The final resistance value is determined by the spiralling, where the metal film is cut helicoidally to form a spiral around the carrier rod. The required machines use either a sharp high speed grinding wheel or a laser beam for very fine helix cuts.

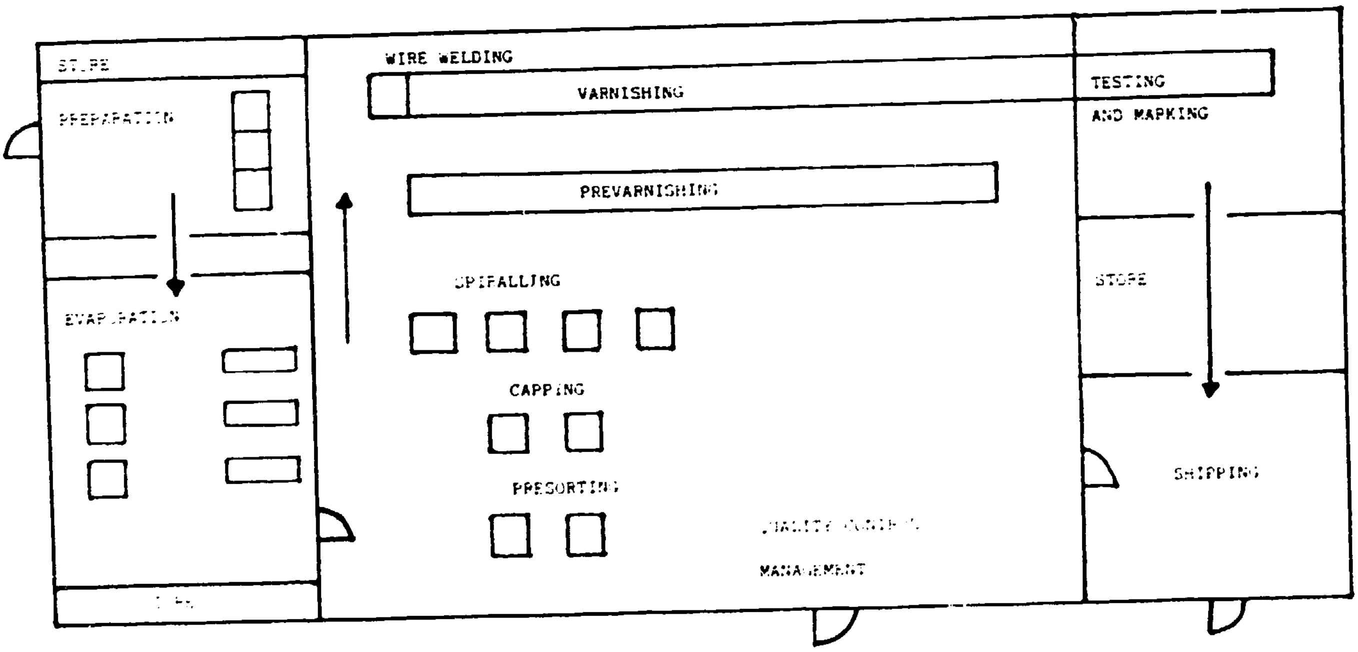
In the last production phase the connection wires are welded to the caps. The product is then varnished or molded with epoxy resin to be isolated and protected properly, tested, marked and packaged. In this stage the resistor is ready for shipment. Only high quality items should be aged a couple of days under elevated temperature prior to their application.

4. LOCATION CONDITION

The production plant has to be split into the following three areas (see Figure 3):

1. Ceramic rod preparation and metal film deposition by evaporation (and/or chemical deposition)
2. Capping, spiralling, varnishing or molding
3. Testing, marking, packaging, storing and shipping

Figure 3. Layout for the manufacturing plant



The total area requires about 300 m^2.

5. The minimum economic production for the small, mostly used size of 2 x 5 mm is around 1 million resistors per week or 4 million resistors per month, based on a two 8 hour shift production.

Cost of production, machines and equipment (FOB)

Air filtering and conditioning equipment	$ 20,000
Metal evaporation units	$ 300,000
Presorting, capping and spiralling machines	$ 80,000
Prevarnishing line	$ 20,000
Production line with welding, varnishing and testing units	$ 200,000
Other required equipment (e.g., for production control and final inspection)	$ 180,000
Subtotal equipment	$ 720,000
Subtotal building	$ 100,000
Manufacturing plant	$ 900,000

Raw materials and other production materials required	Quantity per 1,000 resistors	Price per 1,000 resistors
Ceramic rods	1,200 pieces	$ 1 ... 3
Nickel, Chrome and Nickel-Chrome-Alloy for evaporation	1 ... -10 g	
Pure argon	0.01 - 0.1 g	
Varnish or epoxy resin for protection coating	100-1,000 g	$ 1 ... 3
Silver paint	0-10 g	
Caps	1,200 pieces	∼ $ 1
Copper wire, tinned	80 m	∼ $ 1
Paints for coating	10 g	
Paper tape for production and shipment	100 m	

Manpower requirements

Engineers	2
Skilled technicians for maintenance of equipment and machinery	4
Skilled workers to be trained on the job	10
Unskilled workers	4
Complete manufacturing plant	20

Utility requirements	Quantity per 1,000 resistors	Price per 1,000 resistors
Electrical Power	1 - 2 kWh	$ 0.2
Water		negligible
Liquid nitrogen	0.1 ... 0.5 l	

2. DIODES

2.1 SILICON POWER DIODE

Silicon power diodes are designed for high current or high voltages in forward direction.

1. APPLICATION AND MARKET

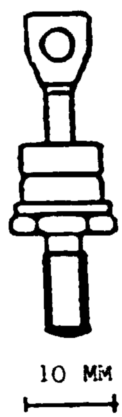
The high current type power diode is used as semiconductor switch for rectifier purposes, and for DC as well as AC current sources. The high voltage type, for instance, is used for X-ray power supplies. The market situation is as follows:

	1982	[illegible]	[illegible]	[illegible] (Estimates)
Europe (rectifier)	179.3	188.[illegible]	201.[illegible]	460.6
Japan (high and low power)	[illegible]	233.7	24[illegible].2	[illegible].8
United States (high and low power rectifier)	164.2	173.0	18[illegible].9	21[illegible].6

2. DESCRIPTION

A silicon power diode consists of a p-n junction which is formed at the transition between a p- and n-doped region of single crystalline material. The dimensions and weight of power diodes depend on the current or voltage which passes through them.

