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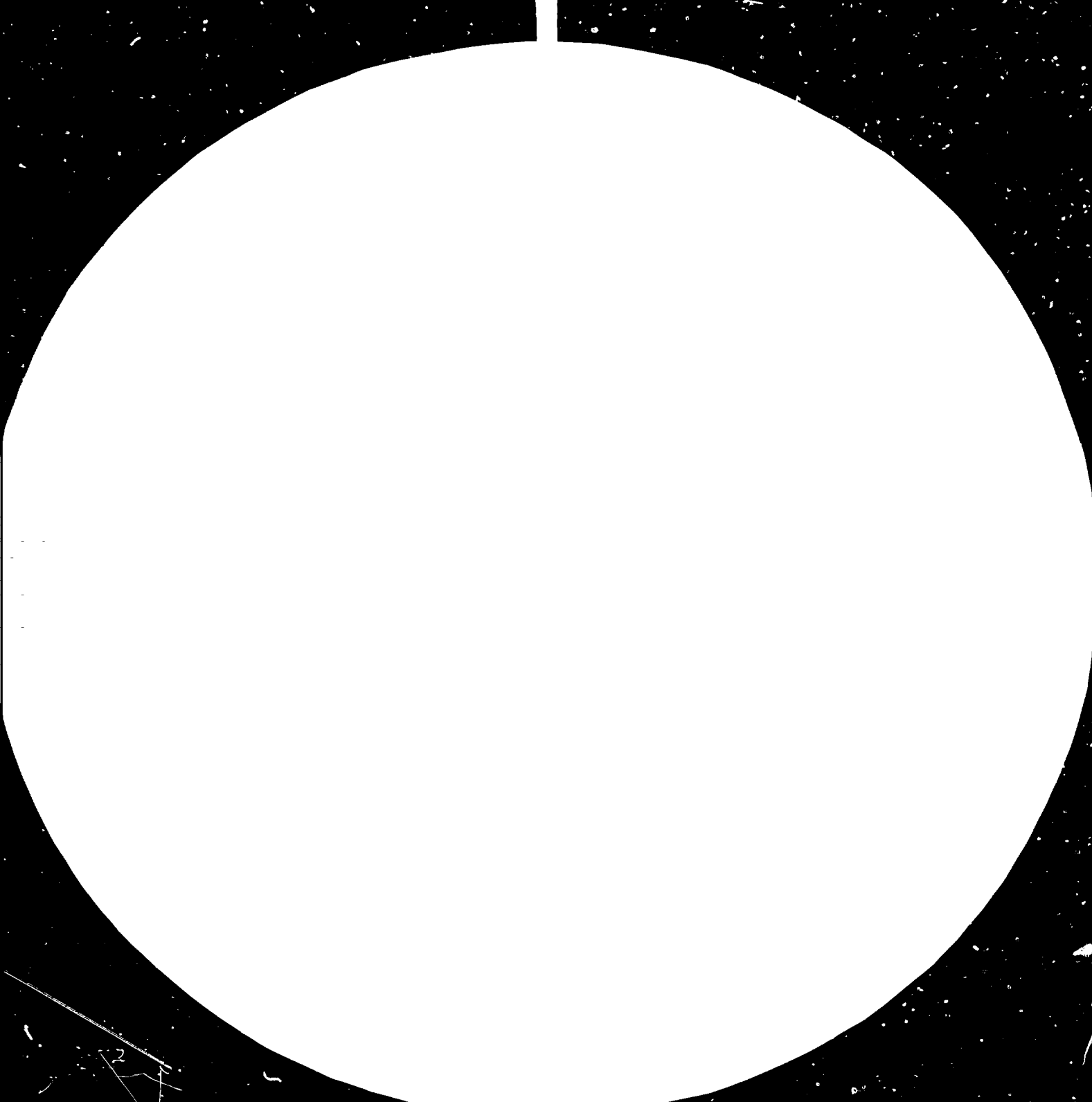

