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DP/IND/72/045

INDIA

Technical Report: INTEGRATED CIRCUITS

Prepared for the Government of India by the
United Nations Industrial Development Organization,
executing agency for the
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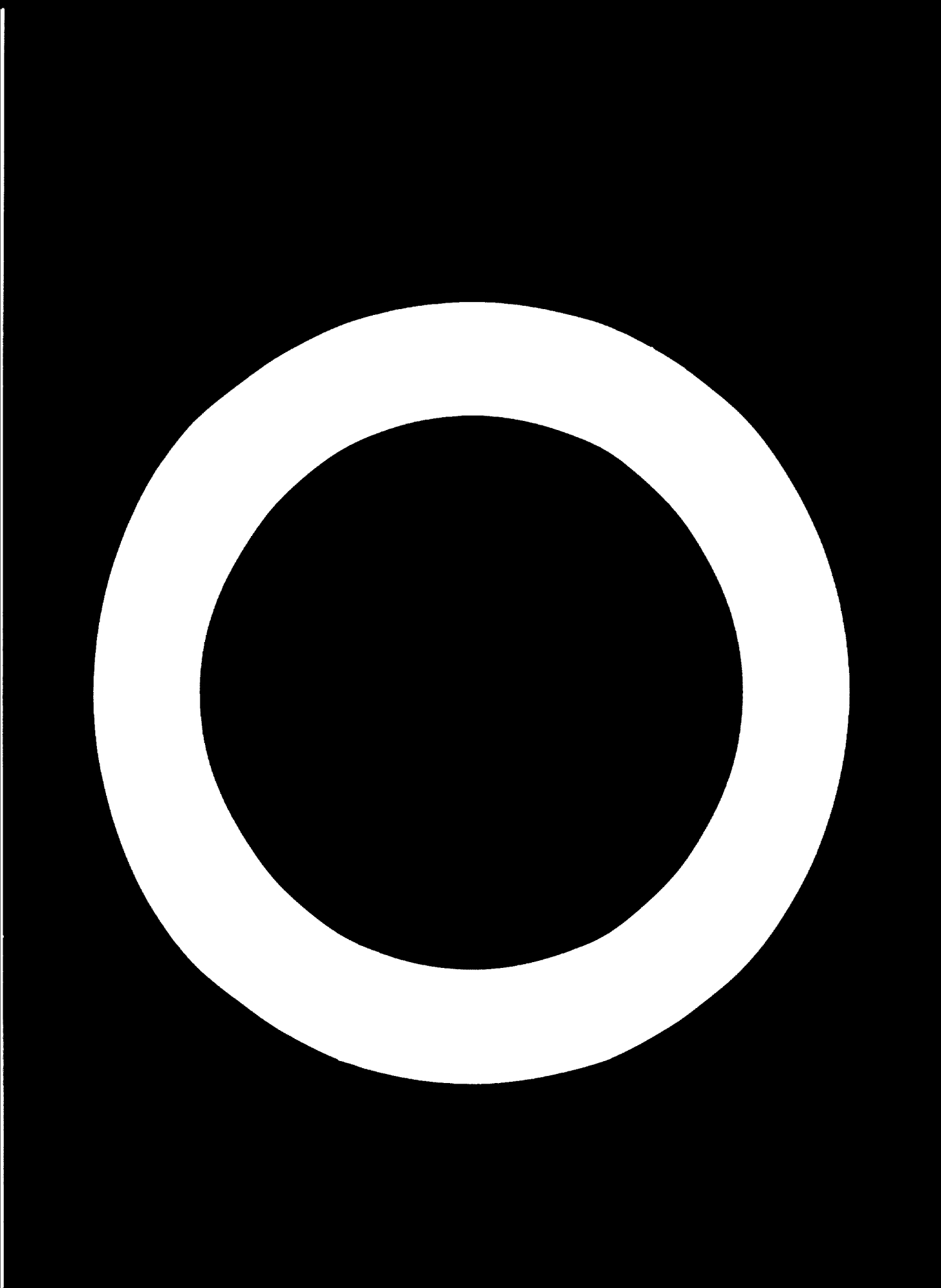

PRODUCT ADAPTATION AND UPGRADING OF QUALITY

(DP/IND/72/045)

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Technical report: Integrated circuits

Prepared for the Government of India
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Edward Keonjian, expert in integrated circuits

United Nations Industrial Development Organization
Vienna, 1975

Explanatory notes

The following symbols have been used throughout the report:

A comma (,) is used to distinguish thousands and millions.