Figure 1. Construction of a silicon power diode

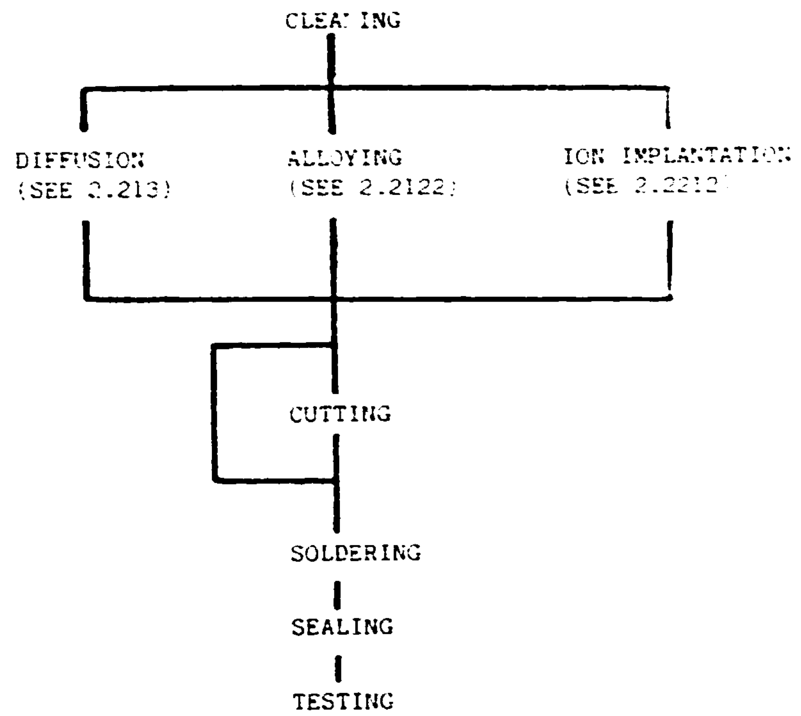


In addition to the static characteristics, it is necessary to characterize the thermal behavior, such as housing temperature, necessary heat sink, thermal resistances, power loss, and if necessary, the frequency behavior.

3. PRODUCTION PROCESS TECHNOLOGY

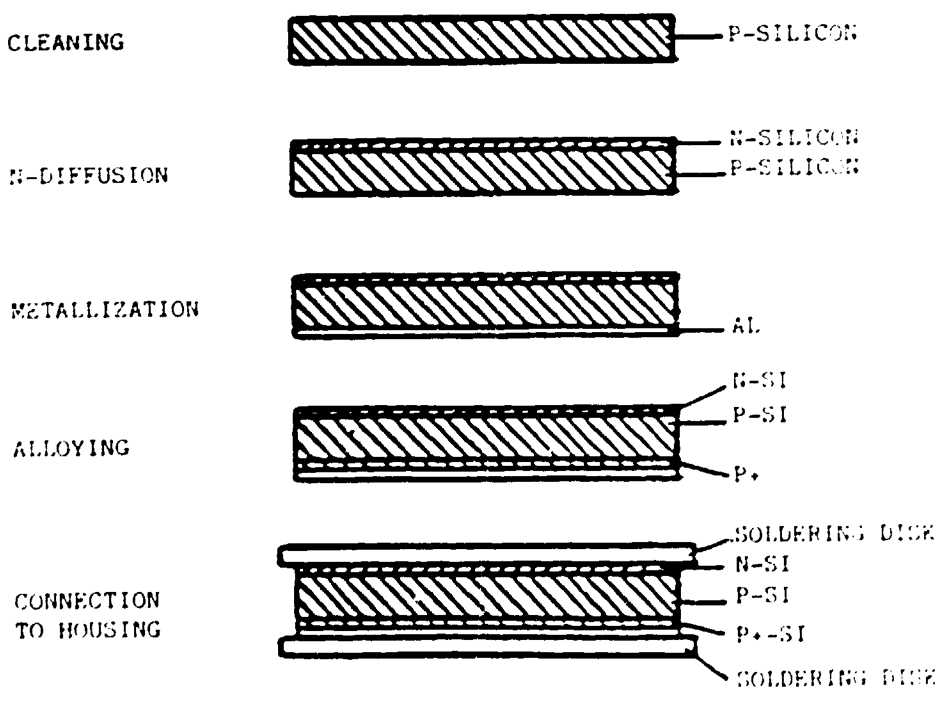
Silicon p-n-junctions for power diodes are basically produced by diffusion processes (2.2 Silicon General-Purpose Diode) and alloying processes (2.3 Zener Diodes). The diffusion step produces a very homogeneous p-n-junction over a large area. This is very important, because the power consumption is directly proportional to the silicon area (typically 100-200 A/cm^2). On the other hand, an alloy allows a very good thermal contact to the housing and, therefore, to the heat sink. A typical process flow chart is given in Figure 2.

Figure 2. Process flow chart



The diameter of the single crystalline silicon diode depends on the maximum switching current and covers the range between a few mm and [illegible] inches. The wafers are the basic material and are bought with p- or n-doping. For a combined diffusion and alloying step the diffusion is carried out first because it occurs at about 1,100°C, whereas the alloying needs only [illegible]°C - [illegible]°C. The finished wafers are cut for low power diodes, whereas for high power devices the complete wafer is used.

Figure 3. Combined diffusion and alloying process



Sealing and contacting of the power diodes is a very important task and is a major part of the total assembly costs. To protect the p-n-junction of the diodes, the sealing has to be leak proof in order to avoid moisture and corrosion. Therefore, the diode is carefully dried before it is encapsulated. The encapsulation is done in an inert atmosphere or under vacuum conditions.