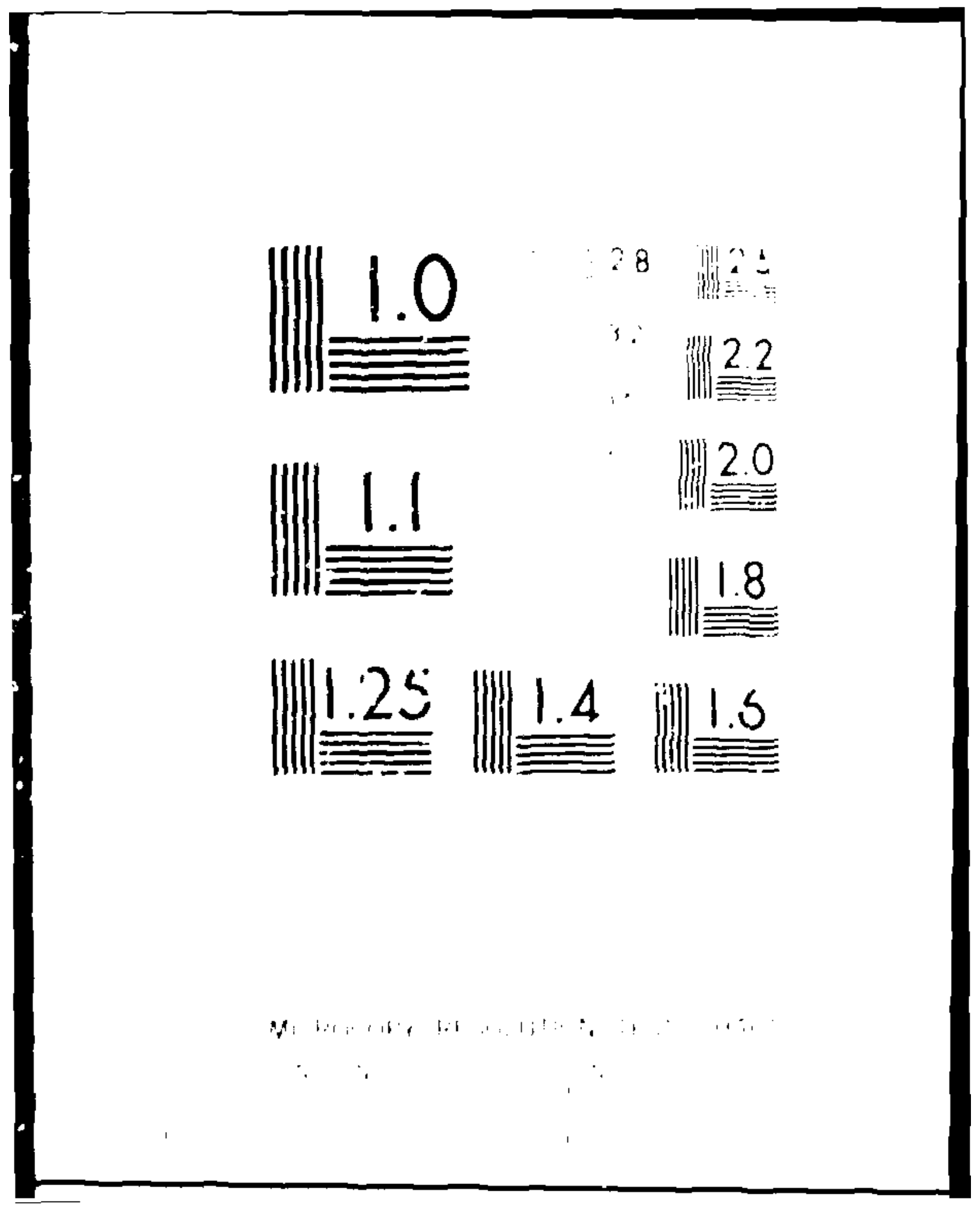
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EXCHANGE OF VIEWS WITH EXPERTS ON THE IMPLICATIONS OF TECHNOLOGICAL ADVANCES IN MICROELECTRONICS FOR DEVELOPING COUNTRIES

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SEMICONDUCTOR INDUSTRY AND R+D IN INDIA*

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1. INTRODUCTION

The "Electronics" industry has come to be a 'Key' Industry in almost all the developed countries of the world. Advances in this industry are a measure of the state of development of these countries. The United States of America, Japan are the world leaders in electronic production.