Use of a hyphen (-) between years, e.g., 1964-1966, signifies the full period involved, including the beginning and end years.

References to "dollars" indicate United States dollars, unless otherwise stated.

IC: integrated circuits

CONTENTS

SUMMARY

The project "Product Adaptation and Upgrading of Quality" sponsored by the United Nations Development Programme (UNDP), is part of a comprehensive plan of export development of the Government of India. Designed to assist Indian manufacturers in achieving greater export potential, the project mainly involves bringing, to carefully selected industries, highly qualified technicians and product experts from developed countries to analyse problems, point out needed improvements and help carry out the necessary modifications. Three product groups have been selected for the current project: electronic equipment and components, bicycles and bicycle components and sporting goods.

The objectives of the mission covered in this report were to:

(a) Survey various Indian semiconductor manufacturers to determine whether expansion of this technology into integrated circuit (IC) production would be feasible;

(b) Advise on the type of IC technology that would best suit India;

(c) Review current IC standards, specifications and manufacturing and testing techniques. 1/

The decision of India to begin manufacture of IC devices is fully justified, considering the ever-growing importance of IC in almost all new technological developments of consumer and industrial goods and services. IC technology, however, is still in an early stage of development in India. It also varies considerably among companies, with the government sector having an advantage over the private sector. The development of IC technology is about five years behind western Europe and about a decade behind the United States of America.

Thus, for rapid implementation of the most advanced know-how in India, effective collaboration between Indian manufacturers and leading IC manufacturers from developed countries is necessary. It is also recommended that, at first, India adapt well-established technologies and devices currently in world-wide use rather than the most advanced technology still in the development stage.

1/ In addition to this mission by an expert on IC technology, experts on the following electronic products have been included in this project: tantalum capacitors, power transistors, metal film resistors and solid state devices.

INTRODUCTION

The rapid development of the integrated circuits (IC) industry and the growing importance of IC devices as basic elements in an endless number of modern electronic and non-electronic goods, for both consumer and industrial markets, led to the adoption of the mission which had the following objectives:

(a) To survey the state of the art and the capabilities of various Indian semiconductor manufacturers, both in the government and the private sectors of the industry, in order to determine whether expansion of this technology into production of IC is feasible and what modifications or improvements will be necessary;

(b) To consider the pros and cons of various IC technologies and advise on the type of product that would be best suited for production in India, considering India's immediate and future needs for domestic consumption and export, as well as the rapid changes in semiconductor technologies;

(c) To review current IC standards, specifications and manufacturing and testing techniques, especially those in the United States of America. The review should also include the availability and cost of certain testing equipment, reliability data and the effect of such factors as moisture, dust, dirt and vibration on the failure of IC.

The mission was from 3 to 31 March 1975.

FINDINGS

The decision of India to begin manufacturing IC devices for both domestic consumption and export is fully justified, considering the ever-growing importance of IC in almost all new technological developments of consumer and industrial goods and services.

The state of the art of IC in India is still at an early stage of development. It is approximately five to six years behind western Europe and eight to ten years behind the United States of America. The existing facilities, the local managerial and administrative arrangements and the availability of skilled labour vary considerably among firms and locations. The government sector has, in general, an advantage over the private sector in terms of available facilities and equipment.

The following are descriptions of most of the companies visited and their capabilities. A complete list of the organizations and companies is contained in the annex.

UNDP and Trade Development Authority of India

The expert spent two days familiarizing himself with the functions of the organizations and their place in industry. His schedule of travel and visits to various companies was arranged at this time.