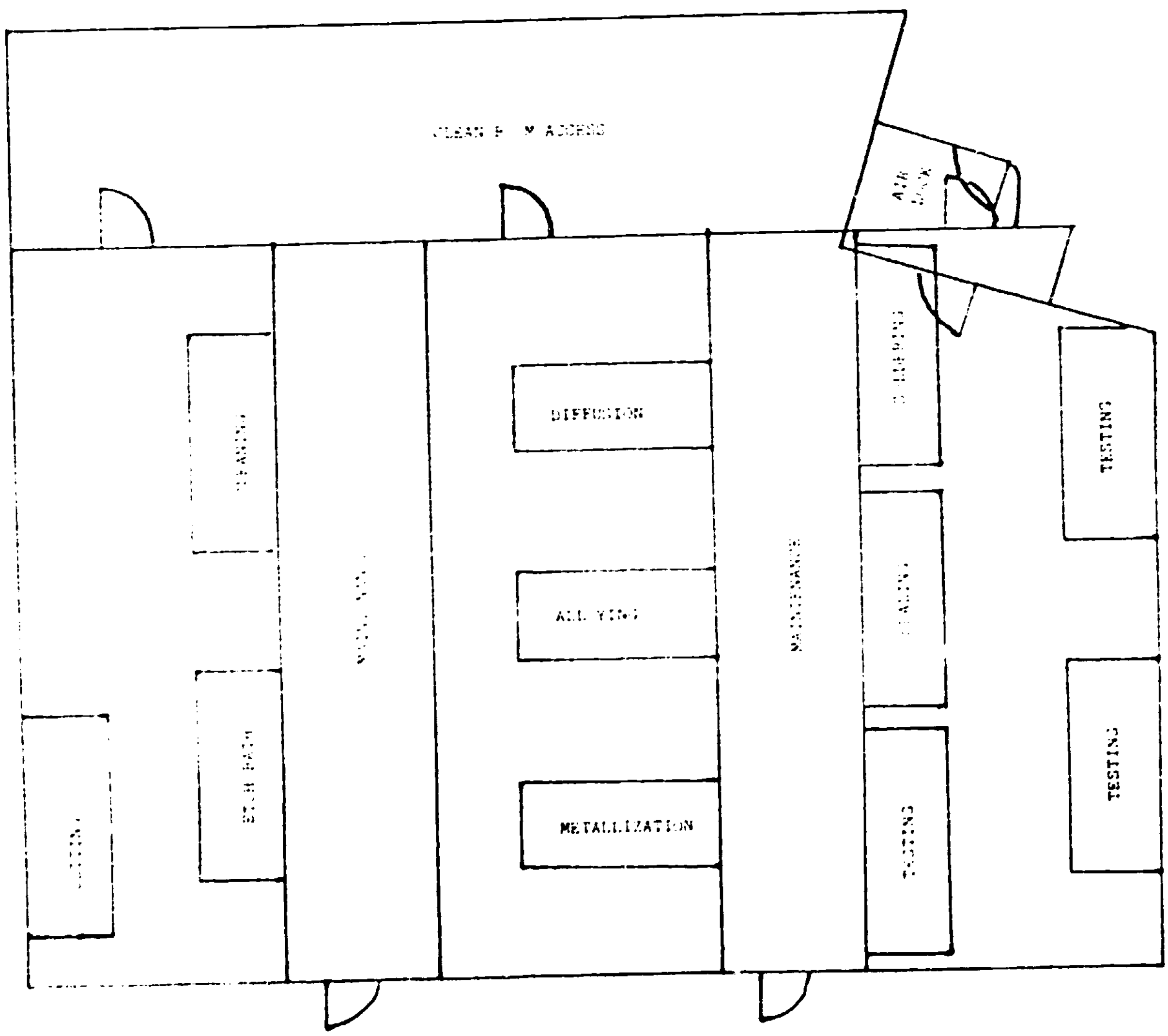
For very high power switches, the heat sink which normally is air cooled can also be water cooled in order to be more effective. In addition, the thermal properties such as heat resistance between p-n-junction and housing, heat resistance between p-n-junction and air, and heat resistance between housing and heat sink have to be labelled.

4. AREA AND PLANT

The production plant is generally divided into four parts (see Figure 4):

1. Cleaning
2. Mechanical processing
3. Layer processing
4. Encapsulation, packaging and testing

Figure 4. Layout of the manufacturing plant



Area 1 requires distilled and filtered water and filtered pressurized air. The vapors from the etch baths have to be siphoned off and drained. For the etchants and solvents, it is necessary to supply special storage.

Area 2 requires distilled water.

Area 3 requires cooling water and heat exchange.

Area 4 requires exhaust fans for the solvent fumes.

Maintenance of pumps, motors, gas and water supply, etc., should be done via the maintenance access.

Severe safety precautions have to be taken if gaseous sources are used for the diffusion.

5. The number of diodes on a wafer depends on the switching current. For an economical production line, it is necessary to handle about 50 wafers (2 or 3 inch) a day. It should be noted that the production process allows the production of a whole spectrum of diodes and the factory need not exclusively produce power diodes.

The following equipment is required:

<u>Cost of production, machines and equipment (FOB)</u>

Etching and cleaning	$ 70,000
Mechanical preparation (cutting and polishing)	60,000
Diffusion oven	40,000
Metallization	55,000
Alloying	50,000
Soldering and encapsulation	210,000
End control	60,000
Packaging	70,000
Small equipment	90,000
Subtotal equipment	$ 705,000
Subtotal building (including installations for air conditioning, etc.)	600,000
Manufacturing plant	$ 1,305,000

Raw materials and other production materials required	Average quantity per 1,000 diodes (diode area 25 mm^2)
Silicon wafers with a diameter of 3 inches	7
Distilled and filtered water for cleaning	140 l
HCl, H_2O_2, H_2O_4 for etching	14 l
Pure nitrogen in pressure bottles	140 l
Polishing material	100 g
Phosphine in pressure bottles for doping	
Metal for alloying	15 g
Soldering disks and soldering material	2,000 pieces
Housing material	1,000 pieces
Paints for marking	10 g
Paper for packaging and shipment	300 m

Manpower requirements

Engineers	2
Skilled technicians	4
Skilled workers to be trained on the job	12
Unskilled workers	3
Complete manufacturing plant	21

Utility requirements	Quantity per 1,000 diodes (diode area 25 mm^2)
Electrical Power	50 ... 150 kW
Water	200 ... 300 l

2.2 SILICON GENERAL PURPOSE DIODE

Diodes are the simplest active components in semiconductor technology. They can be used as rectifiers, demodulators, switches, limiters, stabilizers, mixers or oscillators in electronic systems. Silicon general purpose diodes are low cost rectifiers made out of silicon as semiconducting material.

1. APPLICATION AND MARKET

Silicon diodes are applied in nearly all electronic items for professional and consumer electronics.

A classification of general purpose diodes according to their capability and application is as follows:

1) universal diodes
2) switching diodes
3) rectifier diodes

According to Electronics, January 1984, the following market expenditures (in millions of $) existed for diodes:

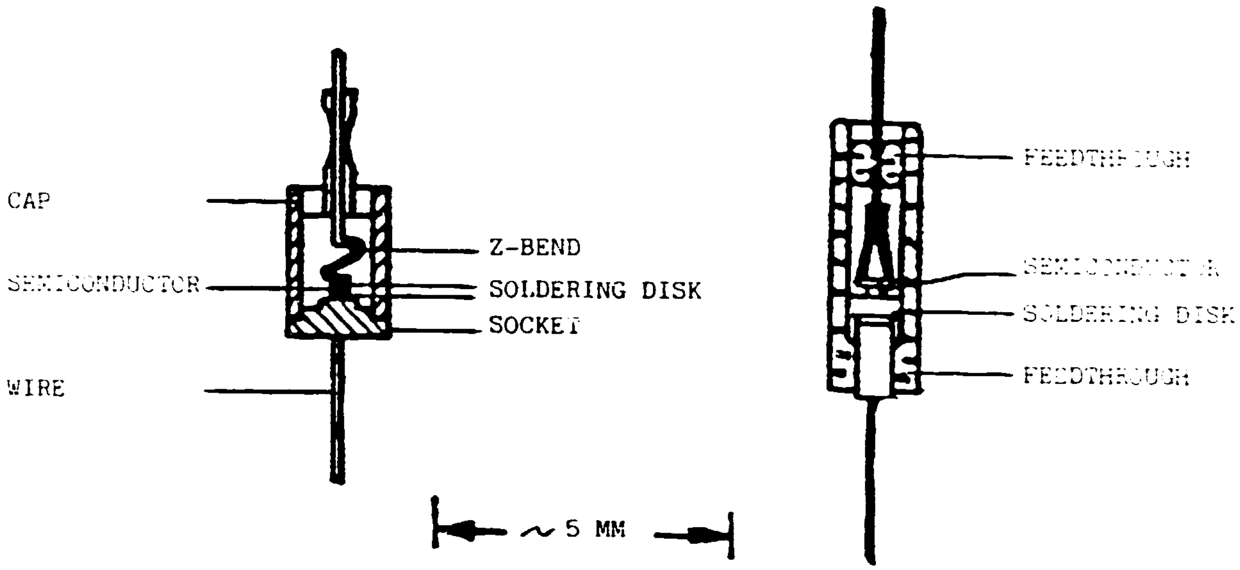
		1982	1983	1984	1987 (Estimates)
Europe	Rectifier	179.3	188.3	201.3	420.2
	Signal	56.0	59.7	62.2	85.6
Japan	Rectifier	220.8	233.7	249.2	540.6
	Signal	83.4	96.2	103.3	160.2
USA	Rectifier	212.2	226.6	242.0	480.9
	Signal	59.0	60.6	61.4	88.4

2. DESCRIPTION

The most important part of a semiconductor diode is a p-n-junction which is formed at the transition between a p- and n-doped semiconductor material. For silicon diodes, single crystalline material is used.