The semiconductor components industry has played a very critical part in expanding this electronics industry. With the recent advent of LSI's, the electronics industry is poised for another explosive growth. The LSI's (Large Scale Integrated circuits) will be the building blocks of all future electronic systems and as such, they are crucial to any country which is interested in electronics development.

In India, the semiconductor industry has not advanced to the same extent as in other developed countries. India accounts only for .45% of world electronic production. The reasons for this are many. This report describes in brief the semiconductor industry in this country. As Research and Development is an important constituent of semiconductor industry, the different R&D activities within India are also described in this report.

2) MAJOR PUBLIC SECTOR (GOVT. OWNED) INDUSTRIES.

1) Bharat Electronics Ltd., Bangalore, India.

The Bharat Electronics Ltd. (BEL) entered the semiconductor area in 1963, by making germanium transistors in collaboration with Philips (Holland). After a period, they started manufacturing Silicon planar transistors for entertainment market like radios etc., and also diversified the production of these devices to include devices for professional market. This was also with the technical collaboration of Philips (Holland). Over the last few years, they have acquired CMOS Metal Gate capability from RCA. This CMOS circuits are SSI (Small Scale Integrated circuits) gates (CD 4000 series) for computers and CA series for TV applications. They have developed on their own and in collaboration with TIFR, Bombay TTL integrated circuits. The company caters for 50% of the market demands for certain devices within the country.

The Company has so far invested a ~10 million dollars in capital equipment for semiconductors and has more than 30,000 sq.ft. of clean area. This facility is highly vertically integrated. Starting from growth of Si single crystals, through diffusion, photolithography, evaporation, ion implantation, computer aided design, mask making, packaging, lead frames, automatic testing, they have a complete production facility. At the present time, this is the best production facility

upto MSI (Medium Scale Integration) complexity in CMOS Metal Gate technology in the country. They also have a full-fledged hybrid facility.

The company does not possess an intensive industrial R&D for this area. The LSI's have not been attempted so far. The company employs 2000 people in this area consisting of skilled workers and engineers. The production plans, and introduction of new devices or circuits are largely dictated by local market demands.

2) Bharat Heavy Electricals Ltd, Bangalore, India.

This is a very large Government-owned enterprise dealing with heavy electrical machinery. Recently, they have established (1978) a semiconductor device facility for making large area power devices like thyristors, diodes etc. (1500 V, 1000 Amps) for traction etc. This is in collaboration with Siemens, West Germany. The facility includes, apart from other semiconductor process equipments, crystal pulling also. The investment is of the order of 3 to 4 million dollars and the facility,as it is set up, is good for power devices. They have no plans for Microelectronics or VLSI.

NGEF, another State owned company, located in Bangalore has a facility to produce similar devices in collaboration with AEG, Telefunken, West Germany.

3) Keltron Power Semiconductors, Kerala, India.

This is a large Kerala State owned company dealing in diversified product range. They have put up two factories in Kerala at a cost of nearly 3 to 4 million dollars, one for power transistors and the other for power diodes and SCR's. The total area is about 30,000 sq.ft. The two facilities are adjacent to each other, but have different complement of equipment tuned to their own product ranges. Both the facilities are integrated upto the diffusion stage. They import Silicon wafers, process them through diffusion, masking, evaporation, packaging and testing. They are in power field and they do not have R&D and the two factories have been set up on their own without any foreign collaboration.

They don't have any plans for LSI or VLSI or for any type of microelectronic devices.

4) Meltron Semiconductors Ltd., Nasik, Maharashtra, India.

Meltron Semiconductors Ltd., like Keltron, is a State owned company with a portion of their shares open to public. The Meltron Semiconductors has been set up in Nasik, 150 KMS from Bombay (in 1978). They have a 50,000 sq.ft. facility out of which, 10,000 sq.ft. is clean area. They have set up this plant in collaboration with Thomson-CSF, France. The total investment in the plant is about 4 million dollars.

The product line consists of glass passivated fast rectifiers, thyristors upto 30 Amps. and Triacs entirely meant for entertainment market. They also export some percentage of their production back to France.