Electronic Commission and Department of Electronics

Discussions were held with several officals. They differentiated between two groups of Indian industrialists with separate approaches to the manufacturing of IC. The first group is composed of industrialists who are unfamiliar with electronics, especially solid state electronics, and who therefore are indifferent to the field. The second group covers industrialists who are already in the electronics field but who lack the motivation to enter the new field of IC.

The government officials seek to link these groups together and persuade both groups to enter the IC field, with the primary aim of exporting IC to Europe and to other Asian countries. The Government is willing to provide the necessary financial support for this endeavour.

The discussion was resumed a few days later with the [illegible] specialist on IC. He has prepared a report recommending that India [illegible] manufacturing industry by expanding existing IC facilities [illegible] the available cheap labour.

Continental Devices India Ltd

Discussions were held with key personnel of the company, which was set up in 1965 as a joint venture with Continental Device Corporation (now Teledyn Semiconductor), Hawthorne, California. Initially the company was set up as an assembly operation, and in 1970-1971 a wafer fabrication facility was added. It has become self-sufficient in the manufacturing of bipolar transistors and diodes, currently the main activity of the company.

Facilities

Most of the equipment for diffusion and device fabrication are commercially-available American machines of considerable vintage. The only micro-probe in evidence is a rather primitive instrument, which needs replacement. Wafer sorting is done manually because of cheap labour and low-volume production.

Semi-automation in this and other critical areas, such as testing chips and devices, is highly desirable. Microscopes and even simple magnifying glasses are in short supply for the numerous manual operations.

Although independent quality control exists, its effectiveness is hampered by the lack and inadequacy of basic equipment, e.g. pull/pressure testers and vibration/shock testers.

Current technical literature from abroad is rather scarce; this is unfortunately true of most of the companies visited. In short, it would be difficult for this firm to enter the sophisticated and competitive field of IC manufacturing, without considerable expenditure for new equipment (approximately $US 200,000, excluding mask-making facilities and automatic micro-probes).

Availability of skilled labour

Skilled labour is not readily available; hence labour must be trained in-house. In addition, there are no established training methods and manuals, and these are very much needed by this company and by other IC manufacturers as well.

Engineering skills, however, are readily available. The engineers seemed to be well-informed in the state of the art of IC and eager to utilize their knowledge and experience, received primarily abroad in on-the-job practice. However, the lack of adequate facilities and equipment has greatly hampered their effectiveness.

Electronic Corporation of India Ltd (ECIL)

Discussions were held with the heads of several departments of ECIL, a constituent commercial undertaking of the Department of Atomic Energy. This public sector enterprise has several modern buildings in a very attractive set-up outside Hyderabad. The annual gross in 1974 was approximately $22 million: defence equipment accounted for 20 per cent of this total; commercial products, 20 per cent; university supply, 20 per cent; and industrial goods, 40 per cent.

The product line includes electronic components, frequency counters, microwave gears, semiconductors and navigational, bio-medical and nuclear equipment.

Facilities

The facilities are up-to-date, and the company plans to start producing IC by 1978 for domestic consumption. The need for mask-making facilities will be met by utilizing equipment existing at Bharat Electronics in Bangalore. The reliability group has facilities for burn-in, component life and environmental testing, which is done in close alliance with the United States MIL-STD-883, MIL-STD-202C and MIL-STD-750A. For failure analysis and automatic testing of IC, the company plans to purchase from the United States an electronic scanning microscope (ESM) and an automatic micro-probe machine.

Availability of skilled labour

It was difficult to determine the type of training programme needed by assembly workers and the availability of specific training manuals. However, the key personnel seemed knowledgeable in their respective fields, especially in

marketing research and reliability. They seemed to place emphasis on the reliability of their firm, probably as a result of reliability requirements for defence equipment.