A typical universal diode in a glass sealing is shown in Figure 1. The weight is about 0.2 g.

Figure 1. Typical construction of diodes



The following technical data are achieved with the present technology:

Temperature stability (forward direction)	- 2	mV/K
Temperature stability (reverse bias)	7	%/K
Switching time	0.01 - 10	µs
Capacity	~ 1	pF

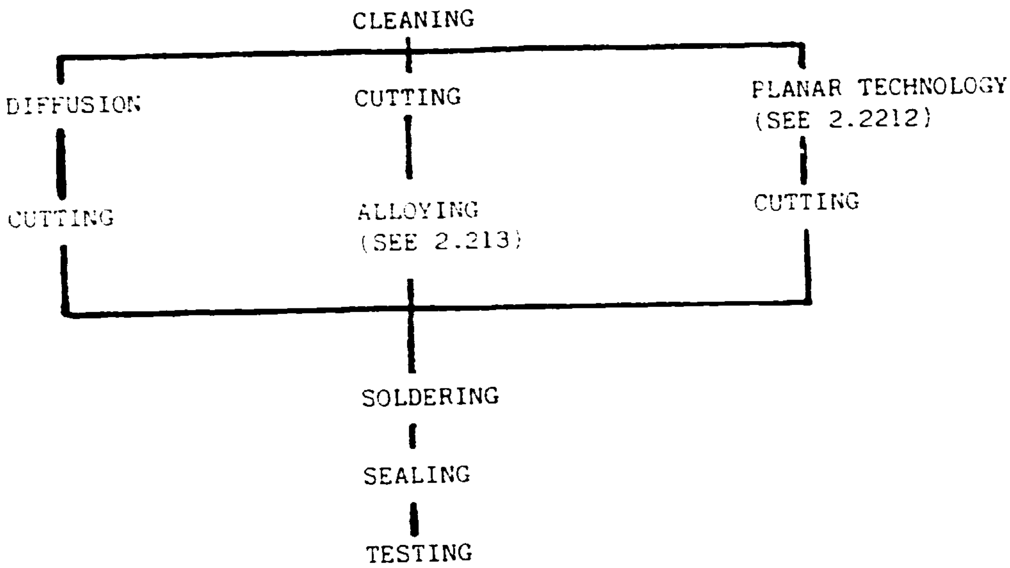
		Universal	Switching	Rectifier	
Reverse bias	V_R	50-300	30-80	6-300	V
Forward bias	V_F	1.3	1.3	1.1	V
Reverse current	I_R	0.2	0.1-5	1	µA
Thermal resistance	R_{th}	380	300-700	500	mK/W

3. PRODUCTION PROCESS TECHNOLOGY

The base material is single crystalline silicon wafers with a diameter between 2 inches and 5 inches. They are usually bought with a finished surface. The thickness of the wafers is about 0.35 mm and they are n- or p-doped.

A typical process flow chart for silicon diodes is given in Figure 2.

Figure 2. Process flow chart



The main technological step is doping of the wafer. A batch of 50-100 silicon wafers is usually processed at the same time.

For the diffusion process the p-doping is carried out with boron and the n-doping with phosphor. Gaseous, liquid or solid material sources can be used.

The thickness of the diffused layer should be about 1-2 µm.

Because the diffusion process takes place on both sides of the wafer it is necessary to take away one side by polishing, etching and cleaning the surface after the first diffusion step. After the second diffusion, the oxide layer is etched away. Then a nickel layer is deposited by either evaporation or sputtering in vacuum, or by electroplating. The finished wafers are cut with the help of a diamond saw to appropriate squares of 0.5×0.5 mm^2.

Sealing and contacting of the finished structures is a major part of the total assembly. Three different possibilities of sealings exist. They are listed below in decreasing order of cost:

1) Metal housing (suggested for high reliability application and for a wide temperature range (-55 ... +175°C)).

2) Glass housings.

3) Polymer housings.

For testing, it is necessary to control the quality of the individual layers and the finished device.

Each diode has to be marked by a color code which describes the base material, the type of diode, and the tolerance.

The p-n-junction can also be produced by alloying as is described in the Profile 2.213 (Zener diode) and by a planar technolcgy which is described in detail in Profile 2.2212 (Bipolar Transistor).