The facility is operational and consists of diffusion masking, glass passivation, packaging, testing. This is a very good production facility for these types of devices. Their future plans do not include LSI devices.

5) Punjab Semiconductors Ltd., Mohali, Punjab.

Punjab Semiconductors, is a State owned unit of Punjab State Government, and was set up in 1975-76. The plant has been set up by Indian professionals and the company deals in diodes of low amperage and pwer transistors. They cater to entertainmant market.

The total cost of the plant is about 2 million dollars and the area of the facility is about 40,000 sq.ft. The plant is fairly integrated, starting from crystal preparation, diffusion, masking, evaporation, packaging and testing. They don't have a R&D and they concentrate mainly on low cost high volume production of devices.

They have no plans for LSI.

6) Semiconductor Complex Ltd., Mohali, Punjab.

This is a fully owned Government of India company which was set up in 1978. The proposed total outlay of the plant is

about 20 million dollars. This plant will have two wings, one for production and one for R&D. The plant will solely devote itself to manufacture MOS/LSI products like calculator chips, watch chips, computer memories, interfaces and telecommunication products. The technology for implementation was to be bought from overseas. The entire plans for this company were made at TIFR, Bombay.

At the present time, it is understood that they have signed an agreement for purchase of MOS/LSI technology and the plant is to go into production by about 1983-84.

As per the original plans, the plant will be vertically integrated with a very intense R&D back up and the plant is proposed to have all the sophisticated semiconductor processes.

7) Central Electronics Ltd., Ghaziabad, Delhi.

This is a Government owned company primarily set up to productionise some of the items developed by various national laboratories. The outlay of the plant is about 5 million dollars. The product range includes, in the component field, items like ferrites, light emitting diodes based on III-V compounds, liquid crystal displays and silicon solar cells for terrestrial applications.

At the present time, the main emphasis of the plant is to produce Silicon solar cells to meet the energy crisis partly. For this item they are fairly equipped including crystal pullers. The future plans include GaAs solar cells, silicon ribbon growth etc. They have no plans for VLSI.

8) Electronics Corpn. of India Ltd., Hyderabad.

This is a giant Government owned company like BEL, Bangalore, dealing in diversified electronic products like computers, T.V, process control, passive components and semiconductors.

The semiconductor operation deals in low power diodes and entertainment transistors. The investment in this area may be of the order of 4 - 5 million dollars and the equipments set up cater for fabrication of small area devices. This plant has been set up by Indian professionals.

They have no immediate plans for LSI or VLSI.

9) Solid State Devices, Hyderabad.

This plant has been set up a few years ago by private individuals with substantial equity participation from the State Government. The plant is supposed to manufacture Schottky Barrier Diodes, Schottky TTL circuits of SSI variety and linear operational amplifiers.

The total outlay is about 4 million dollars and the built-up area is about 30,000 sq.ft.. The equipments include diffusion furnaces, evaporators, mask aligners, bonders etc. The plant does not have direct collaboration with any one company but was to be run by a group of expatriate Indians returning from Silicon Valley/USA. They have no R&D and no present plans for diversification into VLSI.

3. MAJOR PRIVATE OWNED COMPANIES (PRIVATE SECTOR)

1) Semiconductors Ltd., Poona.

This plant was the earliest semiconductor company in India and was set up by private individuals. In the early stages, they manufactured Germanium transistors in collaboration with Raytheon, USA. They are still one of the major suppliers of Germanium transistors within the country next to BEL, Bangalore. Subsequently, they have set up, on their own, Silicon facility for manufacturing radio type transistors. The total outlay is about 5 million dollars. The product range includes discrete plastic transistors, IC's for T.V. and nigh power diodes and SCR's.

They have a fairly well laid out and integrated facility which includes crystal pulling and preparation, mask making, diffusion, epitaxy, evaporation, all types of automated assembly equipments etc. They have a fair share of the local market and they have no R&D and no plans for LSI or VLSI.

2) Hind Rectifiers, Ruttonshah Simpson, Navar Electronics, Khandelwal-Herman, Solid State Devices, Bombay.