Santa Cruz Electronics Export Processing Zone (SEEPZ)

The Development Commissioner of SEEPZ guided the expert through the Zone and explained the set-up and aims of this project. The Zone is specifically allocated by the Indian Government for foreign companies and their Indian subsidiaries to set up manufacturing facilities using Indian labour. The products made in the Zone are exported back to foreign countries without having entered the domestic market in India. A large number of buildings have been completed and are already allocated to various companies.

Intersil (Indian name. Indosil Ltd), a United States IC manufacturer, is bringing in IC assembling equipment for operation in the Zone. Other United States IC manufacturers who plan to set up their assembling facilities in the Zone include: Semicon Electronics Pvt. Ltd, associated with the Microsemiconductor Company; and Mahajan Hybrids, associated with the Helex Company (both located in the United States).

Semicon Electronics Pvt. Ltd

The company plans to assemble a large array of reliable diodes for multiple applications. These include temperature-compensated Zener diodes, pellet-type diodes and microminiature diodes for wrist watches, clamp circuits, memory devices and many other electronic control circuits.

The labour cost for a skilled assembly worker is approximately $0.50 an hour, including the direct labour cost, supervision and other overhead. Because of the availability of cheap labour, the company hopes to achieve a considerable savings in labour costs, as compared to that in the United States.

Semiconductors Ltd

The firm has three divisions of which the Semiconductor Division is the largest. The Division currently produces silicon and germenium transistors and diodes. The facilities are very limited, and a considerable outlay of capital for new equipment will be required for it to undertake the manufacture of IC. The company plans to purchase masks abroad and do the diffusion and assembly work in Poona.

Availability of skilled labour

As with other plants, written procedures and training manuals for assembly workers were not in evidence. Trained labour is not available and training is done on the job.

Engineering skills are readily available, but again, for their proper utilization, the equipment should be upgraded and the engineers given better and more systematic access to foreign technical literature. The managerial personnel, almost without exception, appeared to be competent, and most have been exposed to Western technology.

Hindustan Conductors Pvt. Ltd

A two-day discussion was held with key personnel. This is a relatively new company, primarily engaged in the manufacture of transistors and diodes, and in 1974 they produced close to 7 million units. Other products include: unijunction and field transistors, Zener diodes, solar cells, microwave products, RF filters and other solid state devices, including the assembly of IC with foreign-made chips.

Facilities

The well-planned plant includes provision for further expansion in terms of floor space, electrical outlets and water, gas and other utilities. The equipment is relatively modern, including Hugel epitaxil reactors, microtesters, compression bonders, vacuum evaporators (by Nortou), automatic wafer prober (by Pacific Western) and diffusion furnaces. There is no mask-making facility; masks are therefore imported from the United States and Japan at a cost of $1,200 for discrete mask art work and $6 for each $2\frac{1}{2}$ x $2\frac{1}{2}$ inch print. It was also noted that the incapsulation process is not automated and, as in other companies, the technical library leaves much to be desired. The firm has an application laboratory for developing new applications for their products, and they periodically publish application sheets for potential users of their products. As for reliability, the company almost parallels the United States MIL-STD-883, and in general, they appear to place emphasis on the reliability of their firm.

A large amount of additional new equipment has been ordered from the United States inoluding: ceramic dip equipment (from [illegible] Furnaces Company), testers (from Signetics Company) and thermo-pressure bonders (from Unitec Company). The company appears to be sufficiently mature to go into IC production, although full implementation of this technology would require collaboration with a firm in a developed country.

Availability of skilled labour

As with other plants, skilled labour is not readily available, and should be trained in-house.

The engineering and managerial personnel seemed to have sound technical and administrative knowledge and high quality standards. They are taking painstaking measures to maintain the quality of their product in spite of some limitations in the area of independent quality control.

Electronics and Computers (India) Ltd

The company's main products are electronic calculators and some electronic circuit assemblies, made of IC chips purchased from abroad. (General Instruments Company in the United States is one of the suppliers.) The company apparently intends to enter the IC manufacturing business in 1976-1977, and it already had the Government's permission to purchase approximately $1 million of equipment from abroad.