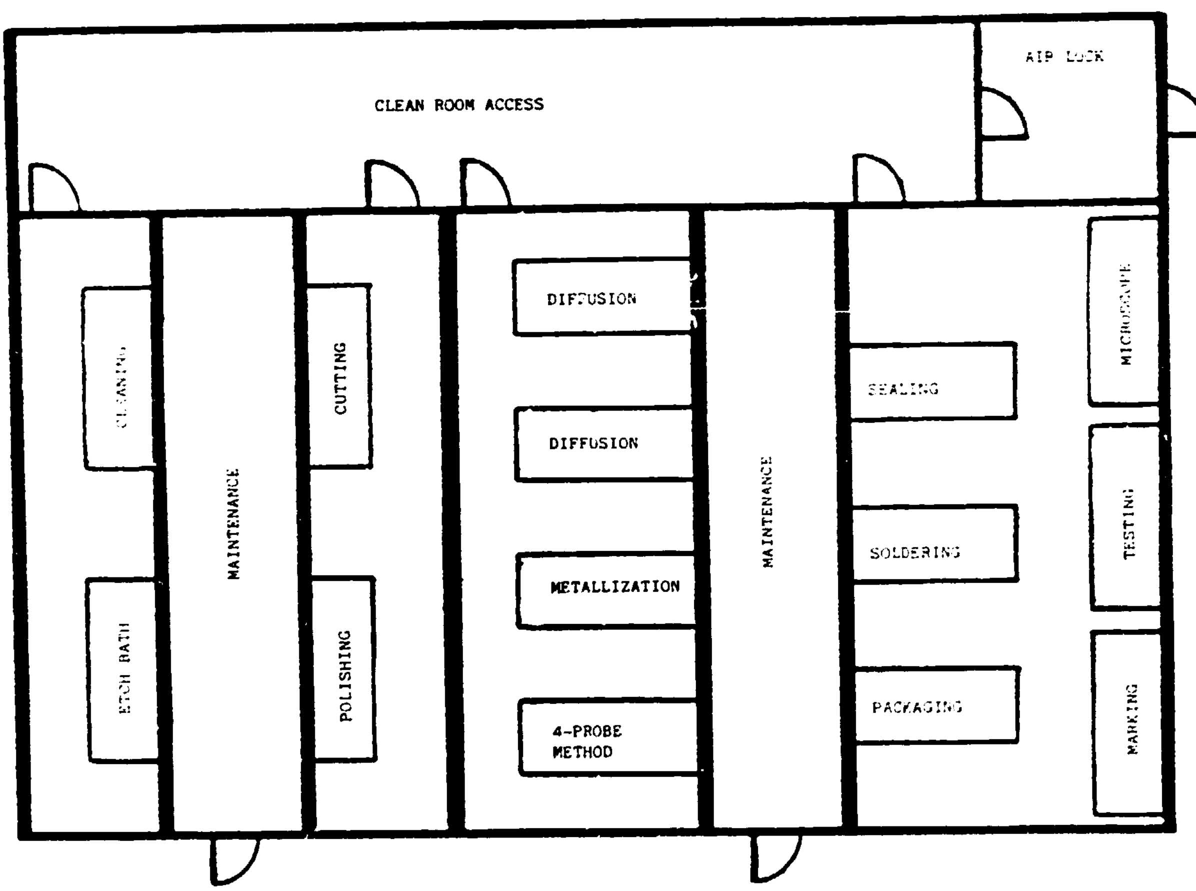
4. AREA AND PLANT

The production plant is generally divided into the following four areas (see Figure 3):

1. Chemical processing
2. Mechanical processing
3. Layer processing
4. Encapsulation and testing

The economic building size is given by the diffusion ovens, which have a length of about 8 m. This defines the length of the third section of about 10 m. The total length amounts to about 30 m, and for the total area approximately 300 m^2 should be considered.

Figure 3. Layout of the manufacturing plant



Area 1 requires distilled and filtered water and pressurized air. The vapors from the etch baths have to be siphoned off and drained over the roof. For the etching agents and solvents, it is necessary to supply neutralization.

Area 2 requires water supply and pressurized air.

Area 3 requires effective heat exchange, cooling water and pressurized air.

Area 4 requires exhaust fans for the solvent fumes caused by the soldering process.

Airconditioning is necessary in all sections. The air must be filtered. Maintenance of pumps, motors, gas and water supply, etc., should be done via the maintenance access located outside the cleanroom sections.

Safety precautions have to be taken if gaseous sources (PH_3, B_2H_6) are used for the diffusion.

5. The minimum economic production is about 50 wafers per day with 2,000 diodes on each wafer. The yield of a properly running line should be around 90%. To be profitable, it is necessary to fabricate about 1 million diodes per month.

Cost of production, machines and equipment (FOB)

Etching and cleaning	$ 70,000
Mechanical preparation (cutting and polishing)	60,000
Diffusion ovens	80,000
Metallization	55,000
Production line with soldering and sealing	180,000
End control	60,000
Packaging	70,000
Small equipment	110,000
Subtotal equipment	$ 685,000
Subtotal building (including installations for airconditioning, etc.)	600,000
Manufacturing plant	$ 1,285,000

Raw materials and other production materials required	Quantity per 1,000 diodes
Silicon wafers with a diameter of 3 inches	0.5 wafers
Distilled and filtered water for cleaning	10 l
HCl, H_2O_2, H_2SO_4 for etching	1 l
Pure nitrogen in pressure bottles as protective gas	10 l
Polishing material	10 g
Phosphine and diborane in pressure bottles for the doping (only if gaseous sources are used)	
Nickel for metallization	5 g
Soldering material	20 g
Copper wire	60 m
Housing material (only for metal cases)	1,000 pieces
(only for glass or polymer)	100 g
Paints for marking	10 g
Paper for packaging and shipment	100 m

Manpower requirements

Engineers	2
Skilled technicians for maintenance of equipment and machinery	3
Skilled workers to be trained on the job	13
Unskilled workers	2
Complete manufacturing plant	20

Utility requirements	Quantity per 1,000 diodes
Electrical Power	10 ... 20 kW
Water	20 ... 30 l

2.3 ZENER DIODES

1. APPLICATION AND MARKET

Zener diodes (Z-diodes) are used for reference purposes and for stabilizers (for instance, voltage stabilizers) in professional and consumer electronics. Furthermore, they can be used as limiters and for gating. The market situation (in millions of $) is as follows:

	1982	1983	1984	1987 (Estimates)
Europe	44.4	46.6	50.0	84.6
Japan	36.1	38.3	45.0	110.8
United States	103.0	117.4	134.1	160.6

2. DESCRIPTION

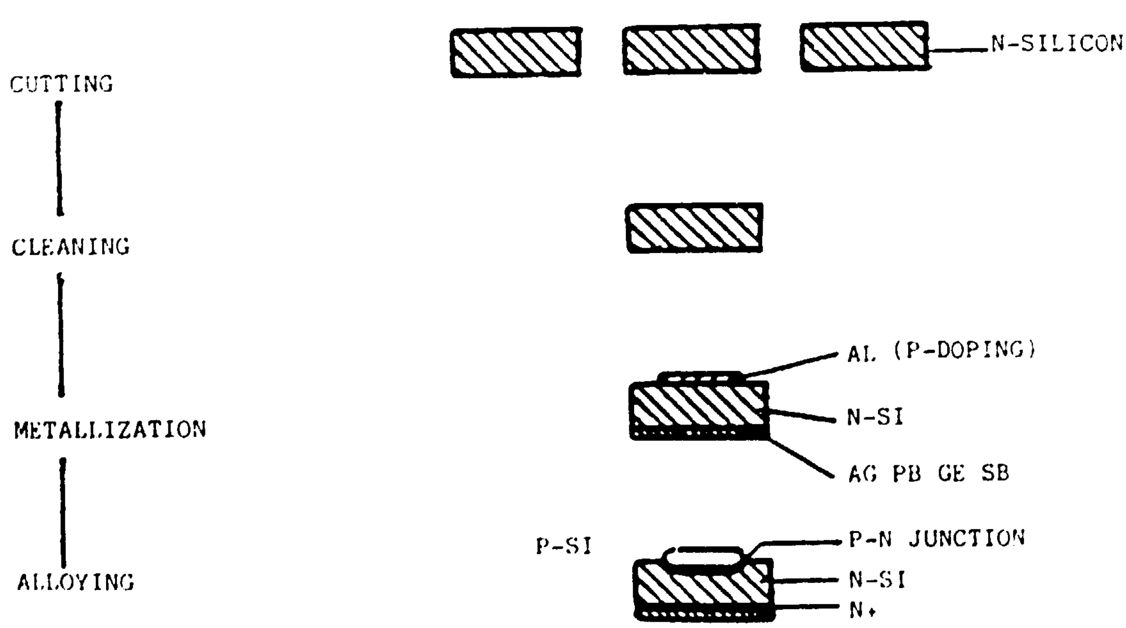
Z-diodes are the only diodes which are used in the reverse "breakdown regime" of a p-n junction. This junction is formed between a p- and n-doped region of a single crystalline silicon material.