All these companies are privately owned dealing specifically in the area of power electronics. All of them have collaboration with some company or other overseas. Some of these companies are, westinghouse, U.K., International Rectifiers, USA, Siemens, west Germany etc.

None of these companies is vertically integrated. They deal mainly in packaging of these devices, and they diffuse for very specific types only.

They don't have either R&D or any plans for LSI.

3) Hindustan Conductors, Nadiad, Gujarat.

This is a privately owned company stituated about 200 miles from Bombay and deals primarily in the area of small signal devices for entertainment applications and integrated circuits of operational amplifier type.

The total outlay is about 5 million dollars. They have diffusion, epitaxy, masking and packaging facilities. They have a large number of assembly equipments. They don't have a in-house R&D. The entire plant is set up and run by Indian professionals.

They have no plans for LSI.

4) Continental Devices India Ltd., Faridabad, Delhi.

Continental Devices is one of the first companies set up in private sector to produce Silicon planar transistors. They, like all other privately owned companies, deal in small signal devices and integrated circuits. They are integrated from diffusion but no mask making capability.

The outlay is about 3 million dollars. They have set up a R & D for certain devices like liquid crystal displays etc.

Like all other private companies, their production plan is dictated by local market conditions.

They have no plans for LSI.

5) Usha Rectifiers, Faridabad,Delhi.

Like other companies in power electronics, this company also deals in power diodes etc. They have no particular capability for LSI or other high technology items.

4. SUMMARY OF INDIAN INDUSTRIAL SCENE.

India has adequate capacity and capability to produce most of the discrete silicon devices like transistors and diodes to meet the overall demands of the country. These devices are usually based on foreign types and their designs are either bought out or locally made. The reason for lack of wide variety of devices is partly due to market situation existing within the country and partly due to economy of numbers.

Almost all private owned houses do not have a strong base for industrial R&D. They usually tend to acquire future technologies from countries abroad and again the technology purchase is based on cost benefits. Some of the regulatory measures adopted by the Government for saving foreign exchange may have adversely affected a more rapid growth into new technology areas.

The Indian semiconductor industry has one thing lacking and that is device design and it also lacks new innovative

programmes in cost reducing processes. This will come only when the economy of scales of production necessitates further investments.

As far as high technology area of the LSI is concerned, Bharat Electronics Ltd., Bangalore and Semiconductor Complex Ltd., Chandigarh, both Government owned companies, are supposed to do these devices. It may take some time before they really produce these devices in quantities. Before this, a large amount of effort on R&D and on training of personnel has to be undertaken by these companies. The major market addressed by these companies is still the consumer sector.

5. SEMICONDUCTOR R&D IN THE COUNTRY.

The Semiconductor R&D within the country, has received considerable attention from the Government from time to time, and yet its impact on the local industry is not as great as one would have expected it to be. There are various reasons, chief of which is purely commercial. The market forces the policy of industrial investment and hence, the industry is in need of devices which are proven, tested etc. This can only mean import of designs and import of technology. Further, the R&D have to work fully on import substitution basis rather than new innovations This is hardly conducive to rapid technological growth of R&D. In spite of these restrictions, there are many labs. engaged in this area manned by a fairly large number of scientists. Some of

these laboratories and their activities are described below.

1) Central Electronics Engineering Research Institute (CEERI), Pilani, Rajasthan

This laboratory is situated about 150 KMS north of Delhi. The entire funding of the laboratory is from Council of Scientific and Industrial Research (CSIR), a Government of India organisation. This laboratory is housed in a 10 acre plot with about 50,000 sq.ft. of built-up area.

The activities of CEERI include, microwave devices like magnetrons etc., instrumentation, consumer oriented developments like colour T.V., studio consoles, microphones, control electronics for large installations like paper mills etc., and finally solid state devices.

The device area includes, high power Silicon transistors, varactor diodes, small scale IC's and GaAs based devices and solar cells. They have a complete line of equipment for the fabrication of solid state devices. They have set up clean rooms and auxiliary facilities like water, gas etc.