RECOMMENDATIONS

1. Determination of the kind of technology and the type of IC appropriate for manufacturing in India should be based on a realistic appraisal of the capabilities of the industry. It would be unwise to select the latest or the most advanced technology, which might be still in a stage of development or in a pilot production stage in a fully developed country. The end result would be uncertain and not worth the long struggle necessary for its adaptation. It would be wiser to adapt at first well-established technologies and devices that are currently used world-wide rather than those in development stages. This approach would have the greatest marketing potential over the next five or six years.

The selection of basic bipolar monolithic IC, such as TTL Series 7400 (digital) and Series 723 and 741 (linear), is therefore recommended. CMOS devices, chiefly for wrist-watch circuits and microprocessors, are also recommended. Hybrid circuits should also be considered seriously for various types of custom applications for which no standard circuits are available.

2. As the development of IC technology in India is far behind that of the developed countries, in particular the United States, some multiple forms of tie-up and collaboration of the Indian industry with leading IC manufacturers are strongly recommended. Their expertise and know-how should be fully utilized in the following areas, listed in order of priority:

(a) Semiconductor IC processing and process control for higher yield and better reproducibility. A technical assistance agreement should be reached with one of the leading IC manufacturers. The agreement should provide for 6 to 12 months training of qualified Indian personnel in a developed country, such as the United States, or the placement in India for the same duration of an expert who is highly specialized in processing;

(b) Another expert should be placed in India to establish a uniform training programme and standard manuals. The approximate time required for the training is 6 to 12 weeks;

(c) Each company should be required to establish a list of the most essential equipment to be purchased abroad, depending on its product line and actual needs. Some additional sophisticated equipment, such as the computer added design (CAD) for generating mask art work, the electronic scanning microscope (ESM) for failure analysis, and automatic parametric and functional testers (APFT), could be purchased with the financial assistance

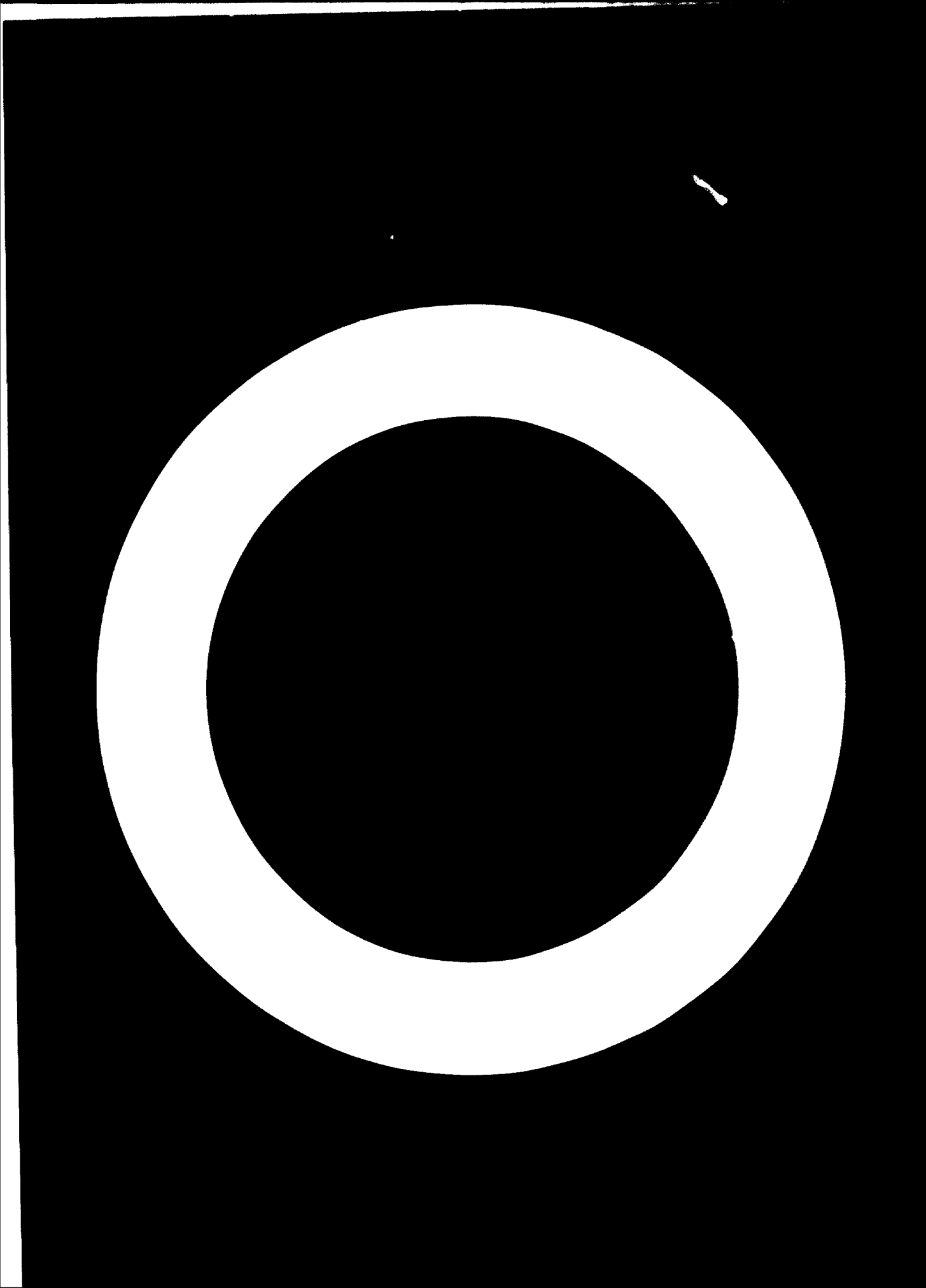
of the Indian Government for the use of all companies;