3. PRODUCTION PROCESS TECHNOLOGY

Technology and Process flow are the same as for other diodes of small and medium power. A typical process flow chart is given in the Profile 2.2122 Silicon General Purpose Diode. The most common technologies for single diodes are the diffusion process (2.2122) and, as an alternative, the alloying process which will be described here.

The base material is single crystalline silicon wafers with a diameter between 2 inches and 5 inches and a finished surface. The basic technological step is the alloying of the dopant material (Figure 1) in order to achieve a p-n junction.

Figure 1. The Alloying Process for the Production of p-n junctions



Unlike the diffusion process, the cutting of the wafers takes place before the preparation of the p-n junction. The homogeneously n-doped wafer is cut in 2 x 2 mm^2 pieces. To produce the p-n junction, aluminum is alloyed into silicon at about 600°C to 800°C. During a slow cooling process the silicon in the alloy crystallizes and forms a p-layer. At the same time, the n-type silicon base material is alloyed to form a n-n+ ohmic contact (n+ means highly doped) at the back side. A typical alloy for this process consists of Ag + Pb + Ge + Sb.

After the alloying, the diode crystal is mounted into the diode housing. The surface must be coated with a surface protection because the p-n-junction extends all the way up to the surface. Metal housing, glass housing and polymer housings are available (see profile 2.2).

For testing, it is necessary to control the quality of the individual layers and the finished device.

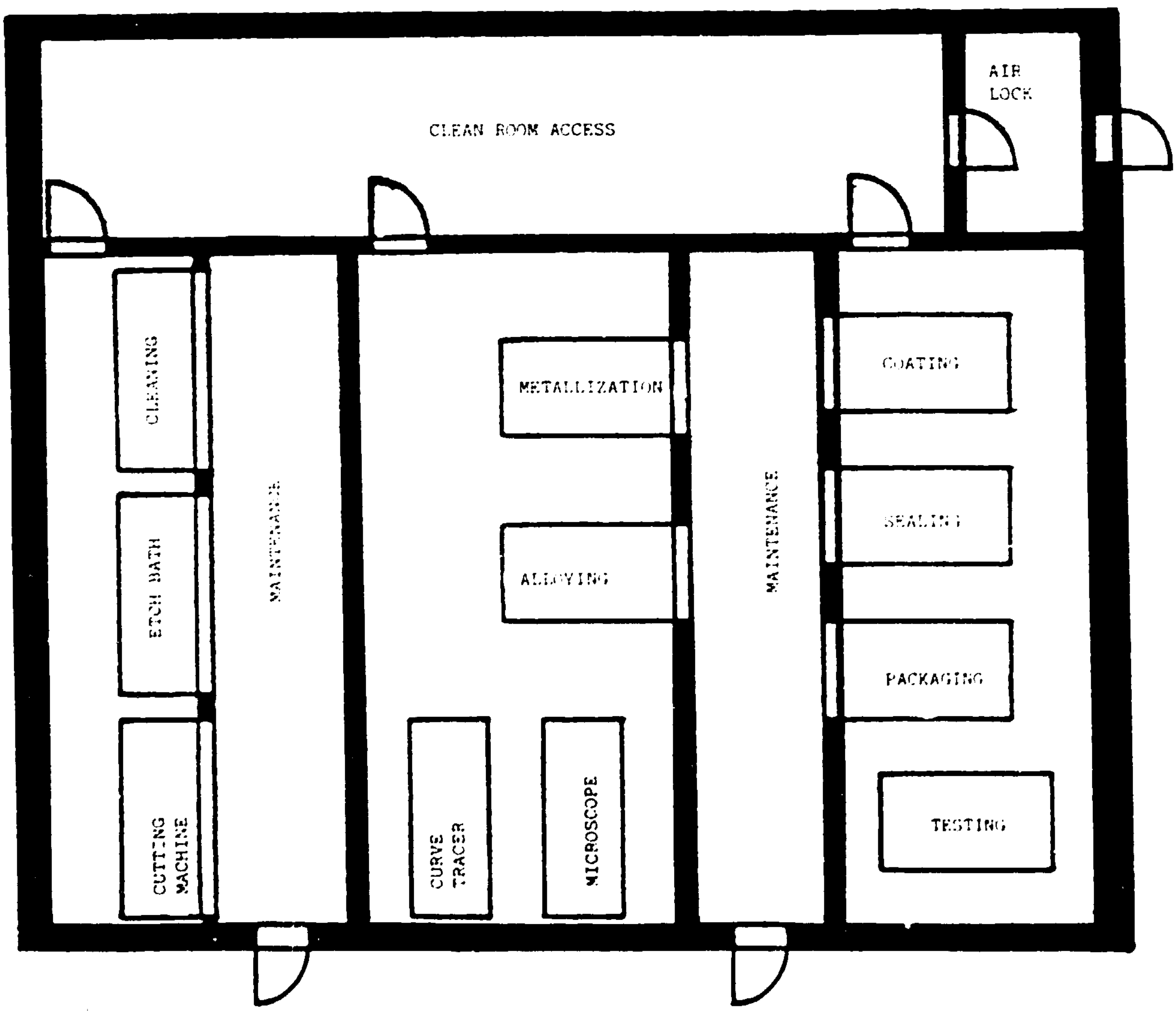
Each diode has to be marked by a color code which describes base material, type of diode, tolerance, and the Z-voltage.

4. AREA AND PLANT

The production plant is generally divided into three areas (see Figure 2):

1. Cutting and cleaning
2. Layer processing
3. Encapsulation and testing

Figure 2. Layout of the production plant



The economic building size not including any offices is about 250 m^2. Air conditioning is necessary in all sections to guarantee temperature stability. The air must be filtered. Maintenance of pumps, motors, gas and water supply, etc., should be done via the maintenance access which is outside the cleanroom sections.

Area 1 requires water supply, distilled and filtered water, and pressurized air. The vapors from the etch baths have to be siphoned off and drained over the roof. For etchants and solvents it is necessary to supply neutralization.

Area 2 requires cooling water and pressurized air.

Area 3 requires exhaust fans for the solvent fumes generated by the soldering process.

5. The minimum economic production is about 50 wafers per day. For 3 inch diameter wafers the output is about 700 diodes for each wafer. The yield of a properly running line should be around 90%. To be profitable, it is necessary to fabricate about 600,000 diodes per month. Because the production process for signal diodes and Z-diodes is the same, it is useful to produce more than just one type of diode at a production site.