Recently, they have received an aid of 1.5 million dollars from UNDP, to do advanced R&D on integrated circuits. Under this grant, they have acquired an Electromask pattern generator for making masks, an ion implanter and a complete hybrid facility. They are also acquiring a complete commercial CAD facility at a cost of .5 million dollars under UNDP. With these facilities,

they are geared to make masks for LSI. However, their wafer processing capability has to be augmented before they can realise VLSI.

The laboratory has a number of scientists trained abroad both at higher and lower levels. Since the laboratory is to cater for industrial undertakings, their programmes have to obviously be tailored for this purpose.

2) Solid State Physics Laboratory, Delhi.

This laboratory is funded entirely by Department of Defence. The mandate for the lab is to cater for new materials and for new devices usable by Defence.

The laboratory has a built up area of nearly 50,000 sq.ft. and is engaged in Research and Development of Group III-V Compounds, Infra red materials and some solid state devices and circuits. They specialise in Space quality solar cells.

They have an excellent complement of Research equipments for low temperature studies like liquid Helium, NMR, Raman Spectrometer etc. In the device development area, they have a mask making capability for large structures, diffusion, ion implantation etc. They also have large crystal pullers.

Their programmes are heavily committed towards Defence requirements. Their capability is not towards high technology Microelectronics, namely LSI.

3) National Physical Laboratory, Delhi.

This is a very large laboratory funded by the Council of Scientific and Industrial Research. They have a wide variety of programmes. The solid state device activity forms a substantial part of these programmes.

In the solid state area, they specialise in materials area, like polysilicon and single crystal silicon. It is understood that they have successfully completed polysilicon based, inexpensive solar cells. Apart from this, they work on nigh current devices like SCR's etc.

4) Indian Institute of Technology (IIT), Delhi.

I.I.T., Delhi is one of the premier teaching institutes within the country. They have two large funded programmes of research in the Solid State area, (1) Cadmium Sulphide, heterojunction solar cells and (2) Charge Coupled Devices (CCD) for signal processing applications under the Centre of Advanced Research in Electronics (CARE).

They have basic facilities for MOS device studies. They have a regular flow of graduate students, who work on basic problems in Device Physics and Technology. Some of these students come to TIFR for training. For MOS, this is the second largest group next to the group at TIFR.

5) Indian Institutes of Technology, Kanpur & Kharagpur, Jadavpur University and Institute of Radio Physics & Electronics, Calcutta.

All these are teaching institutes except the Institute of Radio Physics at Calcutta which is an advanced research centre for solid state devices. The main programmes in most of the institutes are directed towards new materials and low cost Silicon solar cells. They work on Group III-V compounds also. They don't have any viable programme in MOS device design and technology.

6) Indian Institute of Technology, Madras.

Like other IIT's mentioned above, they have a funded programme in devices. They concentrate on high power PIN Diodes for microwave applications and molecular beam epitaxy methods for Group III-V compounds growth.

Recently, a programme for VLSI design course has been instituted here with TIFR faculty.

7) Indian Telephone Industries Ltd., Bangalor

This is a large Government-owned corporation for manufacture of all types of communication equipments. They have a large R&D group in the area of system design, Computer Aided Design and Hybrid circuits. They have an excellent Hybrid facility. They have no viable device programme especially LSI.

8) Solid State Electronics Group, T.I.F.R., Bombay.

A comprehensive report on this laboratory, describing the programmes and facilities, is available. This laboratory has built up a strong base for LSI work.

6. CONCLUSIONS.

From the above, it can be seen that in a vital area like MOS/LSI, there are no major efforts ecept in two or three laboratories. It is necessary therefore that these efforts are augmented.

In order to push the state-of-the-art as it exists today, it is necessary to acquire the facility for fine line geometry like electron beam equipment. This equipment and other auxiliary facilities are absolutely necessary, and they cost around 2.5 million dollars. This facility should be located in a place where further design and processing can take place. With this facility it would be possiole to design meaningful LSI circuits as applicable to underdeveloped world. These circuits may be used in agriculture, transportation, literecy etc.

Any thought about alleviating the sufferings of common man in an underdeveloped country by resoting to electronics, that means LSI, should be directed towards providing this facility in an environment where maximum benefit can be derived. The Solid State Electronics group at TIFR may be considered as a suitable place for this type of work.

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