(d) The creation of a regular marketing survey [illegible] very rapid response to the needs of the industry is also recommended.

3. The IC manufacturing industry is highly sophisticated and extremely competitive. Therefore, for rapid implementation of the most advanced know-how in India, effective collaboration between Indian manufacturers and those in developed countries is a must. To advance this collaboration, a special unsponsored project should be established. An expert-consultant would be retained for one year. The expert should be a recognized leader in the field and thoroughly familiar with the most advanced technology in the semiconductor industry, its products and personnel. He would advise Indian manufacturers on the selection, availability and specifications of equipment and on the prevailing test methods and standards in the developed countries. He would also supply Indian IC manufacturers with relevant conference papers, non-classified government standards etc. Such an expert, acting under a United Nations mandate, would have easy access to many sources of technical information that would be of great interest to the Indian IC industry.

4. In addition, Indian IC companies must establish their own basic research and development facilities for follow-up of the new developments in IC technology, including the recent, very promising techniques of I^2L, silican gate technologies and nitride passivation.

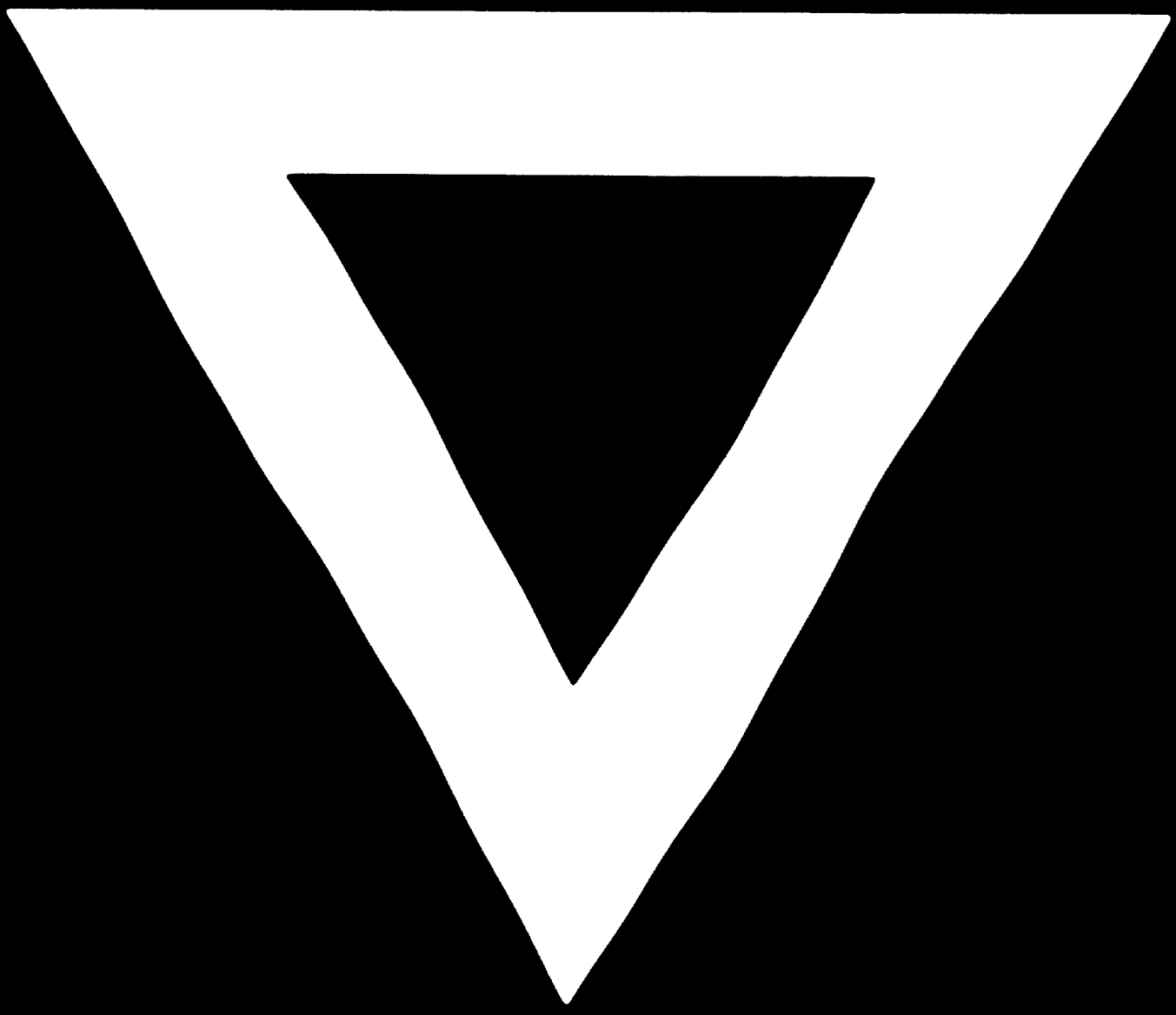
5. Major improvement in the technical library services of every company should be seriously contemplated.



Annex

COMPANIES AND ORGANIZATIONS VISITED

Name of company or organization	Company personnel with which discussion was held	Number of days visited
UNDP and Trade Development Authority of India, New Delhi		2
Electronic Commission and Department of Electronics, New Delhi	IAS Technical Director Government Specialist on IC	1
Continental Devices India Ltd, Naraina Industrial Area, New Delhi	General Manager Research and Development Manager New Projects Manager Quality Control Manager Managing Director General Manager	2
Department of Electronics and Trade Development Authority, New Delhi		1
Electronic Corporation of India Ltd (ECIL), Hyderabad	Head, Marketing Head, Components Group Head, Reliability and Quality Control	1
Santa Cruz Electronics Export Processing Zone (SEEPZ), Bombay	Development Commissioner of SEEPZ	1
Semicon Electronics Pvt. Ltd, Bombay	Director	1
Semiconductors Ltd, Poona	General Manager	1
Hindustan Conductors Pvt. Ltd, Solid State Devices Division, Nadiad	General Manager General Manager, Operations Manager, Manufacturing Technical Manager Reliability and Quality Control	2
Electronics and Computers (India) Ltd, Ghaziabad, Uttar Pradesh	Managing Director	1



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