The following equipment is required:

Cost of production, machines and equipment (FOB)

Mechanical preparation (cutting)	$ 50,000
Etching and cleaning	70,000
Metallization	100,000
Alloying	60,000
Production line with soldering and sealing	180,000
End control	60,000
Packaging	70,000
Small equipment	90,000
Subtotal equipment	$ 680,000
Subtotal building (including installations for air conditioning)	600,000
Manufacturing plant	$ 1,280,000

Raw materials and other production materials required	Quantity per 1,000 diodes	Price per 1,000 diodes
Silicon wafer with a diameter of 3 inches	1.5 wafers	$ 7.5
Distilled and filtered water for cleaning	30 l	$ 0.9
HCl, H_2O_2, H_2SO_4 etc. for etching	3 l	$ 0.9
Pure nitrogen in pressure bottles	30 l	
Materials for metallization	15 g	$ 0.3
Soldering material	20 g	$ 0.5
Copper wire	60 m	$ 1.0
Housing material (for metal cases)	1,000 pieces	$20.0
(for glass or polymer cases)	100 g	$20.0
Paints for marking	10 g	
Paper for packaging and shipment	100 m	

Manpower requirements

Engineers	2
Skilled technicians for maintenance of equipment and machinery	3
Skilled workers to be trained on the job	12
Unskilled workers	2
Complete manufacturing plant	19

Utility requirements	Quantity per 1,000 diodes	Price per 1,000 diodes
Electrical Power	10 ... 2[illegible] KW	$ [illegible]
Water	20 ... [illegible]0 l	

3.0 MOS FIELD EFFECT TRANSISTOR

MOS field effect transistors are mostly used for large scale integrated digital circuits.

1. APPLICATION AND MARKET

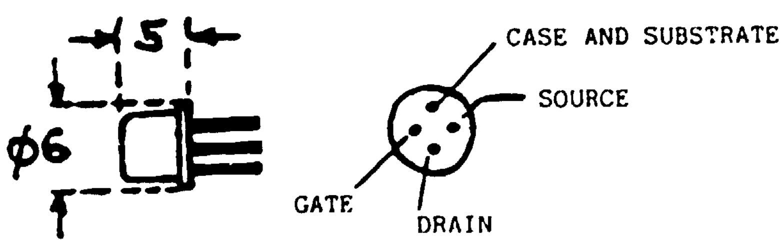
Discrete MOS field effect transistors are mainly used as high impedance input stages in amplifiers and other electronic circuits. The market demand (in millions of $) is as follows:

	1982	1983	1984	1987 (Estimates)
Europe	28.8	29.6	33.3	60.6
Japan	53.4	65.3	79.2	110.[illegible]
United States	43.3	61.2	81.9	140.8

2. DESCRIPTION

The MOS field effect transistor consists of a current channel at the surface of a silicon single crystal. The resistance of this channel is determined by an electric field perpendicular to the channel which is applied via a gate electrode. For p-channel MOS transistors, two strongly doped p+ areas are diffused into an n-type doped substrate. They act as current injecting (source) and absorbing (drain) electrode. The gate electrode, together with the dielectric (silicon dioxide) and the channel in the silicon substrate, acts as a capacitor. For negative gate voltages, an increased hole density in the channel area exists, and a current flow between source and drain occurs. Typical supply voltages without additional ion implantation steps are 15-24 [V]. The packaging for the transistors is done in metal housings or epoxy molds as shown in Figure 1.

Figure 1. Typical housing for a MOS transistor



3. PRODUCTION PROCESS TECHNOLOGY

Single MOS field effect transistors are usually built on surfaces of n-type single crystalline silicon. In planar technology, the necessary doping steps are carried out by diffusion or ion implantation (see Profile 2.2212). The gate material usually is aluminum. A typical process flow chart is given in Figure 2.

The basic material is 3 or 4 inch silicon wafers. Including the pads for bonding, a transistor has a typical size of 0.3 x 0.3 mm^2.

Sealing and contacting is very important and is a major part of the total assembly costs. The sealing has to be leak proof in order to avoid moisture and corrosion.

4. AREA AND PLANT

The production plant is generally divided into five areas (see Figure 3):

Area 1: Cleaning and etching
Area 2: Photolithography
Area 3: Layer processing
Area 4: Testing, bonding, and encapsulation
Area 5: End test and packaging

All areas should be air conditioned in order to guarantee temperature stability.

The areas 1 - 4 are clean rooms with a particle density below 100 per cubic foot. The following special requirements are necessary:

Figure 2. Process flow chart

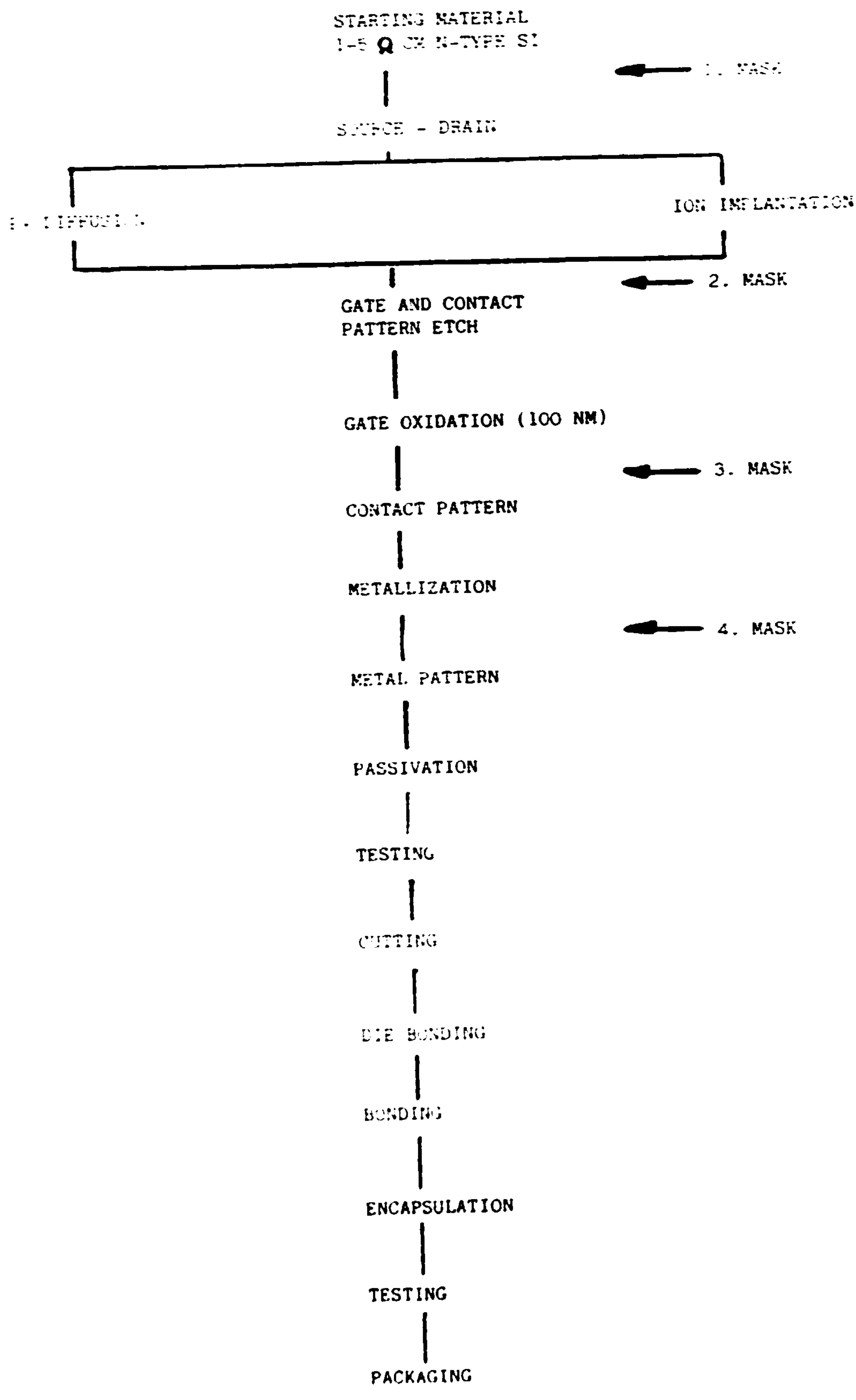
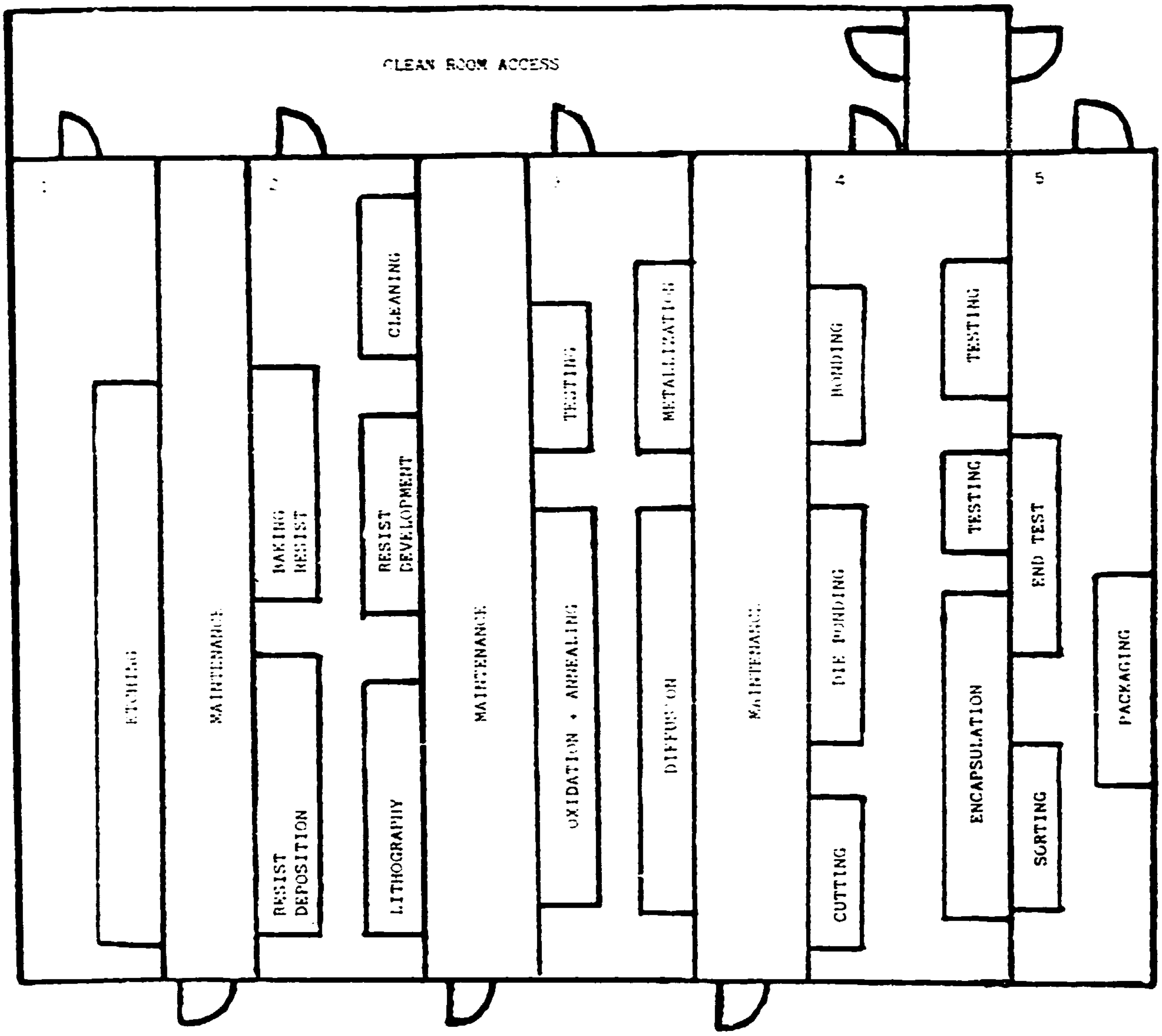


Figure 3. Layout of the manufacturing plant



Area 1 requires distilled and filtered water and filtered pressurized air. The vapors from the etch bath have to be siphoned off and drained. For the etchants and solvents, it is necessary to supply special storage.

Area 2 requires distilled water.

Area 3 requires cooling water and heat exchange. For the diffusion, usually gaseous doping sources are used, which are poisonous. Therefore, severe safety precautions, such as leak detection, have to be included.

Area 4 requires exhaust fans.

Area 5 has no special requirements.

5. For a 3 inch diameter, usually 4,000 transistors are produced per each wafer. The yield of a proper running line is about 80-90%. For an economical production line, it is necessary to handle about 30-50 wafers a day. It should be noted that the production process allows the production of single transistors and small scale integrated circuits. Circuit and mask design, as well as working masks, should be bought. Otherwise, the costs are increased significantly.

Cost of production, machines and equipment (FOB)

Etching and cleaning	$ 80,000
Photolithography	150,000
Oxidation and annealing	180,000
Diffusion	180,000
Metallization	130,000
Cutting	35,000
Die bonding	30,000
Bonding	30,000
Encapsulation	180,000
Testing	90,000
Sorting, marking and packaging	105,000
Subtotal equipment	$ 1,190,000
Subtotal building (including installations for air conditioning, etc.)	900,000
Manufacturing plant	$ 2,090,000

Raw materials and other production materials required	Average Quantity per 1,000 resistors	Average price per 1,000 resistors
Silicon wafers with 3 inch diameter		
Distilled and filtered water for cleaning		
HCl, H_2O_2, H_2O_4 for etching		
Liquid nitrogen		
Special gases (O_2, H_2)		
Doping gases ($POCl_3$, BBr_3)		
Metal for metallization		
Working masks		
Bonding material		
Housing material		
Paints for marking		
Paper for packaging and shipment		

Manpower requirements

Engineers	5
Skilled technicians for maintenance of equipment and machinery	6
Skilled workers to be trained on the job	12
Unskilled workers	3
Complete manufacturing plant	26